

A STUDY FOR DEVELOPMENT OF STATISTICAL LITERACY SCALE FOR
UNDERGRADUATE STUDENTS

by

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ABSTRACT

A STUDY FOR DEVELOPMENT OF STATISTICAL LITERACY SCALE FOR UNDERGRADUATE STUDENTS IN A UNIVERSITY

Statistical literacy was defined as the ability to understand basic concepts, vocabulary and symbol of statistics, and some probability; and critically evaluate statistical information in everyday life situations. The aim of this study was to develop a valid and reliable instrument measuring statistical literacy for university students. Statistics content covered in previous instruments on statistics learning (CAOS- Web ARTIST Project, 2005; Statistical Literacy Skills Survey, Schield, 2008; ARTIST Topic Scales, 2006) and 6-12 grades curricula implemented in Turkey were examined. A Statistical Content Rating Form (SLCRF) was formed in the light of knowledge and skills involved in the related domain. Scholars who were offering statistics and research methods courses were asked which statistics topics undergraduate students are required to know for being statistically literate. Content coverage was determined according to scholars' answers, and then questions were selected among existing instruments in the literature. For topics that questions in the literature are insufficient then new questions were written by the researcher. Suggested questions were examined by experts and the 42 questions were chosen and tried out with a pilot study with 33 participants. Based on the results, the number of questions was reduced to 20 and it was tried again with a sample consisting of 90 participants. Then, the number of questions was reduced to 17 and Statistical Literacy Scale (SLS) was developed. SLS was administered to 476 undergraduate students. The construct validity of SLS was examined with experts' item based opinions and results of factor analysis. Content validity was assured with SLCRF results. From the data gathered from 476 participants the Cronbach alpha coefficient was calculated as .532. It is possible to say that SLS has the attributes of construct, content, and curricular validity.

ÖZET

LİSANS ÖĞRENCİLERİ İÇİN İSTATİSTİKSEL OKURYAZARLIK ÖLÇEĞİ GELİŞTİRİLMESİ ÇALIŞMASI

İstatistiksel okuryazarlık günlük hayat durumlarında verilen istatistiki bir bilgiyi anlayabilmek, yorumlayabilmek ve istatistiki bilgi ve bu bilgi üzerinden yapılan yorumu eleştirebilmek olarak tanımlanmıştır. Bu çalışmanın amacı istatistiksel okuryazarlığı ölçen, bir devlet üniversitesinde okuyan lisans öğrencileri üzerinde geçerli ve güvenilir bir ölçek geliştirmektir. İstatistik öğrenmeleri üzerine geliştirilmiş enstrümanların (CAOS- Web ARTIST Project, 2005; Statistical Literacy Skills Survey, Schield, 2008; ARTIST Topic Scales, 2006) ve Türkiye’deki 6-12 sınıflar müfredatının (MEB, 2005 ve 2009) içerdikleri istatistik konuları incelenmiştir. Bu konular ve becerilerden yola çıkarak İstatistiksel Okuryazarlık İçerik Derecelendirme Formu (İÖİDF) oluşturulmuştur. İstatistik ve araştırma yöntemleri dersi veren öğretim elemanlarına üniversite öğrencilerin istatistiksel okuryazar olmaları için hangi konuları bilmeleri gerektiği sorulmuştur. Alınan cevaplara göre konu içeriği belirlenmiş, ilgili konulardaki sorular literatürdeki ölçme araçlarından seçilmiş ve eldeki soruların yetersiz kaldığı konularda yeni sorular araştırmacı tarafından yazılmıştır. Önerilen sorular uzmanlarca incelenmiş ve seçilen 42 soru 33 katılımcının katıldığı bir pilot çalışma ile denenmiştir. Sonuçlar ışığında soru sayısı 20’e düşürülmüş ve 90 kişilik bir örnekleme yeniden denenmiştir. Bu çalışma sonunda soru sayısı 17’e düşürülmüş ve İstatistiksel Okuryazarlık Ölçeği (İÖÖ) geliştirilmiştir. İÖÖ 476 lisans öğrencisine uygulanmıştır. İÖÖ’nin kavram geçerliliği uzmanların soru bazında kanıları ve faktör analizi sonuçlarıyla değerlendirilmiştir. Kapsam geçerliliği İÖİDF sonuçları ile belirlenmiştir. Dört yüz yetmiş altı kişiden alınan veriler üzerinde ölçeğin Cronbach alpha katsayısı .532 çıkmıştır. İÖÖ’nin kavram, kapsam ve müfredat geçerliliği özelliklerine sahip olduğu söylenebilir.

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LIST OF SYMBOLS

d^2	Square of the value of the deviation that is aimed to be achieved
n_1	Quantitative majors
n_2	Combined majors
n_3	Social sciences
N	Number of participants
p	Probability of selecting a participant
q	Probability of not selecting a participant
t^2	Square of the theoretical value found according to the t table
σ	Standard deviation
σ^2	Variance

LIST OF ACRONYMS/ABBREVIATIONS

SLS	Statistical Literacy Scale
Q1 - Q42	Question 1 to Question 42
TQ1- TQ17	Question 1 to Question 17 in the Turkish version of SLS
EQ1 – EQ17	Question 1 to Question 17 in the English version of SLS
CAOS	Comprehensive Assessment of Outcomes for a first course in Statistics
SRA	Statistical Reasoning Assessment
QRQ	Quantitative Reasoning Questionnaire
UCALL	Union College for Lifelong Learning
SOLO	Structure of the Observed Learning Outcome
SLCRF	Statistical Literacy Content Rating Form
GPA	General Point of Average
AERA	American Educational Research Association
APA	American Psychological Association
NCME	National Council on Measurement in Education
IRF	Item Rating Form
KMO	Kaiser Mayer Olkin
DS	Descriptive Statistics
P	Probability
ISI	International Statistical Institute
BIO	Biology
CHEM	Chemistry
HIST	History
MATH	Mathematics
PHIL	Philosophy
PHYS	Physics

PSY	Psychology
SOC	Sociology
TI	Translation and Interpreting Studies
TLL	Turkish Language and Literature
WLL	Western Language and Literatures
AD	Management
EC	Economics
POLS	Political Science and International Relations
CET	Computer Education and Educational Technology
ED	Educational Sciences
FLED	Foreign Language Education
PRED-M	Undergraduate Program in Mathematics Education
PRED-P	Undergraduate Program in Preschool Education
PRED-S	Undergraduate Program in Science Education
CEDU	Integrated B.S. and M.S. Program in Teaching Chemistry
MEDU	Integrated B.S. and M.S. Program in Teaching Mathematics
PEDU	Integrated B.S. and M.S. Program in Teaching Physics
CHE	Chemical Engineering
CE	Civil Engineering
CMPE	Computer Engineering
EE	Electrical and Electronically Engineering
IE	Industrial Engineering
ME	Mechanical Engineering
INTT	International Trade
MIS	Management and Information Systems
TA	Tourism Administration
Sig.	Significance
Std.	Standard
Std. Dev.	Standard Deviation
df	Degree of Freedom

Min.

Minimum

Max.

Maximum

1. INTRODUCTION

In today's world, the power of information is huge, especially when the information is yielded through scientific research. As findings of research activities are shared with public, statistical results and methods used are also narrated as well as the context and the research problem. Hence, it can be said that statistics is not only part of the researchers' or experts' experiences but in the daily experiences of all individuals. For example, an ordinary person encounters with statistical information while reading a newspaper article. Hence, the ability of dealing with statistical information is a necessity for everyone which constitutes the core ability of statistical literacy. For this reason, statistical literacy was chosen as the topic of this study.

There are different definitions (Hayden, 2004; Wallman, 1993, Schield, 2001, Burnham, 2003, Watson and Callingham, 2003 and 2004; Gal, 2004) and models of statistical literacy (delMas, 2002; Sanchez, 2007). Moreover, related concepts like statistical reasoning and statistical thinking were examined in this study. Based on the analysis of different definitions, common themes that emerge in different definitions of statistical literacy were revealed. These common themes can be listed as understanding of statistical results, understanding (the basic) concepts, vocabulary, symbols of statistics, and some probability, critical evaluation of information, and the context of everyday life. Since everyday experiences cannot be thought apart from the culture, the Turkish context was examined. Taking into account common themes in different definitions, different models of statistical literacy, and the Turkish context, an adapted definition of statistical literacy was formed. According to this definition statistical literacy was defined as understanding basic concepts, vocabulary and symbols of statistics, including some probability, and critically evaluating statistical information as encountered in everyday life situations.

Universities have an essential function as institutions for research and education. Besides producing scientific knowledge through research, students who will be active members of the society are cultivated in universities. In many departments statistics courses are given as a required course. Undergraduate students are expected to be able to

disseminate statistical information arise from research as they encounter everyday life. It is important to examine university students' statistical literacy. Undergraduate students from all departments and years except English Language Preparation School and freshmen year students were considered as the population for this study.

In order to study statistical literacy empirically, there was the need for measuring this construct. Previous instruments measuring statistical literacy (Wilson, 1994; Schield, 2008) and related concepts (Garfield, delMas, and Chance, 2006; Garfield, DelMas, Chance, Poly, Ooms, 2006; Schield, 2008; Allen, 2006; Garfield, 2003) were examined. No similar study about statistical literacy was found in the Turkish context. Since the definition of statistical literacy used in this study was clarified by taking the Turkish context into account, a single instrument among existing instruments developed outside of Turkey was not suitable for this study. Therefore, it was decided to develop a new instrument, Statistical Literacy Scale (SLS), which is tailored to the definition of statistical literacy used in this study. The sample of the study was undergraduate students studying in a public university in Turkey.

Statistical Literacy Scale (SLS) was planned to be a multiple choice test where every question has only one keyed response. Items used in previous instruments were examined according to the cognitive level and content they were measuring. Among them questions that fit the scope of the SLS were selected and new questions were written when necessary. Two pilot studies and a final administration of SLS were carried out.

Moreover, the language was a consideration for the understandability of the scale. The scale was translated into Turkish and administered to a group of participants who had taken the English version of the scale. Qualitative comparisons depending on experts' ideas of equivalency of the two versions of the scale and quantitative comparisons regarding statistical analyses between participants' scores gained from the versions of the scale were done. It was seen that although scores gained from the Turkish version of SLS were higher, qualitative comparisons show that the two versions of SLS were equivalent.

2. LITERATURE REVIEW

2.1. Definitions of Statistical Literacy

The definition of statistical literacy has changed in terms of its scope and content. Nevertheless, the main aim of defining this construct remained the same. Some definitions of statistical literacy can be listed in the following pages.

In general terms, Hayden (2004) defined statistical literacy as the skills that a person needs in order to deal with issues of probability and statistics arise in everyday life. Wallman (1993) defined statistical literacy as the ability to understand and critically evaluate statistical results that guide our daily life. She also stressed the ability to appreciate the contributions that can be done to public, private, professional, and personal decisions by employing statistical thinking in her definition.

Furthermore, according to Schield (2001) statistical literacy is “the ability to review, interpret, analyze, and evaluate written materials (and detect errors and flaws therein).” Also again by Schield (2004) statistical literacy was summarized as being literate about everyday arguments that use statistics as evidence. On the other hand, Burnham (2003) defines statistical literacy as the habit of mind that makes us notice the strengths and weaknesses of claims and reports including statistical information, and also thinking the arguments based on statistical information as the claims, reports or arguments commonly appear in the non-technical media without specific prompting.

Watson and Callingham (2003, 2004) studied the ability of dealing with information provided with an empirical study. They proposed a six level hierarchical construct of statistical literacy where the levels are from idiosyncratic to critical mathematical levels which can be seen in detail in Table 2.1.

Table 2.1. Watson and Callingham's (2004) hierarchical levels of statistical literacy.

Level	Brief characterization of levels
6. Critical mathematical	Critical, questioning engagement with context, using proportional reasoning particularly in media or chance contexts, showing appreciation of the need for uncertainty in making predictions, and interpreting subtle aspects of language.
5. Critical	Critical, questioning engagement in familiar and unfamiliar contexts that do not involve proportional reasoning, but which do involve appropriate use of terminology, qualitative interpretation of chance, and appreciation of variation.
4. Consistent- Non critical	Appropriate but non-critical engagement with context, multiple aspects of terminology usage, appreciation of variation in chance settings only, and statistical skills associated with the mean, simple probabilities, and graph characteristics.
3. Inconsistent	Selective engagement with context, often in supportive formats, appropriate recognition of conclusions but without justification, and qualitative rather than quantitative use of statistical ideas.
2. Informal	Only colloquial or informal engagement with context often reflecting intuitive non-statistical beliefs, single elements of complex terminology and settings, and basic one-step straightforward table, graph, and chance calculations.
1. Idiosyncratic	Idiosyncratic engagement with context, tautological use of terminology, and basic mathematical skills associated with one-to-one counting and reading cell values in tables.

On the other hand, with narrowing the term statistical literacy to the context of adults living in industrialized societies, Gal (2004) formed a special definition consisting of two interrelated components. The first of these components of statistical literacy is the ability to interpret and critically evaluate statistical information, data related arguments, or stochastic phenomena. The second component is people's ability to discuss or communicate their reactions to such statistical information such as meaning, implications, or concerns about the information (Gal, 2004). The illustration of Gal's (2004) definition can be found in Figure 2.1.

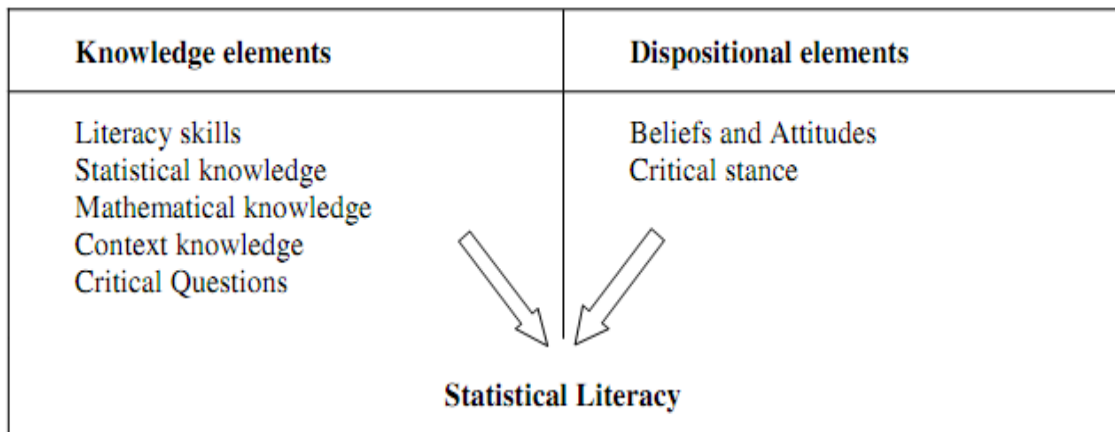


Figure 2.1. Gal's (2004) definition of statistical literacy.

Although there are differences in conceptualizing statistical literacy, there are common elements of definitions in the literature. For instance, from the review of the literature four themes emerged in the definitions of statistical literacy which are:

- understanding of statistical results (Wallman, 1993; Schield, 2001; Burnham, 2003; Garfield, delMas, and Chance, 2003; Watson and Callingham, 2003; Garfield, delMas, Chance, and Ooms, 2006)
- the context of everyday life (Burnham, 2003; Watson and Callingham, 2003; Hayden, 2004; Schield, 2004)
- understanding (the basic) concepts, vocabulary, symbols of statistics, and some probability (Garfield, delMas, and Chance, 2003; Watson and Callingham, 2003; and Garfield, delMas, Chance, and Ooms, 2006)
- critical evaluation of information (Wallman, 1993; Watson and Callingham, 2003 and 2004; and Gal, 2004)

From this synthesis of the literature, understanding statistical concepts, and results; and critical evaluation of information can be considered as the abilities necessary to be statistically literate; where everyday life is the context of statistical literacy; concepts, vocabulary, symbols of statistics and some probability constitutes the content of statistical literacy.

Callingham (2006) stresses the necessity of identifying a framework for assessing statistical literacy. Watson (1997) presented a framework with three hierarchical components with increasing sophistication which can be listed as:

- (i) a basic understanding of terminology of probability and statistics
- (ii) an understanding of statistical language and concepts given in the context of wider social discussion
- (iii) a questioning attitude for questioning the application of concepts to contradict claims made without proper statistical foundation

The four themes emerged from statistical literacy definitions and a tabular representation of the compatibility of Watson's (1997) framework and these four themes can be seen in the following table:

Table 2.2. Comparison of Watson's (1997) framework and statistical literacy themes.

Watson's (1997) Framework	Statistical Literacy Themes
(i) A basic understanding of terminology of probability and statistics	Understanding (the basic) concepts, vocabulary, symbols of statistics, and some probability
(ii) An understanding of statistical language and concepts given in the context of wider social discussion	Understanding statistical results The context of everyday life
(iii) A questioning attitude for questioning the application of concepts to contradict claims made without proper statistical foundation	Critical evaluation of information

2.2. Related Constructs

To better understand statistical literacy, reviewing competencies related to statistical literacy is necessary. These constructs are statistical reasoning and statistical thinking. These concepts will be covered briefly under the following headings.

2.2.1. Statistical Reasoning

Garfield and Chance (2000) and Garfield, delMas, and Chance (2003) define statistical reasoning as the way people reason with statistical ideas and make sense of

statistical information. Some selected types of reasoning necessary for statistical reasoning can be listed as reasoning about data, reasoning about representations of data, reasoning about statistical measures, reasoning about uncertainty, reasoning about samples, and reasoning about association (Garfield, 2003). Garfield, delMas, and Chance (2003)'s clarification on statistical reason was summarized in Ben-Zvi and Garfield (2004) as statistical reasoning may involve connecting one concept to another (e.g., center and spread), or it may combine ideas about data and chance having in mind that reasoning means understanding and being able to explain statistical processes and being able to fully interpret statistical results.

2.2.2. Statistical Thinking

Snee (1990, p.118) defines statistical thinking as

“thought processes, which recognize that variation is all around us and present in everything we do, all work is a series of interconnected processes, and identifying, characterizing, quantifying, controlling, and reducing variation provide opportunities for improvement”.

Pfannkuch and Wild (2004) proposed five types of thinking that are fundamental for statistical thinking: Recognition of the need for data, transnumeration, consideration of variation, reasoning with statistical models, and integrating the statistical and contextual. According to them, recognition of the need for data stands for considering the real situations data as a prime requirement for reliable judgments, transnumeration means “changing representations to engender understanding”, consideration of variation occurs in the process of how variation arises and is transmitted through data and the uncertainty caused by unexplained variation. Moreover, statistical models are taken in a broad range including all types of tools that are used in representing and thinking about reality like graphs and by reasoning with statistical models people are expected to read, interpret and reason graphs, centers, spreads, clusters, outliers, residuals, confidence intervals, and p-values to find evidence on which to base a judgment. Lastly, Pfannkuch and Wild (2004) state that synthesizing statistical and contextual knowledge on concluding what can be learned from the data about the context is necessary for statistical thinking and they name this competency as integrating the statistical and contextual.

Garfield, delMas, and Chance (2003) summarizes that statistical thinking involves understanding of why and how statistical investigations are conducted and understanding “big ideas” like nature of variation and sampling, usage of data analysis methods and visual displays of data, research methods to claim causality. Moreover, statistical thinking includes understanding how models are used and utilizing the context of a problem in drawing conclusions.

From the analysis of definitions given above, it can be inferred that there is an understanding of statistical thinking that embraces statistical processes, variation, and the context. Chance (2002) suggests that from existing definitions it can be said that there exists a more global view of the statistical process which include understanding of variability and the statistical process as whole.

As a final word, delMas (2002) assumes that the content is not a determinant factor in distinguishing these three domains, but the cognitive engagement with the content is. Moreover, he lists the tasks he collected from literature related to each domain in the following table:

Table 2.3. delMas’ (2002) three instructional domains.

Basic Literacy	Reasoning	Thinking
Identify Describe Rephrase Translate Interpret Read	Why? How? Explain (The Process)	Apply Critique Evaluate Generalize

2.3. Models of Statistical Literacy

The models he proposes represent two different perspectives about the relationship between literacy, reasoning and thinking. One perspective he uses is focusing on literacy for the development of basic skills and knowledge necessary for statistical reasoning and statistical thinking. Another perspective is thinking of statistical literacy as a domain that encompasses other domains. In this second perspective, statistically reasoning and statistical thinking are sub goals in the pursuing of developing statistical literacy. In this

point of view, a statistically literate person is the one who also knows how to think statistically. These two models can be seen in Figure 2.2.

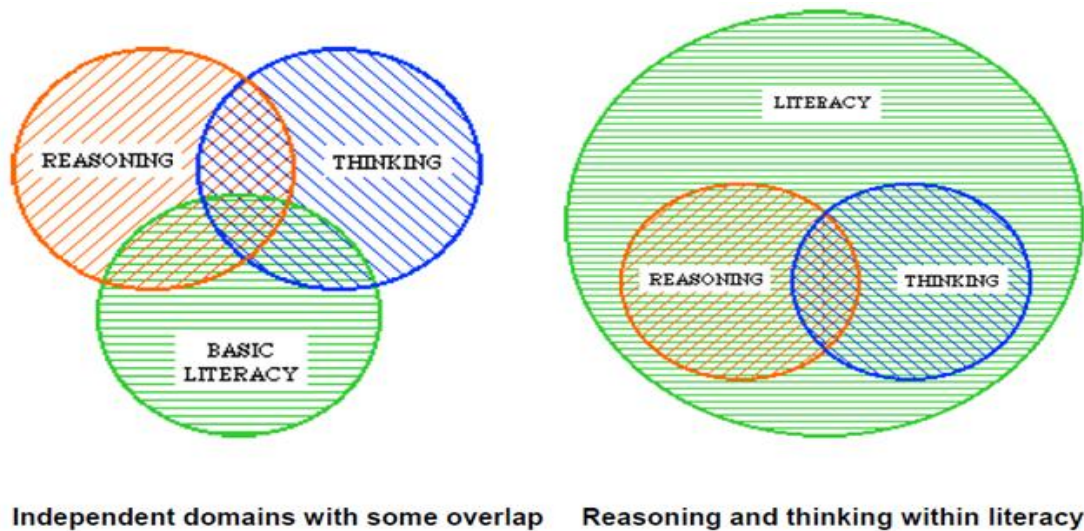


Figure 2.2. delMas' (2002) models of statistical literacy.

In the first model, it is seen that statistical thinking, statistical reasoning, and statistical literacy are independent, yet overlapping domains. In this regard, literacy is considered as the basic literacy for which with identifying, describing, rephrasing, translating, interpreting, and reading is required. These activities can be thought as lower mental processes, which also correspond to “comprehension” level in terms of Bloom’s (1956) taxonomy of educational objectives or “understanding” level in terms of Anderson and Krathwohl's (2000) Taxonomy which is a revised version of Bloom’s taxonomy and equivalent of comprehension level.

On the other hand, Sanchez (2007) proposed two different models of statistical literacy where the complexity of statistical literacy and its relationship with other domains are different in each model. In her model the abbreviations L stands for statistical literacy, R statistical reasoning, and T for statistical thinking. Both models can be seen in Figure 2.3.

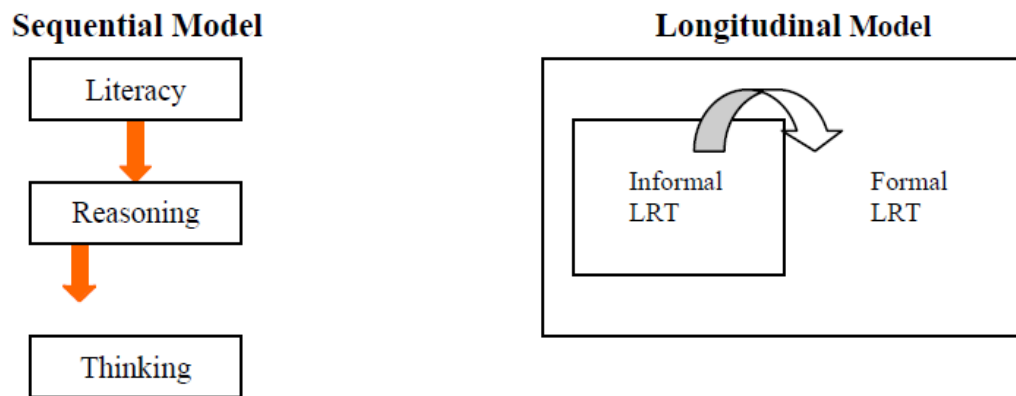


Figure 2.3. Sanchez's (2007) models of statistical literacy.

As Sanchez (2007) declared, in the first model statistical literacy, statistical reasoning, and statistical thinking are independent domains which happen after the accomplishment of the previous one. In the longitudinal model, statistical literacy is the understanding of the whole process and levels of statistical reasoning, statistical thinking and statistical literacy are developing in a synchronized way. In this model, at the informal stage of statistical literacy, people know statistical processes like data collection, description, summary and inference. At the formal level people also know about some formal apparatus like confidence intervals or sampling distributions. From Sanchez's explanation it can be inferred that the content is not determinant of the competency but it is important in the determining the level that the competency is processed. It can be also thought that delMas and Sanchez both agree on the idea that content does not determine the competency.

The idea of having different models is that there are two conceptualizations of statistical literacy: a competency that is as basic as literacy itself and a complex competency that embraces statistical thinking and statistical reasoning. These two conceptualizations can be summarized with the notions basic understanding of statistical literacy and complex understanding of statistical literacy. Moreover, the distinction between these two conceptualizations stems from the cognitive engagement but not the content.

From this perspective, it can be said that Watson and Callingham (2004), Burnham (2003), Schield (2001), and Wallman (1993) perceive statistical literacy as a complex construct. On the other hand definitions of Gal (2004) and Schield (2004) signal that these authors mainly focus on statistical literacy as a construct with basic competency.

The reasons on having different ideas about the complexity of the statistical literacy can be analyzed. As stated previously, there are four themes that emerge in definitions of statistical literacy: understanding of statistical results, the context of everyday life, understanding concepts, vocabulary, symbols of statistics, and some probability, and critical evaluation of information. Among these four themes the context of everyday life and understanding are relatively clear that the probability of affecting the complexity of statistical literacy is low but the competency of critical evaluation can be effective in determining the complexity of statistical literacy. Critical evaluation can mean a wide range of actions like criticizing the relationship between the data and its interpretation, criticizing the relationship between given statistical results and the research methods that the results were yielded through, or criticizing about the variables that are not included in the study but may affect the statistical results yielded. Hence, it can be said that the complexity of statistical literacy concept can differ through how deep individuals are expected to dig in criticizing a statistical expression they encounter.

2.4. Content of Statistical Literacy

As statistical literacy was described with understanding the concepts, vocabulary, symbols of statistics, and some probability (Garfield, delMas, and Chance, 2003; Watson and Callingham, 2003; and Garfield, delMas, Chance, and Ooms, 2006), it can be said that there is not a consensus about what content should be covered in statistical literacy. Identifying the basic concepts of statistics is an important question to be addressed in order to describe the scope of the definition of statistical literacy used in this study. Previous studies on assessment, teaching, proposals for necessary topics for statistics related concepts, and related curriculum were gathered and analyzed in terms of its content.

2.4.1. Statistical Literacy Content in Instruments

Previous studies assessing or teaching statistical literacy were examined in terms of their content coverage. To start with, studies assessing statistical literacy were searched. As it was seen from the models of statistical literacy, statistical can be seen in relation with statistical reasoning and statistical thinking. Therefore, instruments assessing statistical reasoning and statistical thinking were also searched. It was considered that some topics could be covered commonly although the depth of topics could be different in such instruments. In addition, instruments assessing statistics achievement were also searched.

To start with, Schield (2002, 2008) constructed an inventory about “Reading and Interpreting Tables and Graphs Involving Rates and Percentages” and developed it into “Statistical Literacy Skills Survey. The item- total score correlations, percentage of questions which were answered right were calculated, and by modeling different number of questions, he asserts that the improvement of the instrument can be possible by eliminating some of the questions (Schield, 2008). However no evidence for construct and content validity was reported.

Other than statistical literacy instruments, Garfield, delMas, and Chance (2006) published their project named Assessment Resource Tools for Improving Statistical Thinking (ARTIST) aimed at improving research on statistical literacy, reasoning and thinking for undergraduate students. They developed topic based scales which cover 11 topics each consisting of 7-15 multiple-choice items to assess student reasoning in those particular topics. The psychometric properties of these scales are not published that’s why; they cannot be reported here.

Another study is Comprehensive Assessment of Outcomes for a first course in Statistics (CAOS) test produced by Garfield, DelMas, Chance, Poly, Ooms (2006). The aim of such a study is developing an instrument for measuring conceptual understanding of important statistical ideas by a broader range of students who enroll in the first, non-mathematical statistics courses at the undergraduate level. The content validity for CAOS was assured with three rounds of evaluation by content experts for college-level non-mathematical first course in statistics (delMas, Garfield, Ooms, and Chance, 2006). The

psychometric properties of this scale was reported as valid and reliable (Cronbach alpha=.82) when it was tried in undergraduate student groups (delMas, Garfield, Ooms, and Chance, 2006; 2007).

Allen (2006) developed an instrument called The Statistics Concept Inventory for assessing conceptual understanding of students taking statistics courses from different departments including engineering, mathematics, and social sciences. Content validity of the instrument was achieved through surveying faculty about the necessity of statistics topics in their curricular needs. Moreover, the reliability of the instrument was calculated in different administrations and for the last administration the alpha of the instrument was found as .76.

Garfield (2003) developed an instrument for assessing statistical reasoning named Statistical Reasoning Assessment (SRA) consisting of 20 multiple choice items about probability and statistics concepts as it was defined as reasoning with statistical ideas and making sense of statistical information (Garfield and Chance, 2000). The reliability analysis showed that inter correlations between items were low and items were not measuring one trait or ability.

Moreover, in 2003 Sundre Developed Quantitative Reasoning Questionnaire (QRQ) based upon revisions of Garfield's (2003) instrument for the purpose of how students use quantitative information in everyday life. The new instrument consisted of 40 multiple choice items and was tried with 804 sophomore students. The internal consistency was calculated as .62. The compilation and comparison of statistics topics covered in assessment studies can be seen Appendix A in Table A.1 and Table A.2 respectively.

2.4.2. Statistical Literacy Content in Instruction

There were also studies which performed an instruction for the attainment of statistical literacy. Wilson (1994) developed and evaluated a statistical literacy program for the use of undergraduate students at Illinois which was named as "A Brief Course in Statistical Literacy". Dimensions of this program were defined as understanding statistics, applying statistics, and interpreting statistic and topics in this program included picturing

data displays and describing distributions. He also developed an instrument, namely Test of Statistical Literacy I and II, for evaluating the attainment in the course content. He developed two parallel forms of the instrument to evaluate the effectiveness of his instruction, one to be administered as pretest and the other as posttest each consisting of 38 questions; the reliability of the pretest was calculated as .69 and as .82 for the posttest.

Schild (2003) also taught a one semester course in statistical literacy with business majors. This course covered the objectives like reasoning with statistics and describing rates and percents. In 2009, another course, a mini, five two-hour session course was designed for adults in Union College for Lifelong Learning (UCALL) which was named as Numbers in Everyday Life (Hahn, Doganaksoy, Lewis, Oppenlander, Schmee, 2010). Topics covered for this course included some examples and basic concepts, polls and forecasts. In addition, Merriman (2006) designed a unit of work on statistical literacy to ninety 14 years old students in New Zealand using media reports. The duration of the teaching was 12 hours and pre and post assessment were done with questions featured short answer questions involving media reports on statistical literacy concepts. Compilation of statistics topics covered in these instruction studies can be seen at Appendix A in Table A.3.

2.4.3. Suggested Statistical Literacy Content by Authors

There are some studies focused on proposing some important topics in statistics education. For example, Scheaffer, Watkins, and Landwehr (1998, as cited in Gal, 2004) proposed a list of topics that are essential to include in a study like number sense and understanding variables. Garfield and Ben-Zvi (2005) also offered a list of big ideas of statistics that students encounter throughout their education including data and distribution.

Moreover, some other researchers identified some ideas that every student should know. For example, in her article “What educated citizens should know about statistics and probability” Utts (2003) tried to compile ideas which she claims that necessary for every student who takes elementary statistics to be an educated citizen. These essential ideas include knowing when it can be concluded that a relationship is a cause and effect type of relationship and when it is not and the difference between statistical significance and

practical importance. Also Schield (1999) stated three important distinctions that are important in distinguishing a statistical literate person and an illiterate one. These distinctions are association versus causation, sample versus population, and the quality of the test versus the power of the test. The association versus causation distinction indicates the ability to distinguish between causal relationships from others. The sample versus population distinction stands for distinguishing target population from the sampled population and the distinction between the quality and power of a test includes the part and whole relationship. He also gives a full list of the knowledge areas that a statistically literate person accomplishes which also include interpreting what a statistic means and asking various questions about the statistics. The detailed list of statistics topics proposed as necessary by the authors mentioned can be seen at the Appendix A in Table A.4.

2.4.4. Statistical Literacy Content in Curricula

The statistics topics in mathematics curriculum can also be considered as a way to identify basic concepts of statistics. In United States, Sorto (2006) analyzed documents regarding mathematics education in middle grades from ten states, mostly being state standards and constructed contour maps accordingly. The map regarding ten states indicated that the least covered topics were shapes of distribution and the process of statistical investigation where the emphasis is on representations of data and measure of center (Sorto, 2006).

In Turkey, grades 1-8 are compulsory for all citizens and statistics topics in these eight year long curricula can be considered as the basic statistical knowledge that every citizen is expected to know. For university students, statistics subjects covered in grades 1-12 can be considered as the basic content knowledge that a person is expected to attain. Since Turkish curriculum before 2006 was spiral, it repeats the content with different depth and breadth analyzing statistics topics in grades 6-12 sufficient for understanding basic content knowledge that a university student is expected to attain.

The national curriculum at 6-8 grade levels includes subjects on both statistics and probability. The objectives are not separately defined for probability and statistics. The concepts for statistics and probability areas covered in these grades include basic

probability concepts, tables and graphs, and measures of center. When 9-12 mathematics curriculum on statistics and probability areas are analyzed, it was seen that there was only one related chapter. This chapter is in the 10th grade and about probability. However in 10th grade, students are assigned to different areas regarding their orientation and future ideals. Those students who wish to pursue degrees that require preparation on science and mathematics are required to take more and extensive science and mathematics courses. That's why, probability unit is compulsory for only students those who wish to take extensive mathematics courses.

Compared with 1-5 grades curriculum, it can be seen that in 9-12 grades curriculum many of the content covered in primary school is not revisited and three new subjects were added. These new subjects are impossible events, certain events, and conditional probability. All the subjects regarding statistics and probability in grades 6-12 can be organized as follows:

Table 2.4. Basic statistics and probability topics covered in grades 6-12.

Topics for statistics and probability	Concepts
Identifying probable events	Permutation, combination
Basic probability concepts	Experiment, result, sample, random sampling, equal probability, probability of an event
Event types	Joint and disjoint events, dependent and independent events, impossible event, certain events
Probability types	Probability calculation of an event, experimental, theoretical probability, subjective probability, conditional probability
Constructing questions for research and data collection	Research question, suitable sampling, data collection
Tables and Graphs	Data representation, bar graphs, line charts, pie chart, data interpretation, pictorial graphs, histograms
Measures of central tendency and spread	Mean, range, median, maximum, quartile ranks, standard deviation

Moreover, syllabi of statistics courses offered in a public university were collected. Many departments offer these statistics courses to students from majors related to the department like Management and Information Systems (MIS), Economics (EC), Political Sciences (POLS), Sociology (SOC), Psychology (PSY), Mathematics (MATH), International Trade (INTT), Mechanical Engineering (ME) and Civil Engineering (CE). Among the courses offered by the departments mentioned above, syllabi were found for some of the courses. Totally, nine course syllabi from five departments could be found

some of which sequential courses, such as Statistics I and Statistics II. There was a big variation on the topics included in a course depending on the necessities of each department. Although covered in different depth, some common topics were found across syllabuses. These common statistics topics can be found in the following table:

Table 2.5. Common topics covered in statistics courses in a public university.

Topic	EC	CE	ME	MATH	INTT
Data representation	*			*	*
Descriptive statistics	*	*		*	*
Basic probability	*	*	*	*	*
Probability distributions	*	*	*	*	*
Estimation			*	*	*
Sampling	*		*	*	*
Testing of Hypothesis	*	*	*	*	*
Hypothesis testing for two population parameters			*	*	*
Correlation		*	*	*	*
Correlation analysis		*		*	*
Regression		*	*	*	*

(Note: EC: Economy, CE: Civil Engineering, ME: Mechanical Engineering, MATH: Mathematics, INTT: International Trade)

From the table, it can be seen that there is a variation in the content coverage even in the common topics. It should be noted that advanced statistics courses are also offered within the university. The statistics content included in those advanced statistics courses was excluded in the analysis regarding the common statistics topics at the university. The detailed list of statistics content as covered in these departments can be found at the Appendix A, in Table A.5. Moreover, the compilation of statistics topics covered in the curriculum in different grades can be seen Statistics Topics in Related Curricula in Turkey at the Appendix A in Table A.6.

2.5. Context of Statistical Literacy

Literature reveals statistical literacy requires understanding statistical claims and arguments and critically evaluating them in everyday life situations. The context in which it is meaningful to observe statistical literacy was defined as the context of everyday life by Burnham (2003), Watson and Callingham, (2003), Hayden (2004), and Schield (2004). There were studies which employed daily life examples in the instruction of statistics (Wilson, 1994; Merriman, 2006; Hahn, Doganaksoy, Lewis, Oppenlander, Schmee, 2010).

As Gal and Garfield (1997) stated, traditional questions used for assessment in statistics education usually lack an appropriate context and therefore are limited in giving information about students' ability to interpret statistical arguments. Hence, statistics questions need to have some context to be effective for assessment.

Using everyday life examples can be seen in assessment of statistical literacy where several studies in statistical literacy were assessed in different contexts. Media articles and research reports (Reston, 2005; Budgett and Pfannkuch, 2007), journal articles (Budgett and Pfannkuch, 2007), and advertisements (Reston, 2005) were seen to be employed as the media for observing statistical literacy.

2.5.1. Statistical Literacy in the Turkish Context

A statistically literate person is expected to be literate about everyday statistics. That's why; the context is important for understanding statistical literacy. Studies about statistical literacy in the Turkish context were searched however, the researcher was unable to find a study that is directly related to statistical literacy that was done in Turkish context. Therefore, studies about statistical thinking and attitudes towards statistics will be reviewed as the related literature about statistical literacy in the Turkish context.

Beginning with the most related study, Şahin (2011a) analyzed undergraduate students' questioning of causality in media excerpts and compared them with Watson and Callingham's (2004) levels of statistical literacy. She found that there is almost one to one correspondence with complexity of participants' answers and hierarchical levels of statistical literacy proposed by Watson and Callingham. From the data, it can be said that

although many students are aware of the need for experimentation and control to infer causality, many hold idiosyncratic beliefs at the same time.

Moreover, Yılmaz (2003) examined university students questioning of media inferences and observed that university freshmen and sophomore students had the tendency of questioning information in terms of theory or agent where junior and senior students had the tendency of questioning information in terms of data and statistics.

Akkaş (2009) examined 6th – 8th graders' statistical thinking in describing, organizing, representing, analyzing, and interpreting data procedures using SOLO (Structure of the Observed Learning Outcome) taxonomy. This taxonomy describes developmental cognitive levels of thinking which are pre-structural, unistructural, multistructural, relational, and extended abstract levels (Biggs and Collis, 1991). In this taxonomy, students at pre-structural level have little understanding of the question posed and his answer is not related to the question. Students in unistructural level shows some understanding, he focuses on the question but only one aspect of it, he gives limited answers to questions. Students in multistructural level can approach the question from multiple aspects but his answers are not aligned with each other, the relationship between aspects emerges at the relational level. The student at relational level can give consistent answers and can understand the role of different aspects in his answer. In the extended abstract level, in addition to the previous level, student can make generalizations and can use reasoning beyond the task. Mooney (2002) developed a Statistical Thinking Framework based on SOLO taxonomy. In his study done with 6th, 7th, and 8th grade students, he tried to identify statistical thinking levels of participants which resulted in four levels: idiosyncratic, transitional, quantitative, and analytical levels with increasing complexity. Mooney found that no students were at the fourth level in Statistical Thinking Framework in all the four processes of data handling. Similarly, Akkaş found that most students were at the second and third stages, and most students are at the third level. Moreover, she also found that none of the students were at the fourth level in the data representation procedures with no students were found at the fourth level in all of the procedures. These results are in line with the previous research as she suggests.

There are also studies about the attitude and self-efficacy. Diri (2007) investigated attitude towards statistics in a vocational school. He developed a scale called “Attitude towards Statistics Scale” based on attitude scales in the literature and a mathematics attitude scale which assumes to measure attitude in the dimensions of love, profession, fear, pleasure, importance, interest, and confidence dimensions. Similarly the Attitude towards Statistics Scale he developed was seen to consist of the same seven dimensions. Moreover, these seven dimensions can be reduced to three dimensions where the first dimension consist of love, interest, and pleasure dimensions; the second one consist of fear and confidence dimension; and the third one consist of profession and importance dimensions. From the data he collected from vocational school students, he observed that students’ attitude varied for differed dimensions of attitude. Students were holding positive attitude for fear and importance dimensions; medium attitude for profession and pleasure dimension, and negative attitude for interest and confidence dimensions.

Sevimli (2010) studied about pre-service mathematics teachers’ misconceptions in statistics lessons, their self-efficacy in statistics, and attitude towards statistics. She translated Statistics Concept Inventory developed by Allen (2006) for measuring participants’ achievement levels in statistics. She concluded that participants are at low achievement level in statistics and have some misconceptions in statistics. Using the “Attitude towards Statistics Scale” developed by Diri (2007), she investigated pre-service mathematics teachers’ attitude levels. She found that participants attitude towards statistics are medium levels of attitude in fear, pleasure, importance, confidence dimensions and negative attitude towards profession and interest dimensions. Moreover, she also measured self efficacy towards statistics with the instrument developed by Finney and Schraw (2003) for this aim. She founded that preservice mathematics teachers in her sample showed high levels of self- efficacy towards statistics.

In a study comparing intercultural modes of thinking and reasoning Akarsu (2009) stated that there are differences between Western and Turkish cultures in terms of attributing place to statistics in their everyday lives. For instance, the lack of recording and reporting, and understanding of science, mathematics, and statistics as “unconnected” with everyday life was stressed in the Turkish culture whereas recording and reporting, and

understanding of science, mathematics, and statistics are more connected with everyday life in the Anglo-Saxon cultures.

To sum, when attitude of university students were examined (Diri, 2007 and Sevimli, 2010), it can be said that students hold medium and low levels of attitude towards statistics. Studies related to questioning inferences (Şahin, 2011a and Yılmaz, 2003) signal that many undergraduate students have the tendency to have idiosyncratic beliefs and questioning information in terms of theory or agent. When 6th to 8th grade students' statistical thinking was examined (Akkaş, 2009), students were found to be at medium levels during different procedures. Finally, with a look to the culture, Akarsu (2009) found that statistics was understood as unconnected with everyday life in the Turkish culture. From this review, it can be said that thinking with statistics is not expected as a habit of mind for most of the students in Turkey in different levels. That's why, it is reasonable to study statistical literacy as a basic competency in the context of Turkish undergraduate students.

2.6. Statistical Literacy and Research Competency

The relationship between adult college students' level of statistical literacy and their academic background was examined by Wade (2009) and Wade and Goodfellow (2009) with a quasi-experimental design of research. The sample was taken from students enrolled in statistics, research methods course without a prior statistics course, research methods course with a prior statistics course, and a control group consisting of people who had taken neither of those courses. The results suggest that there were significant differences between students who have taken any of these classes and those who have not taken any of them in terms of the scores they gained from CAOS test. Moreover, there were statistically significant differences between students who had research method courses with prior statistics course and those who did not take that course, and those who have taken research methods course without prior statistics course. This difference can stem from research methodology course content which Cobb and Moore (1997) summarized as including (a) experimental method and the use of experimental and control groups, (b) pilot studies, (c) the logic of sampling and the need to infer from samples to populations, and (d) the notions of representativeness (as cited in Wade, 2009) which have overlaps with the contents of statistics courses offered. As an example, referring to the Table 2.5 it can be seen that

sampling which is a topic in research methods courses is a topic that is commonly covered in statistics courses given in a public university.

Pérez López (2006) examined theses and dissertations in educational psychology in terms of the statistics used in those studies and found that students had the following difficulties: a) their choice of a suitable statistical test concerning their objective of research, b) the way of interpreting data, c) selection of the design consistent with their objectives, d) their comprehension of the meaning of some statistical concepts, and e) their decision use of charts or graphs. Among the difficulties of comprehension of statistical concepts identified by Pérez López (2006), confusing association and causation, and validity and reliability are the most significant ones.

As for a study done in Turkey (Kabaca and Erdoğan, 2007) investigated about the statistical mistakes done by thesis writers in the field of education. They randomly chose 129 Master of Science and Doctor of Science theses from different universities in the fields of computer education, science education, physics education, chemistry education, and mathematics education. In the results, they found that there were errors in many thesis studies and those mistakes could be categorized into seven dimensions. These dimensions could be listed as errors related to validity and reliability of data collection instruments, sampling, using descriptive statistics, identifying normal distribution, using parametric and non-parametric studies, expressions used, and format. They concluded that encountering with many errors stems from insufficient statistics education. This study can be informative for describing the academic proficiency of graduate students in terms of their background in statistics.

In the Turkish context the national curriculum includes an elective course named as “research methods” for 10th grade high school students who are pursuing a quantitative oriented major and receiving a curriculum focusing on quantitative courses. The aims of this course include defining basic concepts of research methods courses, recalling data collection methods and explaining the importance of research (TMoE, 2010). However, it is should be noted that this course is not frequently elected in high schools since it does not cover material that students are responsible for the university entrance exams. That’s why,

the contribution of this course for students' understanding of research and appreciating the relationship between statistics and research methods is considered to be limited.

Review of these statistics signal that there is a relationship between competencies in statistics competencies in research methodology. Students dealing more with research are expected to gain some competencies related to statistics. It is important to look statistical literacy in universities where research is conducted and preparing students to research is among the aims of universities. In Turkey undergraduate students' capabilities in research and statistics can be low since their academic background may not be sufficient enough as depicted from the curriculum. From the relationship between statistical literacy and research competency, it is concluded that statistical literacy of undergraduate students is important to be examined, however an understanding of basic competency should be chosen as the framework of the study since students' background can be limited.

2.7. Definition of Statistical Literacy Used in This Study

A definition of statistical literacy can be formed to be used in this study under the understanding of statistical literacy as a basic competency using the themes emerged from synthesis of the literature on definitions of statistical literacy. In this regard, a statistically literate person is expected to understand basic concepts, vocabulary and symbols of statistics, and some probability; and critically evaluate statistical information as he or she encounters them in everyday life situations. Understanding basic concepts, vocabulary and symbols of statistics, and some probability can be operationalized as knowing and interpreting them using verbs that Bloom (1956) and Anderson and Krathwohl (2000) associated with the levels of the taxonomies they suggested. Since criticizing can be considered at the evaluation level in Bloom's (1956) and Anderson and Krathwohl's (2000) taxonomy, it was necessary to specify the boundaries of criticizing to stick with the comprehension or understanding level of cognitive engagement. For this reason, critical evaluation of information can be clarified as criticizing the relationship between a given statistics and a conclusion derived from it. The reason for clarifying narrow boundaries for critical evaluation is to stick with the basic understanding of statistical literacy rather than complex understanding of statistical literacy as these were explained previously. The tabular representation of this definition can be found in the following table:

Table 2.6. Statistical literacy definition used in this study.

Statistical Literacy		
Ability	Context	Content
Understanding the statistics (interpreting concepts and results)	Everyday situations	Basic concepts, vocabulary and symbols of statistics, and some probability
Critical evaluation of information (criticizing the relationship between data and results)		

As a summary, different definitions and models of statistical literacy were examined. To give meaning to models related constructs like statistical reasoning and statistical thinking were also examined. The content of statistical literacy was not clear in the definitions. Therefore, the content coverage of previous instruments, instruction studies, curricula related to statistics, and important statistics topics that were suggested by authors were reviewed. It was also seen that research competency is also related to statistics competency. It was seen that the daily life situations could be seen as the context of statistical literacy. Related studies done in the Turkish context were also examined. It was concluded that there were few studies and commonly signal poor background in statistics.

3. SIGNIFICANCE

Learners' experiences with statistics in and outside of educational settings is thought to affect their habit of mind, how they place statistics in understanding the world around them and how they can understand statistical information in everyday life. There are theories which claim that the way that people place statistics change as they their experience with statistics becomes enhanced (delMas 2002 and Sanchez 2007).

Studies done in the Turkish context reveal employing statistics in evaluating everyday life experiences may not be considered as a habit of mind for most of students (Şahin, 2011a; Akarsu, 2009; Akkaş, 2009; and Yılmaz 2003). Moreover, studies related to statistics achievement (Sevimli, 2010; Kabaca and Erdoğan, 2007) signal that there are university students and thesis writers have some flaws in their knowledge in statistics. Moreover, studies assert that university students have fear towards statistics and not interested (Diri, 2007; Sevimli, 2010). Hence, it can be stated that statistical literacy is important capability that needs to be addressed in the Turkish context. However, no research study related to statistical literacy was found in the literature. This study will be among the first studies about statistical literacy in Turkey.

There are different definitions understandings of statistical literacy. The researcher tried to extract key themes in understanding and defining statistical literacy in the literature, and come up with a statistical literacy definition that can be valid in the Turkish context. The key themes of understanding statistical literacy extracted in this study are expected to be a contribution to the literature.

Since there is no statistical literacy instrument measuring statistical literacy which can be valid and practical at the same time, the instrument developed for this study can be an instrument for researchers in statistics education to administer to university students and to adapt to students from other levels of education. It is also hoped that, although this instrument was tailored to the Turkish context, researchers from other countries can also adapt the instrument for their use.

4. STATEMENT OF THE PROBLEM

The aim of the study is to develop a valid and reliable instrument for measuring statistical literacy of undergraduate students in a public university in Istanbul who enrolled in various departments.

4.1. Research Questions

Main research question 1: Is this instrument valid for measuring statistical literacy for undergraduate students?

Sub question 1.1: Is the content of the instrument valid for measuring statistical literacy of undergraduate students?

Sub question 1.2: Is this instrument valid for measuring statistical literacy construct for undergraduate students?

Sub question 1.3: Are there differences of statistical literacy scores between groups of participants who had different years of study at the university?

Sub question 1.4: Are there differences of statistical literacy scores between participants who pursue different type of majors?

Sub question 1.5: Is there a correlation between participants' GPA and their scores gained from the instrument?

Main research question 2: Is this instrument consistent in measuring statistical literacy?

Sub question 2.1: Is this instrument internally consistent?

Sub question 2.2: How are individual items correlated with the total score gained from the instrument?

4.2. Instruments

4.2.1. Statistical Literacy Content Rating Form

This form is used for clarifying the essential statistics topics that are required for statistical literacy. This instrument was delivered to scholars who have given lectures on statistics and research methods within the two years of time as this study was done. The statistics topics covered in previous studies (Section 2.4) were listed and respondents were asked to rate their opinion on the necessity of each topic for statistical literacy. As an example a part of Statistical Literacy Content Rating Form (SLCRF) was given below:

Statistics Content	Necessity		
	Not necessary	Neither necessary nor unnecessary	Essential
Study designs (observational, experimental)			
Hidden variables			
Random sample			
Bias in sampling			

Figure 4.1. Part of Statistical Literacy Content Rating Form.

Responses were coded as the values 1, 2, and 3 where “not necessary” was coded as 1, “neither necessary nor unnecessary” was coded as 2 and “essential” was coded as 3. The complete version of SLCRF can be found at the Appendix B.

4.2.2. Item Rating Form

The aim of Item Rating Form (IRF) was to gather evidence on respondents’ opinions on the items regarding the functionality of items in measuring the intended learning outcome and collecting evidences for deciding whether the items should be eliminated or included in the scale. In order to help the raters, topics intended to be measured by the questions in the scale and item rating forms were embedded in the scale and the questions were asked right after the item. The respondents to this form were also given the test plan of the instrument including the initial questions and what is meant to be measured with each question. In the form, they were expected to write their opinions to the spaces where

the questions and the intended measuring outcome match (see Appendix C). To provide an example, a part of the Item Rating Form was given below:

Question Code	Opinion		Decision		
	Measures the intended	Comments / Suggestions	Should be included	Should be eliminated	Needs Improvement
SCI27					
CAOS 7					
A-DC-8					

Figure 4.2. Part of Item Rating Form.

4.2.3. Demographic Survey

Demographic survey is a small survey asking about sampled students' student number, their department, grade, general point of average (GPA), and whether the participant is an exchange student or not. The aim of this instrument is to gather data about participants' profile and to inhibit administering the instrument to a participant twice to a participant. Since responses will be not reliable if a participant answers the instrument twice, students' unique student number was checked.

5. METHODOLOGY

To keep in line with the accepted methodology of test development, 12 steps for effective test development which was proposed by Downing (2006) were followed when applicable. This 12 step framework was organized according to the relevant Standards for Educational and Psychological Testing which was developed jointly by American Educational Research Association (AERA), American Psychological Association (APA), and National Council on Measurement in Education (NCME) in 1999 (APA, nd; Downing, 2006). Moreover, Downing states that every step should be followed in some detail and some steps can occur simultaneously or with different order where each step organizes sources of validity evidence.

The steps followed are listed as

- (i) Overall plan
- (ii) Content definition
- (iii) Test specifications
- (iv) Item development
- (v) Test design and assembly
- (vi) Test production
- (vii) Test administration
- (viii) Scoring test responses
- (ix) Passing scores
- (x) Reporting test results
- (xi) Item banking
- (xii) Test technical report

The headings of these 12 stages Downing (2006) suggested will be explained in the following paragraphs. In the overall plan, test developers are expected to decide on what the construct to be measured is; what necessary score interpretations are; the format and the administration mode of the test; major sources of validity evidence; and the purpose of the test. In the content definition step, it is necessary to define the content that should be tested, a defensible method for clarifying the content. At the test specification step, the developers should clarify the operational definitions of the test characteristics, i.e. the type and format of the test items, the cognitive classification etc. At the item development stage the test developer must decide upon what item formats to use and need to write and edit items. The step of test design and assembly includes designing and creating test forms, formatting the test to maximize understandability and minimize the cognitive burden unrelated to what the test is measuring. Test production step includes the publishing and printing of examinations. Test administration is the step where concerns about validity are handled by controlling extraneous variables and making the conditions identical for all examinees. After administering the test, it is necessary to apply scoring key to examinees' responses which occur in scoring step of test development. Establishing passing scores are necessary for most but not all of the tests and it is necessary for tests that require a cut score. Reporting scores are essential especially for large scale test, it requires timely, meaningful and useful reporting of scores to the examinees. Item banking is important for ongoing testing programs where it requires storing potential items for future use. As for the last step of test development, documenting the validity evidence for the test, identifying threats to validity, providing a systematic summary of important test development activities for review need to be accomplished.

The outlined steps of test development were followed in the process of developing SLS. The phases of developing SLS can be thought as aligned with the steps mentioned above. For example in Phase 1 of the study, initial preparation of the instrument was carried out and steps one to six were performed. In Phase 2, 3 and 4 where two pilot administrations and a final administration were done and revisions were made, the steps of test design and production were revisited, and test administration and scoring were actualized which correspond to steps seven and eight. Defining passing scores, reporting test results, and item banking were considered but were not seen necessary within the scope of this study which correspond to levels nine, 10, and 11. Lastly, this thesis can be

thought as the technical report of the test corresponding to 12th step of the test development procedure. The phases of this study will be narrated in detail in the following parts. Within each phase special instruments used, if any; participants, sampling, the administration process, analysis of data yielded after the administration will be reported. Statistical analysis for evaluating items will be done using methods suggested by Classical Test Theory (CTT) such as item- total correlation, item difficulty, and item discrimination. Detailed interpretation of the data analysis will be given in the results section.

5.1. Phase 1 - Initial Preparation of the Instrument

5.1.1. Clarifying the Content

After clarifying the cognitive dimensions of statistical literacy, the content of this construct was to be clarified. Content of previous instruments and experimental instruction studies were examined in terms of their content. Then, the content coverage was questioned in terms of suitability in the Turkish context.

Previous instruments related to statistics learning were examined. Not only statistical literacy instruments but also other related instruments were examined bearing in mind that statistical literacy is a construct that can have overlappings with statistical reasoning and statistical thinking as delMas (2002) claimed. The instruments examined for their content coverage were Comprehensive Assessment of Outcomes for a first course in Statistics (CAOS) developed by the Web ARTIST Project (2005), Statistical Literacy Skills Survey (Schield, 2008), ARTIST Topic Scales (2006).

Meanwhile, instructional studies for developing statistical literacy were also examined. Among them Wilson's (1994) "A Brief Course in Statistical Literacy" was chosen because this study was done with university students. The content coverage of Test of Statistical Literacy used to measure the attainments of the instruction was used for examining the content coverage of this instruction study.

Previous studies in Turkey were also searched, however; no measured instructional experiments or measurement attempts were found during the time of conducting this study.

That's why, statistics topics in The Turkish national curriculum on grades 6 to 12 (Turkish Ministry of Education, 2005; 2009) were added. This way, a general list for statistics topics was yielded.

This list of statistics topics were examined by four experts: a doctoral student studying probability in Mathematics department, an associate professor in operations research statistics in Industrial Engineering department , a full professor in operations research statistics in Industrial Engineering department, and a full professor in Mathematics Education department. With their comments, some new topics were added to the list, the wordings of some topics were changed, and the sequence of the topics was rearranged according to phases of methods of research. It was concluded that Statistical Literacy Content Rating Form (SLCRF) could be developed with 35 topics.

After clarifying topics to be included in the SLCRF, a cover page describing briefly what statistical literacy is prepared. Then the only question for collecting experts' ideas was written as "Please indicate the necessity of each statistics topic for being a statistically literate undergraduate student". For every topic, the answers of this scale consisted of three options with increasing degree "Not necessary", "neither necessary nor unnecessary", and "essential".

As for the participants of SLCRF, scholars who are offering or have previously offered statistics or research methods courses within the last two years were recruited as experts. The website of the Registrar's Office of the public university in which this study held was searched for statistics and research methods courses that were given in previous years. From this webpage, the title of the courses offered between 2009 and 2011 were examined and those courses which hold the words research methods or statistics were listed. The name of the instructor who gave the course was recorded and the email address of the instructor was found via the university website. Thirty-two instructors were found for being potential participants to respond SLCRF.

SLCRF was sent to 32 experts by email. Answers from experts who volunteered to respond to the questionnaire were gathered. Eleven scholars responded to the survey, one of them was from Management and Information Systems Department, one from

Economics Department, five from Secondary School Science and Mathematics Department, two from Computer Education and Educational Technology Department, and two of them were from Primary Education Department.

Experts' answers were analyzed using frequency of each choice. If a statistics topic was rated as necessary by more than the half of the eleven experts, which is six, then it was thought as necessary for statistical literacy. It was also observed that except the topic "correlation" none of these topics were rated as "unnecessary" by the experts. The statistics topics for which less than six participants rated as necessary were mostly rated as "unnecessary" or "neither necessary nor unnecessary". The data collected from the experts can be found at Appendix D. From the analysis of the answers, the 30 statistics topics were chosen to be considered as necessary for statistical literacy.

Statistics topics that were mostly rated as essential were given in the Table 5.1. It is worth noting that none of participants rated any of these topics as unnecessary.

Table 5.1. Frequency of Most rated statistics topics.

Topic	Unnecessary	Neither Necessary nor Unnecessary	Essential
Frequency			11
Mean (sample mean/ population mean)			11
Median			11
Probability of events		1	10
Types of variables		1	10
Levels of measurement		1	10
Standard deviation		1	10
Dependent and independent events		2	9
Histograms		2	9
Hypothesis testing		2	9
Random sample		3	8
Line charts		3	8
Pie charts		3	8
Bar charts		3	8
Maximum		3	8
Outlier		3	8
Quartiles		3	8

Following table displays the least rated topics. It is seen that most of the participants were undecided about the necessity of these topics. These topics are study designs, stem

and leaf plots, hidden (spurious) variables, box plots, modeling, and regression. The distribution of the topics can be seen in Table 5.2.

Table 5.2. Least rated statistics topics.

Topic	Unnecessary	Neither Necessary nor Unnecessary	Essential
Study designs (observational, experimental)	2	4	5
Stem and leaf plots	2	4	5
Hidden variables	4	3	4
Box plots	1	6	4
Modeling	3	5	3
Regression	3	5	3

The list of statistics topics worked as an initial point for studying the content coverage of the instrument. In every trial of the instrument the content coverage was refined for the aim of making the instrument more valid, reliable, and practical. Thus, the changes taking place in content coverage selection will be given in each of the steps.

5.1.2. Overall Plan and Test Specifications

After the statistics topics necessary to be statistical literacy were identified, these topics were matched with the cognitive dimensions of statistical literacy. The abilities constituted statistical literacy were understanding basic concepts, vocabulary and symbols of statistics and some probability which were operationalized as knowing and interpreting and critical evaluation of information which was operationalized as criticizing the relationship between a given statistics and a conclusion derived from it (See Section 2.6.).

Statistical literacy was taken into account with three cognitive competencies: Knowing, interpreting, and critical interpreting. Then the necessary statistics topics were matched with these three cognitive competencies of statistical literacy. Since the focus on statistical literacy was not on knowledge but interpretation, the focus of the test plan shifted to interpretation and critical interpretation items. As the process of developing the instrument proceeded, the test plan was revisited.

As for the items, most of the items in the existing instruments were select response type questions. Therefore, using multiple choice type questions was seen suitable for this study. Although it is possible to have different number of choices in a test, it was preferred to have the same number of options in each question whenever possible. The reason for this decision is that the undergraduate students are accustomed to taking tests and they are expected to be able to predict the keyed response of a test item if there were not sufficient number of options. That's why, the number of options in questions were tried to be kept at a maximum and the same for almost all items for minimizing the factor of guessing.

5.1.3. Item Selection and Construction

As it was stated in the literature, there are several instruments developed for measuring statistics learning and statistical literacy. After clarifying the necessary statistics topics, the literature was searched again. It was seen that there were specific instruments for measuring proficiency in some identified statistics or probability topic. For the topics stated as necessary for statistical literacy, these new instruments were taken into account. These instruments are The Statistics Concept Inventory (Allen, 2006), Statistical Reasoning Assessment (SRA) (Garfield, 2003), Quantitative Reasoning Quotient (QRQ) developed by Sundre (2003), A Test of "Representativeness" (Hirsch and O'Donnell, 2001), and A Scale for Assessing Probabilistic Thinking and the Representativeness Tendency (Afantiti- Lamprianou and Williams, 2003).

The questions from the instruments were examined in terms of what they intend to measure. If a test plan or table of specification was given with the instrument, that test plan was used. In other occasions, the researcher tried to identify the statistics topic that the question intended to measure and the cognitive level at which it measures that topic. After examining each question according to its topic and cognitive level, an initial selection was done according to the statistics topics that the questions are measuring about. Questions that measuring the important statistics topics as revealed by the results of the Content Rating Form were selected among all the questions found in previous instruments. Moreover, there were some statistics topics that were not addressed before in any of the previous instruments such as frequency or line chart. For such topics, new questions were written taking the test plan into account. The aim of writing new questions was filling the

gaps in the questions necessary to measure the essential statistics topics as revealed by the results of SLCRF. These new questions were written by the researcher and examined by another researcher in terms of its suitability and understandability. Some questions were linked to more than one topic, like expecting the participant making connections with their knowledge about another but related topic. Such questions were eliminated to make every question measure participants' knowledge only one topic at a time. Taking into account questions in existing instruments and the questions written by the researcher, a total of 110 questions were formed.

Among these 110 questions a second selection was done regarding other criteria like measuring the topic at the cognitive levels at the adapted definition of statistical literacy which are knowledge, interpretation, and critical interpretation. For example, questions that require calculation were not thought to be suitable for selection because it requires a cognitive engagement different than the intended, which is application. This second selection was done regarding the cognitive level required for solving the items selected according to their content in the first selection. Another criterion for selecting the questions in this second selection was having stimulus that is understandable for Turkish students. For example, questions which had stimuli which are not known by Turkish students like box plots or stem and leaf plot either were not chosen or their stimuli were changed into another form like tabular display. After this second selection, 52 questions were eliminated from the item pool.

Finally remaining 58 questions were sent to the experts. The experts consisted of five scholars: one of them was a full professor specialized in Measurement and Test Construction, one was a full professor in Operations Research Statistics, one was assistant professor in Operations Research Statistics, and two of them were holding doctoral degrees in Mathematics Education. Among them, full professor in Operations Research Statistics was consulted in the construction of SLCRF and the other full professor who specialized in Measurement was a respondent to SLCRF. To guide the experts an Item Rating Form (IRF) was prepared. In this form, experts were asked to voice their opinion on whether the questions were measuring the intended topic at the intended cognitive level, were understandable, and should be eliminated or included in SLS, and any additional comments they would like to have.

In addition to experts' answers on IRF, their comments on statistical correctness, the length of the questions, understandability, and wording were also collected. According to their answers and suggestions 16 questions were eliminated and 42 questions remained.

Some revisions were done in the questions like changing the wording, changing the stimuli, shortening the questions, adding or removing some options to the questions. The aim of these revisions was making the questions more understandable, shorter, and similar with each other. Existing instruments had multiple choice questions with different number of options. On the other hand, students are expected to be experienced in multiple choice tests in nationwide exams, they are accustomed to taking tests with having fixed number of options in the tests; which usually have questions with four or five options. That's why, having a fixed number of choices in the questions was seen useful and some revisions were done accordingly. All but two questions had four choices; other questions had two options. The reason of this difference is that the questions that have two options were about significance levels and the answers included "valid" or "invalid". Although it was possible to increase the number of the options, the questions would function like a two option question because the students would easily guess that the keyed response would be either "valid" or "invalid".

5.1.4. Scoring

There was only one keyed response for every question and all the questions had four options except two questions which had two options. Scoring was done by giving one point to the questions that had four options and .5 points to the questions having only two options. Hence, the minimum score a student can get was set as zero, and the maximum score was number of questions in the instrument minus one. It is announced to the participants that if they did not know the answer to a question, they should leave it blank instead of marking by sole guessing. That's why, blank answers did not contribute to participants' scores, and no point was given or taken for questions left blank.

5.2. Phase 2 of the Study- First Pilot Study

5.2.1. Participants

Students were from four departments, namely International Trade, Management, Management and Information Systems, and Economics. The departments were chosen since students from these departments offer both quantitative courses which require dealing extensively with formula like mathematics, statistics and non-quantitative courses which do not require dealing extensively with formula or other quantitative expressions like marketing. They were thought to be representative of an average student in terms of pursuing a combined major. Sophomore students registered to the indicated departments were chosen as the population for this try-out.

The first pilot study of the instrument was done with 36 participants during their classroom hours in the Summer term of 2011. The administration was done in the very first day of two statistics classes. Among 36 students who took the instrument, four of them were exchange students who came to summer classes from abroad and some were native speakers of English. Exchange students' ideas on the wording and understandability of the questions were collected but their answers were not included in the study. The reason for this was that enculturation can be affective in solving statistics questions in everyday life. Information on students' major areas of study and their general point of averages (GPA) were collected to have an insight of the academic profile of the participants. Moreover, from those who claimed their GPA (General Point of Average), students' average GPA was calculated as 2.318 out of 4. Student distribution according to departments can be seen in the following table.

Table 5.3. Distribution of participants' for the first pilot study.

Department	Number of Students
International Trade	17
Management	7
Management and Information Systems	4
Economics	1
Unspecified	3
Total	32

The attendance percentage was high among students from these departments who attended summer term statistics courses. The sampling adequacy regarding the total number of students in the departments was calculated here. Information on the total number of second grade students registered to the indicated departments was collected from the Registrar's Office. It should be also noted that since the study was done during the summer term, which was optional, only students who attended summer term were available to be in the sample.

Table 5.4. The population for the first pilot study.

Department	Number of Students
International Trade	67
Management	120
Management and Information Systems	62
Economics	119
Total	368

Using the information of number of registered students the necessary number of participants to represent this population can be found. The statistical formula to find sample size when the population size is known is given as the following:

$$n = \frac{Nt^2\sigma^2}{d^2(N-1) + t^2\sigma^2} \quad (5.1)$$

Where N stands for the population size, t^2 stands for the square of the theoretical value found according to the t table for a certain confidence level, σ^2 stands for the variance in the population. Variance can be known through experience or a measurement from the sample. d^2 is the square of the value of the positive or negative deviation that is aimed to be achieved, between the difference of the population mean and sample mean.

From this formula, at confidence level 95 %, with $d= 1$, and variance was assumed as 6.9, necessary sample size for this population can be calculated as 25. This result indicates that a sample size of 32 can be enough to see the variation in a population having 328 individuals with 95 % confidence and at an error rate of 1 point. It should be noted that this

calculation is done after calculating the variance of the sample to check whether the sample size is sufficient to observe the variance in the population with the estimated deviation between sample mean and population mean.

5.2.2. Administration

With having 42 questions in the instrument, the administration of the test took 30- 35 minutes. Although the duration was not too long, it was observed that students lost their concentration and interest in solving the questions. Most of them were not able to finish the last couple of questions within this time limitation. Participants' oral reflections about the test were collected and students revealed that they found the test long and partially hard. These reflections indicated that the 42 question instrument needed improvement to be more practical.

5.2.3. Data Analysis

The level of difficulty of questions was checked by taking the mean of each question, and the dispersion of students' performance on an item was judged by standard deviation. The relationship between each question and the total test was examined with item-total correlations. Moreover, correlations between questions were measured with inter-item correlations. The reliability of the whole instrument was found with Cronbach's alpha as .568.

As for the average performance from the first pilot study, participants' mean point from the instrument was found as 13.69 out of 38.5. In addition to item means, sum of points earned for answering the question, and standard deviation of points earned from the question were calculated. Since one point is given for every question answered correctly, the sum of points also indicates the number of participants who answered the question correctly and the mean indicates the ratio of the number of participants who answered the question correctly to the total number of participants. Descriptive statistics for the individual items can be found in the following table:

Table 5.5. Descriptive statistics of the first pilot study.

Item	N	Sum	Mean	Std. Dev.	Item	N	Sum	Mean	Std. Dev.
1	33	13	0.39	0.496	22	33	20	0.61	0.496
2	33	4	0.12	0.331	23	33	16	0.48	0.508
3	33	27	0.82	0.392	24	33	16	0.48	0.508
4	33	16	0.48	0.508	25	33	6	0.18	0.392
5	33	18	0.55	0.506	26	33	13	0.39	0.496
6	33	1	0.03	0.174	27	33	5	0.15	0.364
7	33	23	0.7	0.467	28	33	4	0.12	0.331
8	33	17	0.52	0.508	29	33	3	0.09	0.292
9	33	24	0.73	0.452	30	33	1	0.03	0.174
10	33	6	0.18	0.392	31	33	18	0.55	0.506
11	33	11	0.33	0.479	32	33	11	0.33	0.479
12	33	18	0.55	0.506	33	33	7	0.21	0.415
13	33	5	0.15	0.364	34	33	7	0.21	0.415
14	33	32	0.97	0.174	35	33	11	0.33	0.479
15	33	11	0.33	0.479	36	33	10	0.3	0.467
16	33	33	1	0	37	33	5	0.15	0.364
17	33	22	0.67	0.479	38	33	9	0.27	0.452
18	33	18	0.55	0.506	39	33	15	0.45	0.506
19	33	13	0.39	0.496	40	33	4	0.12	0.331
20	33	6	0.18	0.392	41	33	2	0.06	0.242
21	33	4	0.12	0.331	42	33	2	0.06	0.242

In order to search for the relationship of each question with the whole instrument, scores earned from a specific item and from the instrument were matched and a correlation coefficient was calculated. This correlation will be mentioned as item- total correlation. The information summarizing the item- total correlations can be found in the following table.

Table 5.6. Item - total correlations for the first pilot study.

Item	Item-Total Correlation	Item	Item-Total Correlation	Item	Item-Total Correlation	Item	Item-Total Correlation
1	.499**	12	-.001	23	.596**	34	.126
2	-.209	13	.044	24	.541**	35	.384*
3	.175	14	.077	25	.389*	36	.355*
4	.565**	15	-.225	26	.229	37	.087
5	.567**	16	Not available	27	.011	38	.344
6	-.258	17	.93	28	.493**	39	.398*
7	.151	18	-.242	29	.160	40	.433*
8	.414*	19	.166	30	.263	41	.085
9	.362*	20	.127	31	.459**	42	.378*
10	-.054	21	-.031	32	.450**		
11	.228	22	.350**	33	.306		

*. Correlation is significant at the 0.05 level (2-tailed).

** . Correlation is significant at the 0.01 level (2-tailed).

Assuming that the participants are consistent in their knowledge, the item total correlations reveal the relationship between the question measures and what the instrument measures as a whole. If the item-total correlation is high (and also significant), then it means that the question is related with the construct measured in the instrument in general. From the item-total correlations given above, it can be seen that there are highly related, relatively less related questions, and unrelated questions in the instrument.

5.2.3. Item Reduction

Practicality is an important property of a test after its validity and reliability. Since the participants also revealed that they found the test long and partially hard, it was necessary to shorten the test. To have a more parsimonious instrument, it was necessary to eliminate some questions. Questions that were measuring the same content at the same cognitive level were compared with each other in terms of their means and item- total correlations. The eliminations were done accordingly. The list of eliminated questions and the reasons for elimination can be found in the following table.

Table 5.7. Questions eliminated and reasons for elimination.

Item	Topic	Reason for elimination
2	Random Sample	Another question of the same content with higher correlation
3	Dependent / Independent Events	Another question of the same content with higher correlation
9	Conditional Probability	Another question of the same content with higher correlation
10	Types of variables	More focus on knowledge less focus on comprehension
11	Levels of measurement	More focus on knowledge less focus on comprehension
14	Pie chart	Another question of the same content with higher correlation
15	Pie chart	Another question of the same content with higher correlation
16	Pie chart	Another question of the same content with higher correlation
17	Pie chart	Another question of the same content with higher correlation
18	Bar chart	Another question of the same content
19	Histogram	Another question of the same content The question is long.
20	Histogram	Another question of the same content with higher correlation
21	Histogram	Another question of the same content with higher correlation Only two people answered the question right
26	Median	Another question of the same content with higher correlation
29	Inter quartile range	Low correlation More focus on knowledge less focus on comprehension
30	Standard deviation	Another question of the same content
31	Standard deviation	Another question of the same content
33	Standard deviation	Another question of the same content
36	Hypothesis testing	Another question of the same content with higher correlation
37	Confidence interval	Question is not easily understandable Another question of the same content using the same stimulus
40	Scatter plot	More focus on knowledge less focus on comprehension
41	Correlation	Another question of the same content with higher correlation

There were also questions which reflect low item-total correlation or extreme levels of difficulty but remained in the instrument for some reason. The reasons for deciding for an item to stay or remain in the instrument mainly depended on the theory for which statistical literacy was explained with. In the literature review part, statistical literacy was explained within delMas' (2002) basic model which assumes statistical literacy as an independent domain having overlaps with statistical reasoning and thinking. Also again from the definition used in this study, it can be said that statistical literacy is mainly dependent on understanding and interpreting everyday statistics but not applying technical calculations or advanced statistics knowledge. Theory and definition of statistical literacy were also effective in the decision of eliminating or not eliminating some questions and some topics from the instrument. Questions remained in the scale in spite of their item-total correlations and means and the reasons for not eliminating those items were given in the following table.

Table 5.8. Comparison of questions remained and reason for stay.

Item	Topic	Reason for Stay
6	Comparing probabilities	Measures statistical thinking
7	Interpreting probability	Exactly measures statistical literacy
23	Frequency	Deals more with logical thinking
27	Median	Focuses on interpreting median It is a short question
28	Median	Uses the exact stimulus with item 27
34	Normal Distribution	The only question measuring this content The stimulus is from daily life Question asks thinking the situation in terms of statistics and interpreting it.
38	Confidence Interval	These questions share the same stimulus. Measures interpretation using different expressions.
39	Confidence Interval	
42	Correlation	The only question measures correlation using words in stimulus Measures the distinction between correlation and causation which is highlighted in literature

5.2.4. Item Revision

Totally 22 questions were eliminated from the instrument and revisions were made when necessary. The remaining 20 questions were compiled and the content coverage of the scale was checked with the test plan. It was seen that remaining 20 questions were

sufficient to measure statistical literacy and the test was prepared for a second try out by item revisions.

Among them some questions were revised when necessary. For example Q8 was about conditional probability, to make the question more specific numbers were added to the question, and a table was added to include these numbers. Q12 also necessitated a revision. The line graph which had two lines in the question was replaced with a graph having only one line. The reason for this revision is making this question more understandable to the participants. Also, in Q13, the categories were changed to names of the football teams in Turkey to make the question more meaningful in the context of Turkey. Q23 was had only a little change of wording in one of the options, and option d of Q24 was changed. It was intended to make option “d” more appealing to the respondents. Also the wording was shortened in shared stimulus of Q27 and Q28 to make the question more understandable. Lastly, in Q35 in the stimulus of the question, instead of saying “a researcher”, “a zoologist, Aylin” was preferred and wording changed accordingly. The results of data analysis and the decisions made for all the questions in the scale were given in the following table:

Table 5.9. Overall properties and decisions of questions in the first pilot study.

Item	Topic	Mean	Std. Dev.	Item-Total Correlation	Decision
1	Random sample	0.39	0.496	.499**	Remained
2	Random sample	0.12	0.331	-.209	Eliminated
3	Dependent / Independent Events	0.82	0.392	.175	Eliminated
4	Dependent / Independent Events	0.48	0.508	.565**	Remained
5	Dependent / Independent Events	0.55	0.506	.567**	Remained
6	Probability	0.03	0.174	-.258	Remained
7	Probability	0.7	0.467	.151	Remained
8	Conditional probability	0.52	0.508	.414*	Revised
9	Conditional probability	0.73	0.452	.362*	Eliminated
10	Types of variables	0.18	0.392	-.054	Eliminated
11	Levels of measurement	0.33	0.479	.228	Eliminated
12	Line chart	0.55	0.506	-.001	Revised
13	Pie chart	0.15	0.364	.044	Revised
14	Pie chart	0.97	0.174	.077	Eliminated
15	Pie chart	0.33	0.479	-.225	Eliminated
16	Pie chart	1	0	Not available	Eliminated
17	Pie chart	0.67	0.479	.93	Eliminated
18	Bar chart	0.55	0.506	-.242	Eliminated
19	Histogram	0.39	0.496	.166	Eliminated
20	Histogram	0.18	0.392	.127	Eliminated
21	Histogram	0.12	0.331	-.031	Eliminated
22	Histogram	0.61	0.496	.350**	Remained
23	Frequency	0.48	0.508	.596**	Revised
24	Mean	0.48	0.508	.541**	Revised
25	Median and outliers	0.18	0.392	.389*	Remained
26	Median	0.39	0.496	.229	Eliminated
27	Median	0.15	0.364	.011	Remained
28	Median	0.12	0.331	.493**	Remained
29	Inter quartile range	0.09	0.292	.160	Eliminated
30	Standard deviation	0.03	0.174	.263	Eliminated
31	Standard deviation	0.55	0.506	.459**	Eliminated
32	Standard deviation	0.33	0.479	.450**	Remained
33	Normal distribution	0.21	0.415	.306	Eliminated
34	Normal distribution	0.21	0.415	.126	Remained
35	Hypothesis testing	0.33	0.479	.384*	Revised
36	Hypothesis testing	0.3	0.467	.355*	Eliminated
37	Confidence interval	0.15	0.364	.087	Eliminated
38	Hypothesis testing	0.27	0.452	.344	Remained
39	Confidence interval	0.45	0.506	.398*	Remained
40	Scatter plot	0.12	0.331	.433*	Eliminated
41	Correlation	0.06	0.242	.085	Eliminated
42	Correlation	0.06	0.242	.378*	Remained

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

5.3. Phase 3 of the Study- Second Pilot Study

5.3.1. Participants

Second pilot study was carried out with 100 volunteer students towards the end of the Summer term of 2011 during their lessons. Among these 100 students, ten of them answered to only first couple of questions. They were excluded from the study and their answers were not regarded as valid. Therefore, answers of 90 students were counted in for this phase of the study. It was seen that participants were from various departments, students' majors can be found in Table 5.10.

Table 5.10. Profile of the participants in the second pilot study.

Department	Number of Registered Students	Number of Participants
Secondary Education	328	12
Computer Education	121	3
Mathematics and Physics	257	11
Primary Education	300	22
Engineering	1342	13
Management and Trade	528	10
Foreign Language Education	212	8
Guidance and Counseling	136	3
History and Philosophy	278	2
Not clarified		6
Total	3502	90

The sampling adequacy regarding the total number of students in the departments was questioned here. The population for this administration can be considered as the second, third, fourth, and if available fifth year students (which is only possible in Secondary School Science and Mathematics Education Department) in these departments. From the information taken from Registrar's Office, the total number of students registered to these departments at second, third, fourth, and fifth years were given in the table.

Since the study was done during the summer term, which was optional, only students who attended summer term were available to be in the sample. The attendance percentage was high among students from these departments who attended various summer term courses given by different departments.

Using the formula to find the sample size, at confidence level 95 %, with $d= 0.6$, and variance was assumed as 6.9, necessary sample size for this population can be calculated as 72. This result indicates that a sample size of 72 can be enough to see the variation in a population having 3502 individuals with 95 % confidence and at an error rate of 0.6 points.

5.3.2. Administration

The duration of the administrations was planned as 20 minutes for 20 questions. Most of the participants requested some extra couple of minutes to complete the test. It was observed that participants took the test seriously, did not lose attention, and completed the test. Participants' oral feedback was taken by the researcher and other proctors involved. Some students told that taking the test in English was a disadvantage for them especially for completing the test in time. Some stated that some of the topics included technical knowledge rather than everyday life knowledge. Few students stated that they had difficulty in remembering their previous knowledge on the topics median or the mean. Moreover, few indicated that they could not have completed the test if they did not take a statistics course before. Some declared that the test was hard. On the other hand, couple of students liked the test and requested a copy to take home. From the feedback taken from the participants, it was decided to make the instrument shorter by eliminating some questions and revise the language of the test to make the English more understandable. To clarify which questions to eliminate and revise data analysis results were taken into consideration.

5.3.3. Data Analysis

The easiness of questions was checked by taking the mean of each question, and the dispersion of students' performance on an item was judged by standard deviation. Item-total correlations and inter - item correlations were also calculated. The reliability of the whole instrument was found by calculating Cronbach's alpha coefficient which was calculated as .604. Cronbach's alpha based on standardized items which is the the Cronbach's alpha of internal consistency when all scale items have been standardized was calculated as .572. This coefficient is used only when the individual scale items are not

scaled the same. Moreover, item difficulty and item discrimination index were calculated to see how distractors function for each item.

Table 5.11. Descriptive statistics for the second pilot study.

Item	N	Sum	Mean	Std. Dev.
1	90	49	0.54	0.501
2	90	40	0.44	0.5
3	90	49	0.54	0.501
4	90	5	0.06	0.23
5	90	68	0.76	0.432
6	90	27	0.3	0.461
7	90	76	0.84	0.364
8	90	58	0.64	0.481
9	90	17	0.19	0.394
10	90	72	0.8	0.402
11	90	66	0.73	0.445
12	90	43	0.48	0.502
13	90	27	0.3	0.461
14	90	37	0.41	0.495
15	90	35	0.39	0.49
16	90	39	0.43	0.498
17	90	29	0.32	0.47
18	90	20	0.61	0.49
19	90	33	0.37	0.485
20	90	16	0.18	0.384
Total			8.85	2.995

From the descriptive statistics it is seen that students' performances vary among the questions. There are relatively easy and relatively hard questions. The easiest question was Q7, and the hardest question was Q4. In order to see how questions are related with the test in general, item-total correlations can be seen in Table 5.12.

Table 5.12. Item- total score correlations for second pilot study.

Item	Item- Total Correlation	Item	Item- Total Correlation
1	.502**	11	.489**
2	.573**	12	.300**
3	.540**	13	.435**
4	0.012	14	.507**
5	.471**	15	.280**
6	0.203	16	.475**
7	.293**	17	.401**
8	.373**	18	0.183
9	0.109	19	.223*
10	0.181	20	0.013

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

There are items which show high and low item- total score correlations. The items which show higher item- total score correlations were Q1, Q2, Q3, Q14 and items which show lower item- total score correlations were Q4, Q6, Q9, Q10, Q18, and Q20.

Item difficulty can be thought as an alternative indicator of item and total score relationship. Item difficulty is the percentage of examinees who answered the item correctly. According to Thorndike (2005), for a multiple-choice test with four options the optimum difficulty level would be about .65 to .70. However, for a criticism of item difficulty as measured this way is that the profile of the participants affects item difficulty. For instance, with poorly educated participants item difficulty can be low. Item difficulty values of the items are given in Table 5.13.

Table 5.13. Item difficulty scores for second pilot study.

Item	Item difficulty	Item	Item difficulty
1	54.39	11	73.26
2	44.4	12	47.73
3	54.39	13	29.97
4	5.55	14	41.07
5	75.48	15	38.85
6	29.97	16	43.29
7	84.36	17	32.19
8	64.38	18	22.2
9	18.87	19	36.63
10	79.92	20	17.76

There are items which show higher and lower item difficulty scores. Among them Q4, Q6, Q9, Q13, Q18, and Q20 showed lower and Q7, Q10, Q11 showed higher item difficulty scores. It can be said that item difficulty can show similar results with item- total score correlations such as having lower values for Q4, Q6, Q9, Q18, Q20 for both calculations.

Other than item difficulty, item discrimination index was also calculated using the formula given by Thorndike (2005). According to his definition, item discrimination index was calculated by top and bottom 27 % of examinees, namely the upper and lower group. Since participants consist of 90 individuals, there are 23 people in upper and lower group. As Thorndike (2005) narrated, the discrimination index is computed by subtracting the number of students who got the item correct in the lower group from the number of students who got it correct in the upper group, and dividing the difference by the number in one group as depicted in the formula below:

$$\text{IDis} = \text{Upper Group \% Correct} - \text{Lower Group \% Correct} \quad (5.2)$$

Where Upper / Lower Group = 27% of Whole Group

This calculation necessitates the interpretation that negatively discriminating items are not plausible in tests. As Thorndike (2005) also states, it means that such an item measures something other than the rest of the test is measuring indicating that items which have discrimination indexes below .20 should be considered to be eliminated and items having discrimination indexes above .50 should be retained. The item discrimination of each question is given in the table below:

Table 5.14. Item discrimination index for questions in the second pilot study.

Item	Item Discrimination Index	Item	Item Discrimination Index
1	0.76	11	0.52
2	0.89	12	0.6
3	0.7	13	0.86
4	-1	14	0.82
5	0.43	15	0.5
6	0.4	16	0.76
7	0.3	17	0.92
8	0.44	18	0.57
9	0.57	19	0.55
10	0.14	20	0.25

Comparison of questions regarding item difficulty, item discrimination index and item total correlations were done. The summary of the decisions made and statistical evidences of these decisions can be found at the end of this section in Table 5.15.

5.3.4. Item Reduction

It was seen that six questions did not have significant item total correlations. For these questions the reasons for insignificant item total correlations were searched by analyzing items individually. Considerations for those questions are given in depth in the following paragraphs.

There were three questions measuring the ability of reading graphs of different types. These three questions were about reading a line chart, a pie chart and a histogram. Inter-item correlations between these three questions were analyzed and it was seen that all three correlations were low. Correlation between line chart question (Q7) and pie chart question (Q9) was found at .050; again correlation between line chart question and histogram question (Q10) was found as -.061. Correlation between Q9 and Q10 was found as .028. On the other hand, in comparing graphic reading questions, item means were used. Out of one, average point earned for Q7 was found as .84; .19 for Q9; .80 for Q10. Therefore, Q7, and Q9 were eliminated.

For the fourth question (Q4), it is possible to say that the question measures evaluating claims based on the statistical information rather than non-statistical information which is peripheral to the intended measurement outcome with this question. This ability can be assumed as a prerequisite of being statistically literate as well as making judgments relying on statistics which is statistical thinking. Therefore, what is measured with this question can be said to be at the intersection of statistical literacy and statistical thinking which is possible according to delMas' (2002) model. This theoretical reliance on another interdependent construct, statistical thinking, can be responsible for the low item-total correlation. Therefore, it was decided to eliminate the item from the test. It is also seen that Q4 has a very low item discrimination index. This finding also supports the idea that Q4 measures a theoretically different construct other than statistical literacy.

Question 6 (Q6) measures critical interpretation of conditional probability. The item had been tried out in the first pilot study, had a relatively high item total correlation (.586) and was revised after expert analysis. For the second pilot study, the stimulus of the question was given with a table. Although few in number, some students narrated that they had difficulty in reading table. Those students were pursuing majors related to social sciences. The form the stimulus presented can be charged for the change in the value of item-total correlation.

For question 20 (Q20), item total correlation was not significant (.127), and the mean of the question was not high (.18 out of 1). This question was asking for the interpretation of a given correlation. In the literature, the distinction between correlation and causation was highlighted and listed among the things that statistically literate person should know (Utts, 2003; Schield, 1999). In this question, one of the options reflected this misinterpretation which worked as a distracter. This distracter can be responsible for the low item mean and insignificant item-total correlation. Since the item measures an indispensable topic for the study, this item has remained in the test.

Lastly, question number 18 (Q18) had low item-total correlation (.183) and a mean of (.61). This question is about confidence intervals and shares the same stimulus with question 19 (Q19). In the common stimulus, the situation is narrated and in each question a statement is given and asked for its validity. The statements could be seen close to each

other especially for a participant who is not so competent in confidence intervals. That's why; the question remained in the instrument. After the analysis, the indicated questions were eliminated for the pursuit of making the instrument even more practical, valid, and reliable.

5.3.5. Item Revision

There was still need for revising some questions. For example, in order to decrease necessary time for reading the question the common stimulus of Q18 and Q19 were refined and shortened. The stimulus of Q20 was revised to better fit to the Turkish context. The instrument was prepared to the third pilot study. The following table displays the content, analysis results, and the decisions made regarding whole list of questions used in this phase.

Table 5.15. Overall properties and decisions for the questions in the second pilot study.

Item	Topic	Mean	Std. Dev.	Item-Total Correlation	Item Discrimination Index	Decision
1	Random sample	0.54	0.501	.502**	0.76	Remained
2	Dependent / Independent Events	0.44	0.5	.573**	0.89	Remained
3	Dependent / Independent Events	0.54	0.501	.540**	0.7	Remained
4	Probability	0.06	0.23	0.012	-1	Eliminated
5	Probability	0.76	0.432	.471**	0.43	Remained
6	Conditional probability	0.3	0.461	0.203	0.4	Remained
7	Line chart	0.84	0.364	.293**	0.3	Eliminated
8	Frequency	0.64	0.481	.373**	0.44	Remained
9	Pie chart	0.19	0.394	0.109	0.57	Eliminated
10	Histogram	0.8	0.402	0.181	0.14	Remained
11	Mean	0.73	0.445	.489**	0.52	Remained
12	Median and outliers	0.48	0.502	.300**	0.6	Remained
13	Median	0.3	0.461	.435**	0.86	Remained
14	Median	0.41	0.495	.507**	0.82	Remained
15	Standard deviation	0.39	0.49	.280**	0.5	Remained
16	Normal distribution	0.43	0.498	.475**	0.76	Remained
17	Hypothesis testing	0.32	0.47	.401**	0.92	Remained
18	Confidence intervals	0.61	0.49	0.183	0.57	Revised
19	Confidence intervals	0.37	0.485	.223*	0.55	Revised
20	Correlation	0.18	0.384	0.013	0.25	Revised

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

5.4. Phase 4 of the Study- Third Pilot Study

5.4.1. Participants

The aim of participant selection was including students from all programs across to constitute a representative sample of university students. Different courses offered by various departments were visited during course hours and the aim of the study was announced. Data collected from students who volunteered to participate to the study. Totally 501 students participated this phase of the study. Using participants' student identity number it was noticed that five students took the scale twice and only the

responses when the instrument was first administered was used. Ten participants were exchange students from other universities, they were not included in the sample and their answers were not included in the study. Ten participants answered less than half of the questions in the instrument which is eight. Their answers were examined and none of them included in data analysis. After the exclusion of 25 participants, 476 participants remained in the study. Information about participants' departments, grades, and GPAs were summarized. Participants were from 32 programs which is the total number of all programs in the university that the study was carried meaning that students from all the departments in the university were reached. The profile of the participants according to their programs and years of study was given in Table 5.16 (Abbreviations were given as; BIO: Biology, CHEM: Chemistry, HIST: History, MATH: Mathematics, PHIL: Philosophy, PHYS: Physics, PSY: Psychology, SOC: Sociology, TI: Translation and Interpreting Studies, TLL: Turkish Language and Literature, WLL: Western Language and Literatures, AD: Management, EC: Economics, POLS: Political Science and International Relations, CET: Computer Education and Educational Technology, ED: Educational Sciences, FLED: Foreign Language Education, PRED-M: Undergraduate Program in Mathematics Education, PRED-P: Undergraduate Program in Preschool Education, PRED-S: Undergraduate Program in Science Education, CEDU: Integrated B.S. And M.S. Program in Teaching Chemistry, MEDU: Integrated B.S. and M.S. Program in Teaching Mathematics, PEDU: Integrated B.S. and M.S. Program in Teaching Physics, CHE: Chemical Engineering, CE: Civil Engineering, CMPE: Computer Engineering, EE: Electrical and Electronically Engineering, IE: Industrial Engineering, ME: Mechanical Engineering, INTT: International Trade, MIS: Management and Information Systems, and TA: Tourism Administration).

Table 5.16. Profile of participants in the third administration.

Faculty or School	Department \ Year of Study	2	3	4 and 5	Not Specified	TOTAL	Faculty Total
Faculty of Arts and Sciences	WLL		4	1	11	16	132
	SOC		4		2	6	
	HIST	1	1		17	19	
	CHEM		4	2	3	9	
	PSY		6	1	4	11	
	TI		9	1	1	11	
	PHIL		1	3	1	5	
	PHYS			1	6	7	
	MATH	3	7	8	22	40	
	TLL		1		3	4	
BIO				4	4		
Faculty of Economics and Administrative Sciences	POLS	2	5		6	13	38
	AD		2	1	8	11	
	EC		5	1	8	14	
Faculty of Education	ED		7		7	14	128
	FLED	2	30	3	20	55	
	MEDU		6	9	22	37	
	CET		2	1	1	4	
	PEDU		1	1	5	7	
	PRED-M		1		2	3	
	PRED-S			1		1	
	PRED-P				1	1	
CEDU				6	6		
Faculty of Engineering	IE		2		6	8	43
	ME		2	3	3	8	
	CE	1	1	1	7	10	
	EE		3	2	2	7	
	CMPE		1		2	3	
	CHE		1		6	7	
School of Applied Disciplines	TA				4	4	38
	INTT				18	18	
	MIS			1	15	16	
Not Specified			1		96	97	
	Total	9	107	41	319	476	

Second, third, fourth, and only for secondary school teaching fifth year students were included in the study. Preparatory class and first grade students were excluded in this sampling since they may not be well uncultured to the university environment and may not be a representative of a university student since it is their first semester at the University.

The sampling adequacy regarding the total number of students in the departments was questioned here.

The population of this administration was all the second, third, fourth and fifth year students from all programs. Number of students registered to all the programs in the university was given below:

Table 5.17. Number of students registered to the departments.

Program	Number of Registered Students	Program	Number of Registered Students
CET	121	PSY	155
PRED-S	90	SOC	169
PEDU	99	HIST	158
PRED- M	117	TLL	129
FLED	212	EC	380
CEDU	88	AD	345
MEDU	141	POLS	324
PRED- P	93	CMPE	247
GUID	136	EE	224
WLL	151	IE	209
TI	149	CE	227
PHIL	120	CHE	206
PHYS	135	ME	229
CHEM	122	TA	171
MATH	167	INTT	183
BIO	116	MIS	174
Total			5587

Using the formula to find the sample size (Equation 5.1), at confidence level 95 %, with $d = .25$, and variance was assumed as 6.9, necessary sample size for this population can be calculated as 423. This result indicates that a sample size of 476 can be enough to see the variation in a population having 5587 individuals with 95 % confidence and at an error rate of .25 points.

Another way of looking to sample size is by stratified sampling. For example, in order to differentiate participants who are familiar of dealing with reading and reasoning quantitative expressions and those who are not, a stratified sampling according to programs can be done. As mentioned before, the programs can be divided into three as quantitative

majors, social science majors, and combined majors. This discrimination was clarified by examining the courses offered in the curriculum of programs. The programs which include physics and calculus courses were considered as quantitative majors like mathematics, engineering, and biology. Programs which include calculus courses but not physics courses in the curriculum like economics and management were considered as combined majors. Lastly, programs which do not include physics courses and include mathematics for social science course instead of calculus courses were considered as social science majors like sociology, psychology, or history.

Number of participants and registered second, third, fourth and fifth year students in each type of major will be given in the following table:

Table 5.18. Number of people by the type of their majors.

Department	Number of Registered Students	Number of Participants	Department	Number of Registered Students	Number of Participants
QUANTITATIVE MAJORS			COMBINED MAJORS		
PRED-S	90	1	EC	380	380
PEDU	99	7	AD	345	345
PRED- M	117	3	POLS	324	324
CEDU	88	6	TA	171	171
MEDU	141	37	INTT	183	183
PHYS	135	7	MIS	174	174
CHEM	122	9	Total	1577	77
MATH	167	40	SOCIAL SCIENCE MAJORS		
BIO	116	4	FLED	212	55
CMPE	247	3	PRED-P	93	1
EE	224	7	ED	136	14
IE	209	8	WLL	151	16
CE	227	10	TI	149	11
CHE	206	7	PHIL	120	5
ME	229	8	PSY	155	11
CET	121	4	SOC	169	6
Total	2538	161	HIST	158	19
			TLL	129	4
			Total	1472	142
GRAND TOTAL	5587	476			

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

When stratified sampling is used, the necessary sample size can be calculated with the formula below:

$$n_o = \frac{pq}{\sigma^2} \quad (5.3)$$

Where p denotes the probability of having selecting a participant from a strata among all population and q denotes not selecting a participant from a strata, σ denotes the standard deviation wanted to be seen, and σ^2 denotes the square of the standard deviation. To make the notations simpler, quantitative majors strata will be denoted by n_1 , combined majors will be denoted by n_2 , and social sciences majors will be denoted by n_3 . Using the formula, the calculation and the necessary number of participants from each stratum will be shown in the table below:

Table 5.19. Stratified sample size calculation for third administration.

Strata / Elements of the formula	P	q (=1-p)	σ	σ^2	$\frac{p \cdot q}{\sigma^2}$
n_1	0.45	0.55	0.05	0.0025	99.16
n_2	0.28	0.72		0.0025	81.04
n_3	0.26	0.74		0.0025	77.62
Total					257.82

Necessary number of participants and actual number of participants were compared below. There were 96 participants who did not declare their departments. Assuming participants who did not declare their department has equal probability of being one of the three types of majors, among these 96 participants, 32 of them are expected to be from quantitative majors, 32 from social sciences majors, and 32 from combined majors. The comparison of necessary number of participants, actual number of participants, and actual and expected number together was given in the following table:

Table 5.20. Comparison of stratified sample size for third administration.

Strata / Elements of the formula	Necessary Sample Size	Actual Number of Participants	Actual and Expected Number of Participants
n_1	99	161	193
n_2	81	77	109
n_3	78	142	174
Total	258		476

In sampling participants according to programs, having participants who did not declare their programs was disadvantageous. It was necessary to either exclude those participants or randomly distribute to departments. Since the number of participants who did not declare their programs was high, it was assumed that those participants can be randomly distributed to the departments. Taking all the participants into account, it can be said that every type of major was represented in the sample.

5.4.2. Administration

Data collection for this administration was done during Fall semester of 2011- 2012 academic year. The administrations were done in various courses. The researcher announced the study either at the beginning or end of the course and volunteer students took the test. Students were willing to take the test and they took it seriously. Almost no technical difficulty was encountered by the researcher. Participation ratio was high in most of the sessions.

Further information about the administrations can be gathered through researcher's journal for administration notes. These notes were used to record some remarks and feedback during administrations which include participants' questions and comments about language of the test, time they spent in taking the test, and frequently asked questions and comments about the questions. The researcher's journal was not used to decide upon the procedure of preparing the instrument but enhancing the interpretation of results by providing possible links with the administrations and the scores.

Researcher's notes indicate that some students mentioned that they would be more comfortable if the test were in Turkish rather than English. They asked the meaning of the words "rush" and "bias". Some said that they confuse the terms mean and median.

Time spent to finish the test was again noted and it was around 15 minutes in most administrations. Nevertheless, it is also observed that groups which have high numbers of students studying English language majors (like Translation and Interpreting, English Language and Literature) finished the test earlier. It can be claimed that language proficiency could have affected time required to finish the test.

Participants' comments about the content of the test were also noted and occasionally participants said that they did not remember mean and median. There were students saying that they couldn't complete the test if they would not take any statistics course before.

The last point seen in researcher's journal was about a question which had a typing error. In option "b" it was written as "This sample is too small to draw any conclusions about the relationship between ... for adults in the U.S." where it should be written as Istanbul instead of U.S. Although the error did not change the keyed answer, it may have confused participants. Number of students who recognized and asked about the error was recorded, in most administrations it was noted that no one recognized the error. In some administrations the number of participants recognized this error increased to three or even five. It may be the case that most students answered the first option with thinking they found the keyed response (true answer) and they did not read the rest of the options. It may also be the case that since it was the last question in the instrument, with willing to finish the test, they did not read all of the options. To sum, it is assumed that the type error did not affect the results.

5.4.3. Data Analysis

Descriptive statistics about this administration were calculated using the sum of the true answers, the mean, and standard deviation for each question and the mean and standard deviation for the whole test.

Table 5.21. Descriptive statistics for third administration.

Item	N	Min.	Max.	Mean	Std. Dev.	Variance
1	476	0	1	.64	.480	.230
2	476	0	1	.64	.479	.229
3	476	0	1	.70	.458	.210
4	476	0	1	.82	.385	.148
5	476	0	1	.34	.474	.224
6	476	0	1	.73	.446	.199
7	476	0	1	.75	.431	.186
8	476	0	1	.73	.444	.197
9	476	0	1	.44	.497	.247
10	476	0	1	.43	.495	.245
11	476	0	1	.46	.499	.249
12	476	0	1	.58	.493	.243
13	476	0	1	.52	.500	.250
14	476	0	1	.34	.475	.226
15	476	0	1	.23	.422	.178
16	476	0	1	.43	.496	.246
17	476	0	1	.29	.456	.208
Total	476	2	16	8.76	2.625	6.891

From the descriptive statistics, it can be said that there were students who could get full point from the test (16 points), and a minimum score of two which is possible by answering at least two questions correctly. Some questions had low standard deviation which means participants' answers were mostly alike. In addition to descriptive statistics item difficulty which is the percentage of participants who answered the item correctly was also calculated. According to item difficulty index, the easiest question of the instrument is Q4, and the hardest question is Q15. Table 5.22 shows the item difficulty index and Table 5.23 shows overall properties of the questions.

Table 5.22. Item Difficulty index for third administration.

Item	Item Difficulty Index	Item	Item Difficulty Index
1	64.03	10	43.03
2	64.44	11	45.53
3	70.47	12	58.21
4	82.12	13	52.18
5	33.47	14	34.30
6	73.38	15	23.07
7	75.67	16	43.45
8	72.76	17	29.72
9	44.28		

Table 5.23. Overall properties and decisions of questions in the third administration.

Item	Topic	Mean	Std. Dev.	Corrected Item-Total Correlation	Item Difficulty Index	Cronbach's Alpha if Item Deleted
1	Random sample, Bias in sampling, Randomization	.64	.480	.212	64.03	.510
2	Dependent / Independent Events	.64	.479	.293	64.44	.493
3	Dependent / Independent Events	.70	.458	.218	70.47	.509
4	Probability of events, Expectation	.82	.385	.212	82.12	.512
5	Conditional probability	.34	.474	.064	33.47	.538
6	Histogram	.73	.446	.203	73.38	.512
7	Frequency	.75	.431	.146	75.67	.522
8	Mean (sample mean/ population mean)	.73	.444	.213	72.76	.510
9	Mean (outlier)	.44	.497	.156	44.28	.521
10	Median	.43	.495	.225	43.03	.507
11	Median and outliers	.46	.499	.213	45.53	.509
12	Standard deviation	.58	.493	.146	58.21	.523
13	Normal distribution	.52	.500	.290	52.18	.493
14	Hypothesis testing	.34	.475	.136	34.30	.525
15	Confidence levels	.23	.422	.077		.534
16	Confidence intervals	.43	.496	.144	43.45	.523
17	Correlation	.29	.456	.114	29.72	.528

For each question frequency of options is computed by the percentage of participants selecting each option. The summary of percentage for each option is given below:

Table 5.24. Percentage of options.

Item	Options				
	A	B	C	D	Blank
1	6.24	64.03	6.03	19.96	3.95
2	1.04	2.29	31.39	64.45	1.04
3	5.41	2.08	70.48	21.00	1.25
4	7.48	2.91	6.03	82.12	1.66
5	54.68	4.78	1.46	33.47	5.61
6	73.9	.33	.44	15.38	1.66
7	3.74	75.68	2.91	14.35	3.53
8	9.36	72.77	4.57	8.32	5.20
9	23.49	3.74	26.40	44.28	2.29
10	8.32	13.31	21.00	43.04	14.55
11	5.41	25.99	45.53	2.70	20.58
12	3.95	3.74	58.21	22.87	11.43
13	22.45	3.33	52.18	6.24	16.01
14	8.94	34.30	31.39	6.65	18.92
15	61.54	23.08	-	-	15.59
16	43.45	36.80	-	-	19.96
17	37.01	8.73	11.64	29.73	13.10

From the frequency of options for each question, the most common answers were extracted. Usually, it is observed that the keyed response, the option where the true answer is was chosen by the participants as the most common option. However, for some questions that an option other than the keyed response was chosen more frequently than the keyed response. The table showing the most and the second most options chosen for each questions can be seen below:

Table 5.25. Most common answers in the third administration.

Item	Most Common		Second Most Common	
	Option	True / False	Option	True / False
1	B	True	d	False
2	D	True	c	False
3	C	True	d	False
4	D	True	None	
5	a	False	D	True
6	A	True	None	
7	B	True	None	
8	B	True	None	
9	D	True	a and c	False
10	D	True	c	False
11	C	True	b	False
12	C	True	d	False
13	C	True	a	False
14	B	True	c	False
15	a	False	B	True
16	A	True	b	False
17	a	False	C	True

From the frequency of options it can be understood that Q4, Q6, Q7, and Q8 were relatively easy questions and the options other than the keyed response were not attractive for the respondents. For Q5, the most preferred option was not the keyed response. This reveals that participants can have a misconception, or misleading ideas about conditional probability. In this case, it can be defended that participants were confused in deciding upon the sample size thinking about conditional probability. For some instances, the researchers' journal reveals that some participants indicated that options a and d seemed alike. In such cases, the participants were told to answer the option which makes more sense to them.

For Q15, the keyed response is again not the most preferred response. This question is about confidence intervals and there are only two options: valid and invalid. For this question, it can be said that participants could be confused in determining whether confidence intervals are indicators of the mean or the actual value of an indicated variable in the population. Moreover, for this question the percentage of participants who left the question blank is not low. Therefore, it can be concluded that most of the participants may not be competent enough to answer questions about confidence intervals.

In Q17, the mostly preferred response is again not the keyed response. This question is about interpreting correlation and the mostly preferred response indicates that the correlation can lead inferring causality between the correlated variables in the question. Moreover, literature reveals that inferring causality from correlation is a common misconception. Therefore, it is not surprise to have more participants who thought that causality could be inferred from correlation than participants who thought that causality cannot be inferred from correlation, which is the keyed response.

The following analysis will try to answer the main research question 1 which is “Is this instrument valid for measuring statistical literacy for undergraduate students in a public university where the medium of instruction is English?” The sub questions will also be revisited.

For checking the construct validity of the scale some analysis were performed which were trying to answer the sub question 1.2 which is “Is this instrument valid for measuring statistical literacy construct?” To answer this research question, analyzing the existence of factors or sub constructs within the scale was necessary. Therefore, factor analysis was performed. In order to check whether data collected was suitable to perform factor analysis Kaiser Mayer Olkin (KMO) test which is a measure of sampling adequacy and Bartlett’s test of sphericity, which is a statistical test testing that the variables are uncorrelated in the population, was conducted.

Table 5.26. KMO and Bartlett’s test results for third administration.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.581
Bartlett's Test of Sphericity	Approximate Chi-Square	711.092
	df	136
	Sig.	.000

Field (2000) indicated that KMO values below .5 indicated that the data is not suitable for factor analysis. Although KMO test result is not so high, it reveals that the data are suitable for factor analysis. Principal factor analysis was calculated. Eigenvalues which are the variances of the factors were considered in determining the number of the

factors to be extracted. Eigenvalues will be equal to 1 when the variables are standardized. Therefore, in determining the number of factors, eigenvalues which are greater than one was taken as a factor. It was revealed that seven factors were extracted explaining the 57.31 % of variance in the scores. The details of this factor analysis are given in the table below:

Table 5.27. Factor analysis for third administration.

Total Variance Explained			
Component	Extraction Sums of Squared Loadings		
	Total	Percentage of Variance	Cumulative Percent
1	2.187	12.863	12.863
2	1.649	9.698	22.561
3	1.382	8.132	30.692
4	1.246	7.331	38.024
5	1.141	6.711	44.735
6	1.084	6.374	51.110
7	1.055	6.204	57.313

In this table, the number of rows corresponds to the number of the factors revealed. Percentage of variance column contains information on the percent of total variance accounted for by each factor. Cumulative percent column includes information of the cumulative percentage of variance accounted for by the current and all preceding factors. Hence, from this table it can be seen that the seven factors extracted are accounted for 57.31 % of total variance.

The correlation of scores from each item and the components extracted is given in matrix form as the component matrix. This matrix can also be thought as an indicator of distribution of each item to the seven components extracted.

Table 5.28. Component matrix for third administration.

Component Matrix							
Item	Component						
	1	2	3	4	5	6	7
1	.311	.312	.146	-.091	-.349	.055	-.156
2	.630	-.196	-.594	-.095	-.024	.118	.014
3	.543	-.266	-.648	-.165	-.005	.059	.050
4	.405	.059	.272	.413	-.374	.194	.089
5	.091	.104	.151	.050	.284	.492	.527
6	.438	-.037	.140	.375	-.370	-.124	-.111
7	.288	-.018	.129	-.283	.051	-.547	.400
8	.468	-.174	.312	-.036	.209	-.244	-.080
9	.340	-.083	.103	.362	.169	.145	.427
10	.402	.062	.239	-.129	.283	.373	-.326
11	.353	.238	.188	-.437	-.158	.239	-.248
12	.227	.186	.268	-.530	-.033	-.115	.204
13	.475	.160	.106	.207	.118	-.344	.013
14	.146	.297	.065	-.047	.507	.056	-.109
15	-.088	.746	-.288	.052	-.021	-.102	.143
16	.037	.752	-.257	.043	-.133	.030	.107
17	.152	.243	-.137	.369	.436	-.215	-.358

These seven dimensions were not easy to interpret, yet it was possible to say that having relatively a big number of factors reveal that questions are not dependent on each other. It is also possible to say that it is not easy to organize questions within the scale and participants' performance of questions highly depend on their performance on cognitive dimensions and content of each question.

Moreover, in order to test the idea that the factors are independent, a rotated component analysis was done with a varimax rotation. The result of this factor analysis is given below:

Table 5.29. Rotated component analysis.

Rotated Component Matrix							
Item	Component						
	1	2	3	4	5	6	7
1	.001	.215	.347	.431	-.051	.062	-.119
2	.887	-.005	.108	.090	.049	.021	.046
3	.903	-.034	-.003	.016	-.007	.059	.000
4	-.021	.010	.715	.123	-.075	-.071	.245
5	-.033	.066	-.095	.082	-.044	-.015	.788
6	.091	-.059	.702	.019	.049	.039	-.094
7	.073	-.008	.011	-.077	-.014	.794	.009
8	.056	-.362	.207	.156	.326	.387	.025
9	.116	-.075	.295	-.172	.114	.101	.581
10	.072	-.215	.027	.577	.357	-.123	.191
11	.074	.052	.057	.728	-.032	.073	-.063
12	-.051	.069	-.104	.413	-.129	.535	.060
13	.086	.059	.364	-.015	.408	.356	.019
14	-.042	.100	-.202	.205	.507	.047	.184
15	-.045	.810	-.055	-.030	.130	.040	-.004
16	.016	.800	.065	.117	.072	-.017	.032
17	.035	.120	.065	-.132	.734	-.110	-.118

From the rotated component matrix, it can be seen that the distribution of items to the components did not change dramatically. This finding can be a support for the idea that the extracted seven factors are independent.

It is not easy to interpret the seven independent factors and not easy to organize those within the statistical literacy construct. Moreover, the KMO value is not so high to indicate that the data are easy to model the data. In PASW, it was possible to extract the indicated number of factors instead of extracting factors based on eigenvalues. Nevertheless, having these limitations and the three cognitive dimensions that are associated with statistical literacy in mind, a Principle Component Analysis with forcing the program to extract three factors was performed.

These three dimensions were capable of explaining only the 30.69 % of the variance in the scores. Nevertheless, these three factors can be more understandable when associated with the statistical content of each question in these three factors. Total

variance explained with the three components and the rotated factor matrix will be given in the following tables.

Table 5.30. Total variance explained with three factors.

Component	Sums of Squared Loadings		
	Total	Percentage of Variance	Cumulative Percent
1	2.187	12.863	12.863
2	1.649	9.698	22.561
3	1.382	8.132	30.692

To give meaning to these three components, component matrix should be examined. The component matrix constructed with three components was given below:

Table 5.31. Component matrix with three components.

Component Matrix			
Item	Component		
	1	2	3
1	.311	.312	.146
2	.630	-.196	-.594
3	.543	-.266	-.648
4	.405	.059	.272
5	.091	.104	.151
6	.438	-.037	.140
7	.288	-.018	.129
8	.468	-.174	.312
9	.340	-.083	.103
10	.402	.062	.239
11	.353	.238	.188
12	.227	.186	.268
13	.475	.160	.106
14	.146	.297	.065
15	-.088	.746	-.288
16	.037	.752	-.257
17	.152	.243	-.137

From this table, it can be seen that Q2, Q3, Q4, Q6, A7, Q8, Q9, Q10, Q11, and Q13 belong to the first dimension. Q1, Q14, Q15, Q16, and Q17 belong to the second dimension. Moreover, Q5 and Q12 belong to the third dimension. It is not possible to say that these three dimensions overlap with the cognitive dimensions as expected. However, it is possible to say that the first dimension holds questions about descriptive statistics; the second dimension unites questions about inferential statistics like hypothesis testing, correlation, and sampling. Although two questions are not sufficient to constitute a

dimension Q5 which is about conditional probability and Q12 which was about standard deviation fall into this dimension. Since there are only two questions left to the third dimension, it seemed reasonable to perform a factor analysis by forcing the program to extract two components. These two components were capable of explaining only 22.6 % of scores.

Table 5.32. Factor analysis for third administration with two factors.

Component	Rotation Sums of Squared Loadings		
	Total	Percentage of Variance	Cumulative Percentage
1	2.187	12.863	12.863
2	1.649	9.698	22.561

The component matrix constructed with two components was given below:

Table 5.33. Component matrix for third administration with two factors.

Component Matrix		
Item	Component	
	1	2
1	.311	.312
2	.630	-.196
3	.543	-.266
4	.405	.059
5	.091	.104
6	.438	-.037
7	.288	-.018
8	.468	-.174
9	.340	-.083
10	.402	.062
11	.353	.238
12	.227	.186
13	.475	.160
14	.146	.297
15	-.088	.746
16	.037	.752
17	.152	.243

From this component matrix, it can be seen that Q2, Q3, Q4, Q6, Q7, Q8, Q9, Q10, Q11, Q12, and Q13 belong to the first dimension. Q14, Q15, Q16, Q17, and with small differences Q1 and Q5 belong to the second dimension. The content of the questions were examined in order to interpret this result. In this table, descriptive statistics was abbreviated with DS, inferential statistics was abbreviated with IS, and probability was abbreviated with P. Some topics can be in both DS and Probability.

Table 5.34. Content of questions and dimensions for third pilot study.

Item	Component	Statistics Topics Measured in Each Item	Associated Field
1	2	Random sampling, random sample, randomization	P
2	1	Dependent and independent events	DS and P
3	1	Dependent and independent events	DS and P
4	1	Probability	P
5	1	Conditional Probability	P
6	1	Frequency	DS
7	1	Histogram	DS
8	1	Mean	DS
9	1	Median, Median and Outliers	DS
10	1	Median	DS
11	1	Median and Outliers	DS
12	1	Standard Deviation	DS
13	1	Normal Distribution	DS
14	2	Hypothesis Testing	IS
15	2	Confidence Interval	IS
16	2	Confidence Interval	IS
17	2	Correlation	IS

From this perspective, it can be said that the cognitive dimensions and the content of the courses can have an overlap. Descriptive statistics topics which are used for determining properties of samples overlap with the first dimension while inferential statistics topics used for making judgments about the population from statistics taken from the sample overlap with the second dimension. Participants' familiarity, their frequency of using these topics in their daily life can be responsible for this overlap. As indicated in the researchers' journal, some participants indicated that they could not have completed the test if they had not taken statistics course before. This feedback can be evidence supporting the interpretation that daily life usage and familiarity can be responsible for participants' performance which was reflected in the dimensions extracted. Nevertheless, it should be remembered that this two dimensions explains only 23 % of data.

To sum the data analysis for the third administration, descriptive statistics reflect that there are both easy and hard questions, the frequency of the options selected were not random. Factor analysis revealed that the instrument is measuring one big construct which

cannot be organized with meaningful sub-constructs. The factors extracted according to the content of the questions are capable of explaining only a small percentage of data.

The following analysis related to the reliability of SLS will try to answer the main research question 2 which is “Is this instrument consistent in measuring statistical literacy?” The two sub questions related to this question will be also mentioned.

To answer the Sub question 2.1 which is “Is this instrument internally consistent?” both Cronbach’s alpha and Cronbach’s alpha based on standardized items were calculated. Cronbach's alpha was revealed as .532 and Cronbach's alpha based on standardized items were revealed as .531.

The relationship between each question and the scale was also analyzed in the pursuit of answering the Sub question 2.2 which is “How are individual items correlated with the total score gained from the instrument?” Coefficients of corrected item- total correlations and Cronbach’s alpha if item deleted were calculated.

Corrected item - total correlation of items which is the correlation of the item designated with the combined score for all other items were also calculated. For analyzing the contributions of each question to the reliability of the whole scale Cronbach’s alpha if item deleted coefficient was calculated. Cronbach’s alpha if item deleted is the correlation Cronbach’s alpha of the scale when the scores taken from the indicated item was excluded from the scale. Both analyses were done using PASW 18 program. The results of these calculations can be found in the following table.

Table 5.35. Corrected item- total correlations and Cronbach's alpha if item deleted.

Item	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
1	.211	.511
2	.300	.493
3	.215	.510
4	.213	.512
5	.068	.538
6	.200	.513
7	.147	.523
8	.211	.511
9	.162	.521
10	.229	.507
11	.217	.509
12	.143	.524
13	.290	.494
14	.132	.526
15	.074	.535
16	.146	.524
17	.109	.530

It is seen that Cronbach alpha if item deleted coefficient for Q5 is the highest and Corrected item- total correlation is lowest among all questions. This means that Q5 did not contribute to the reliability of the test in a positive way. The reason for this can be the statistics topic this question is measuring. The question is asking for critical interpretation of conditional probability and using a table as a stimulus. The reasons for participants' lower performance will be discussed in the discussion part. In addition, it can be seen that Q17 did not change the reliability of the scale in a remarkable way.

5.5. Phase 5 of the Study- Translation of the Instrument

5.5.1. Translation Method

The instrument was developed in English and administered to undergraduate students in a specific public university in Istanbul in which the medium of instruction is English. Students must pass an English proficiency exam in order to enroll courses. There is an English preparatory class to prepare the proficiency exam, and there are Advanced English courses to support students' level of English. Students are expected to be capable of

reading, listening, writing, and speaking in English at levels that enable them do academic studies.

There are few universities in Turkey in which the medium of instruction is English. In order to make the instrument ready to use in other universities in Turkey, the instrument was translated into Turkish. Since the instrument was developed in Turkey considering the Turkish context, the translation of the instrument was seen sufficient to adapt the SLS. Moreover, administrating the Turkish version of SLS to participants who also took English version of SLS can be considered as a way to monitor the effect of language.

According to Hambleton ve Patsula (1999), there are two methods of translating an instrument: forward translation and back translation. In forward translation, the instrument is translated directly to the desired language whereas in back translation, the instrument is translated to the desired language and then translated back to the original language. The translators should be fluent in both languages, familiar with the context and the structure of the test. Moreover, translators should look for any significant differences between the original and the translated versions of the test and make necessary changes. For this study, forward translation method was followed.

5.5.2. Translation of the Instrument

During the translation process, the researcher worked as the primary translator. Other than the researcher, two more translators were recruited in the translation period. The researcher, or the primary translator, translated the instrument. A *mot à mot* (word by word) translation was done. Taking the Turkish context, the length, the frequency, and the usage of the words into account some minor changes was done in the translation. An example of this can be translating “chocolate chips cookies” as “cips” instead of “çikolata parçacıklı kurabiye”, “rush” as “kızarıklık” instead of “kurdeşen, ağır kaşıntı”, and “herbicide” as “zehirli ot” instead of “zararlı bitkileri yok eden ilaç” which are similar in meaning and more frequent in use than the dictionary translation. For translations of statistical terms, International Statistical Institute (ISI) glossary of statistical terms (ISI, 2012) was used.

Other translators were also recruited during this phase. One of the translators has a Bachelor of Science degree in Computer Engineering and is working as a translator for three years. Because this translator has a background in a quantitative major and taken statistics or probability courses previously, she can be considered as competent in understanding the content and the nature of the SLS. Another translator is a doctoral student from Foreign Language Education Department who also works as a freelance translator. Since this translator took courses on research methods and analysis during her education, she can be considered as capable of understanding the content of the SLS. These two translators were given the original English form of the scale and the researcher's first translation and asked for their interpretation and translations individually. The link to ISI's glossary of statistical terms was also shared with these translators.

The two translators made comments on the existing translation, suggested changes, and supplied their own translation when necessary. Their comments and alternative translations were collected and accepted or rejected according to the context by the researcher. Among different suggestions of translations, the ones that are similar to the daily usage and statistically correct were tried to be chosen. The researcher rewrote some translations and formatted the document similar to the original test. Then, this form of the test was sent to three scholars for evaluation.

5.5.3. Evaluation of translations

Three scholars helped in evaluating the translation. All of the scholars were native speakers of Turkish and fluent in English. One of the scholars was a professor from Operations Research Statistics in Industrial Engineering Department. He evaluated the translation in terms of language and statistical correctness of expressions. Another scholar was a doctoral student in mathematics education who also did similar tasks with CAOS questions for her thesis study. She analyzed the translation in terms of language and expressions that participants can have difficulty in understanding, or can find confusing. Finally, the last scholar, a master student from Turkish Language and Literature department who has a Bachelor of Arts degree in both Turkish Language and Literature and English Language and Literature analyzed the usage of language in the Turkish scale referring to the English version of the scale when necessary. Some of her suggestions were

utilized. With the contribution of all scholars, the researcher refined and finalized the translation.

5.5.4. Sample and Participants

A minimum of two months passed between the two administrations. The Turkish version of the SLS was administered to some of the participants who also took the English version of SLS. Among the 476 participants who took the English version, the Turkish version of the SLS was administered to 60 participants; however demographic information of only 30 participants' were matched with the information provided in previous administration. Nevertheless, it was sufficient to make comparison analysis.

Administration of the instrument was done in three steps until sufficient number of participants was reached. In the first administration there were eight participants whose demographic information was matched with the previous, seven participants in the second administration, and 15 participants in the third administration. In the first administration, participants were from various departments including Philosophy (PHIL), Civil Engineering (CE), Industrial Engineering (IE), Economics (EC), and Foreign Language Education (FLED) departments. In the second administration, there were students from Mathematics Education (MEDU) and Physics Education (PEDU). In the third administration there were mostly Mathematics (MATH) and MEDU majors. The total number of participants and their majors can be found in the following table:

Table 5.36. Participants in the fourth administration.

Department	Number of Participants
PRED-M	1
MIS	1
PHIL	1
CE	1
FLED	1
IE	1
MATH	12
EC	1
MEDU	7
PEDU	3
CMPE	1
Total	30

5.5.5. Administration

The administration notes were gathered in researcher's journal. Some sample notes are given below: One student asked the meaning of "açıklık (range)" during the administration. Moreover, after the administration one participant declared that he did not find the English version of SLS difficult and did not think much on terms but saw them as words, however in the Turkish version of the SLS, the Turkish terms sounded strange. In another administration, one of the participants stated that he did not take any statistics courses but could perform the test except some questions at the last part of the instrument. The duration of the instrument was around 15 or 20 minutes. The participants took the test seriously and could perform without showing any signs of disinterest.

5.5.6. Data Analysis

Some analyses were done in order to evaluate the equality of the Turkish and English versions of SLS. There are both quantitative and qualitative ways of understanding the equivalency of two versions of the instrument.

Expert opinions are important for qualitative evaluations. Two experts examined the two versions of SLS and made final comparisons. One is the researcher and the other is a full professor in Operations Research Statistics in Industrial Engineering Department. They agreed that the Turkish version of the SLS is an equivalent translation of the English version of SLS.

As for quantitative evaluation of the translations, analyses regarding participants' answers to two versions of the SLS were done. Participants' answers on both English and Turkish versions of SLS were gathered. Thirty participants' answers were found on both versions of the SLS. Descriptive statistics regarding these 30 participants' scores can be found in the following table:

Table 5.37. Descriptive statistics regarding Turkish and English versions of SLS.

Variable	Mean	N	Std. Dev.	Standard Error of the Mean
English version Score	9.33	30	2.721	.497
Turkish version Score	11.93	30	2.180	.398

The table above shows that scores gained from the Turkish version of SLS are higher. In order to test whether this difference is significant with 95 % confidence, a paired sample t- test planned to be conducted. In order to carry out t- test properly, no partial score was given to Q15 and Q16 and a test of normality was carried out to test whether it is legitimate to conduct a t test for group comparisons. Since the sample size is 30 Shapiro-Wilk test of normality was performed. Table 5.38 shows that the normal distribution assumption is failed to be rejected for the distribution of English version scores and Turkish version scores and a t- test could be conducted.

Table 5.38. Test of normality for Turkish version scores and English version scores.

Variable	Shapiro-Wilk		
	Statistic	df	Sig.
Turkish version Score	.931	30	.052
English version Score	.952	30	.190

Table 5.39. Result of paired samples t- test.

Variable	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Dev.	Std. Error Mean	95 % Confidence Interval of the Difference				
				Lower	Upper			
English version Score Turkish version Score	-2.600	2.343	.428	-3.475	-1.725	-6.078	29	.000

As it can be seen in the following table, there paired sample t- test showed that there was a significant difference between total scores on Turkish and English versions of the SLS in favor of scores gained from the Turkish version of SLS. Nevertheless, the increase in participants' performance can be due to many factors other than the language of the SLS. Those factors include loss of participants due to unmatched participant

information, completing a statistics course between two administrations, and familiarity with the questions due to taking SLS twice.

It can also be speculated that some questions could affect the difference in total scores more than the others. In order to detect such questions, participants' scores on each question were paired and a Mc Nemar Test was conducted. This test is a non parametric test which assumes that the measurements collected are at nominal level and data collected from paired samples. In the following table TQ1 denotes the first question in the Turkish version of SLS, where EQ1 denotes the first question in the English version of SLS.

Table 5.40. Result of McNemar test.

Pairs	Items	N	Exact Sig. (2-tailed)
Pair 1	TQ1 - EQ1	30	.000
Pair 2	TQ2 - EQ2	30	.727
Pair 3	TQ3 - EQ3	30	1.000
Pair 4	TQ4 - EQ4	30	.125
Pair 5	TQ5 - EQ5	30	.003
Pair 6	TQ6 - EQ6	30	.031
Pair 7	TQ7 - EQ7	30	.453
Pair 8	TQ8 - EQ8	30	1.000
Pair 9	TQ9 - EQ9	30	.754
Pair 10	TQ10 - EQ10	30	.727
Pair 11	TQ11 - EQ11	30	1.000
Pair 12	TQ12 - EQ12	30	.687
Pair 13	TQ13 - EQ13	30	.687
Pair 14	TQ14 - EQ14	30	.332
Pair 15	TQ15 - EQ15	30	.388
Pair 16	TQ16 - EQ16	30	.180
Pair 17	TQ17 - EQ17	30	.227

From, the result of Mc Nemar test, it can be said that there are questions for which there is a significant difference between participants' scores taken from the Turkish and the English version. These questions are Q1, Q5, and Q6. Possible reasons for these differences can be discussed separately for each question.

As it was told before, in many sessions participants asked the meaning of the word "bias" which was in Q1. It may be the case that this word is not known frequently and participants could perform better when they encountered with the translation of this word in Turkish version of SLS. Similarly, participants also asked frequently the meaning of

rush which appears in the Q4. Their vocabulary may have affected their performance. In Q5, some participants declared that they confused with options a and d in the English version of SLS. These options included the expressions “a flutist who perform classical music” and “a flutist among classical music players”. These expressions could sound similar for a participant who did not think the situation in terms of sample and population. However, in the Turkish version of SLS the difference between the options can be more apparent for more participants. This could be a reason for difference in participants’ performance in Q5. Q6 is the shortest question in SLS, it includes no numbers or tables which is easy to remember the question. This may be the reason for participants’ significantly increasing performance in this question.

Moreover, Pearson product moment correlation was performed in order to test whether there is significant correlation between scores gained from Turkish and English versions of SLS. Pearson correlation was found as .562 at .01 significance level. Moreover, Spearman rho was founded as .637 at .01 significance level. These correlations can be considered that there is respectively a moderate and moderately high, and significant relationship between scores gained from the two versions of SLS.

5.6. Further Analysis

For the aim of searching for further evidences that can contribute to the argument related to validity of SLS, further analysis was done. Participants’ information related to their year of study, major, and GPA were collected in the demographic survey. Participants’ statistical literacy scores were operationalized with the scores taken from SLS in the third administration.

To start with, differences on participants’ scores on SLS will be examined when participants were grouped according to their year of study at the university, related to the Sub question 1.3 which is “Are there differences of statistical literacy scores between groups of participants who had different years of study at the university?”

In addition to differences related to years of study at the university, differences related to participants’ departments were examined. This section will try to answer the Sub

question 1.4 which is “Are there any differences of statistical literacy scores between participants who pursue different type of majors?”

Lastly, correlation between participants’ GPA and scores gained from SLS was examined. This section is aimed at answering the Sub question 1.5 which is “Is there a correlation between participants’ GPA and scores gained from the instrument?”

5.6.1. Differences Related to Year of Study

This section includes analyses related to years participants spent at university. As stated earlier, some participants did not specify their departments. The question that “Is there a difference between the participants who specified their departments and those who did not in terms of their total scores gained from SLS?” comes out of this fact. To prepare data for this analysis, total scores were calculated by giving one point for every correctly answered question and zero point for incorrect answers. A t- test for independent samples was carried out. Descriptive statistics from both groups was given in the following table:

Table 5.41. Descriptive statistics for participants specified and not specified their years of study.

Variable	Years of Study	N	Mean	Std. Dev.	Std. Error Mean
Total Score	Specified	152	9.66	2.826	.229
	Not Specified	324	8.82	2.638	.147

The result of independent samples t- test was given below:

Table 5.42. Result of independent samples t- test.

		Levene's Test for Equality of Variances		T-Test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
TOTAL	Equal variances assumed	1.684	.195	3.167	473	.002	.841	.266
	Equal variances not assumed			3.090	278.296	.002	.841	.272

From this table, it can be understood that there is a significant difference in participants' total scores gained from SLS between participants who specified and who did not specify their years of study in favor of the participants who claimed their years of study. This result can indicate that those participants who do not feel competent enough for taking a statistics related test did not specify their years of study at the very beginning of the administration. In other words, it is also possible to say that participants who had relatively more confidence in taking a statistics related test did not hesitate to write their information regarding their years of study.

Moreover, among all participants existence of a difference between years of study can also be considered. There are 324 participants who did not specify their years of study (coded as 0), nine participants declared that they are studying their second year (sophomore), 107 declared third (junior), 28 declared fourth (senior), and eight declared fifth (education seniors). Since there are not sufficient numbers in every group, to make data suitable for statistical analysis, it was possible to merge groups two and three, and four and five in order to have sufficient number of participants in every group. There are 325 participants who did not declare their years of study, 115 participants were studying second and third, and 36 people in fourth and fifth. Descriptive statistics related to groupings based on years spent was given below:

Table 5.43. Descriptive statistics for year groupings total score.

Groups	N	Mean	Std. Dev.	Std. Error	95 % Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0	325	8.84	2.642	.147	8.55	9.13	2	17
2 and 3	115	9.25	2.752	.257	8.74	9.76	3	17
4 and 5	36	10.92	2.729	.455	9.99	11.84	5	15
Total	476	9.10	2.725	.125	8.85	9.34	2	17

Test of homogeneity of variances show that it can be assumed that variances are homogenous in groups.

Table 5.44. Result of test of homogeneity of variances total score.

Levene Statistic	df1	df2	Sig.
.062	2	473	.940

Table 5.45. One way ANOVA results for grade groupings total score.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	142.925	2	71.463	9.984	.000
Within Groups	3385.434	473	7.157		
Total	3528.359	475			

ANOVA results show that with 95 % confidence, there is a significant difference between group means. In order to see the comparison between groups in terms of total score means Tukey's post hoc test was carried out. The result of Tukey's test was given below:

Table 5.46. Post Hoc Test results for grade groupings total score.

Tukey B ^{a,b}			
Groups	N	Subset for alpha = 0.05	
		1	2
0	325	8.84	
2 and 3	115	9.25	
4 and 5	36		10.92

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 75.853.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

From post hoc results, it can be said that fourth and fifth year students (seniors) performed significantly higher than second and third year students (sophomores and juniors), and those who did not claim number of years they spent at the university. On the other hand, there is no significant difference between second and third year students, and those who did not claim their years of study.

5.6.2. Differences Related to Departments

It can be speculated that the major that students are pursuing can be affective in shaping students' existing knowledge in statistics, habit of using statistics, and thinking with statistics which can also affect their statistical literacy as measured by SLS. That's why; examining differences between departments can be helpful.

Some departments provide curricula that include more courses with quantitative emphasis. Participants from these departments are expected to be more familiar with quantitative expressions. As explained before, the curricula implemented by each program was examined and depending on the emphasis given to natural sciences and mathematics courses the programs were categorized into three: quantitative, combined, and social sciences (see Table 5.18). Among 476 participants, 380 of them specified their department. Descriptive information about these 380 participants was given in the table below:

Table 5.47. Descriptive statistics for type of majors.

Total Scores								
Groups	N	Mean	Std. Dev.	Std. Error	95 % Confidence Interval for Mean		Min.	Max.
					Lower Bound	Upper Bound		
Social science majors	155	8.74	2.663	.214	8.31	9.16	3	15
Combined majors	64	8.94	2.569	.321	8.30	9.58	3	15
Quantitative majors	161	9.93	2.653	.209	9.52	10.34	4	17
Total	380	9.28	2.697	.138	9.00	9.55	3	17

Number of participants in each group is different. Test of homogeneity of variances show that there is not significant differences in variances in each group.

Table 5.48. Result of test of homogeneity of variances.

Total Score			
Levene Statistic	df1	df2	Sig.
.093	2	377	.912

Table 5.49. One way ANOVA results for type of majors total score.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	121.834	2	60.917	8.718	.000
Within Groups	2634.153	377	6.987		
Total	2755.987	379			

ANOVA results show that with 95 % confidence, there is a significant difference between group means. In order to see the comparison between groups in terms of total score means Tukey's post hoc test was carried out. The result of Tukey's test was given below:

Table 5.50. Result of post hoc test for type of majors total scores.

Tukey B			
Groups	N	Subset for alpha = 0.05	
		1	2
Social science majors	155	8.74	
Combined majors	64	8.94	
Quantitative majors	161		9.93

From post hoc results, it can be said that participants pursuing quantitative majors performed significantly higher than social science majors and combined majors. On the other hand, there is no significant difference between social science majors and combined majors. This result indicates that participants who are dealing with more quantitative subjects show higher scores of statistical literacy.

Comparisons related to departmental categories can be also informative. However, number of participants in each department is not sufficient to establish all departments as separate categories. Therefore, the comparisons were done between the programs which have more than 30 participants, which is the minimum number of participants necessary for making comparison analysis. Therefore, only FLED and MEDU departments were compared with each other. Descriptive information related to both departments was given below:

Table 5.51. Group statistics for MEDU and FLED.

	Department	N	Mean	Std. Dev.	Std. Error Mean
TOTAL	MEDU	37	10.09	2.153	0.354
	FLED	55	8.65	2.187	0.295

Table 5.52. Result of t- test for total score comparison for MEDU and FLED.

		Levene's Test for Equality of Variances		T- test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95 % Confidence Interval of the Difference	
									Lower	Upper
TOTAL	Equal variances assumed	0.34	0.56	3.11	90	0.002	1.44	0.4622	0.521	2.358
	Equal variances not assumed			3.12	78.2	0.002	1.44	0.4608	0.522	2.357

T- test result shows that with 95 % confidence, it can be said that there is a significant difference between group means. This difference is in favor of participants from MEDU department.

Moreover, total scores gained from SLS can be compared between faculties and schools that participants belong to. Descriptive information related to faculties and schools can be found in the table below:

Table 5.53. Descriptive information for faculties and schools total scores.

Faculty / School	N	Mean	Std. Dev.	Std. Error	95 % Confidence Interval for Mean		Min.	Max.
					Lower Bound	Upper Bound		
Engineering	43	10.67	2.990	.456	9.75	11.59	4	17
Arts and Sciences	132	8.86	2.763	.241	8.38	9.33	3	15
Education	128	9.24	2.423	.214	8.82	9.67	3	14
Applied Disciplines	39	8.33	2.609	.418	7.49	9.18	3	13
Economics and Administrative Sciences	38	10.24	2.318	.376	9.47	11.00	6	15
Total	380	9.28	2.697	.138	9.00	9.55	3	17

Number of participants in each group is different. Test of homogeneity of variances show that there is not significant differences in variances in each group.

Table 5.54. Result of test of homogeneity of variances.

Levene Statistic	df1	df2	Sig.
.952	4	375	.434

Table 5.55. One way ANOVA results for faculties and schools total score.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	177.253	4	44.313	6.444	.000
Within Groups	2578.734	375	6.877		
Total	2755.987	379			

ANOVA results show that with 95 % confidence, there is a significant difference between group means. In order to see the comparison between groups in terms of total score means Tukey's post hoc test was carried out. The result of Tukey's test was given below:

Table 5.56. Post Hoc test result for type of majors total scores.

Tukey B				
Faculty / School	N	Subset for alpha = 0.05		
		1	2	3
Applied Disciplines	39	8.33		
Arts and Sciences	132	8.86		
Education	128	9.24	9.24	
Economics and Administrative Sciences	38		10.24	10.24
Engineering	43			10.67

From post hoc results, it can be said that School of Applied Disciplines and Faculty of Arts and Sciences can be thought as a group, Faculty of Education and Faculty of Economics and Administrative Sciences can be thought as another group, and lastly Faculty of Engineering can be thought as a separate group. Moreover, there are significant differences in terms of SLS scores between groups. According to this grouping, it can be also said that participants from Faculty of Engineering performed significantly higher than participants from Faculty of Economics and Administrative Sciences and Faculty of Education. Moreover, participants from Faculty of Economics and Administrative Sciences and Faculty of Education performed significantly higher than Faculty of Arts and Sciences and School of Applied Disciplines.

In addition, it is also possible to interpret this result as if there are two groupings emerging from participants' scores. It is also possible to say that participants from faculty of engineering, and faculty of economics and administrative sciences performed significantly higher than faculty of arts and sciences, school of applied disciplines, and faculty of education. It is possible to say that there is not a significant difference between scores of participants from faculty of arts and sciences and school of applied disciplines in both interpretations.

5.6.3. Correlation between GPA and SLS scores

The relationship between participants' GPA and total scores gained from SLS can be questioned. Pearson product moment correlation was calculated with participants' scores gained from SLS and their GPA as measured in 410 participants who declared their GPA scores. The Pearson product moment correlation revealed as .166 with significance level of

.001. Hence, it can be said that although significant there is a weak correlation between GPA and SLS total scores of participants.

6. RESULTS

6.1. Evidence on Validity

In this section, findings gathered throughout the development process of the instrument will guide to infer about validity of the instrument. This section will try to answer the following research questions:

Main research question 1: Is this instrument valid for measuring statistical literacy for undergraduate students in a public university where the medium of instruction is English?

Sub question 1.1: Is the content of the instrument valid for measuring statistical literacy for undergraduate students in a public university where the medium of instruction is English?

Sub question 1.2: Is this instrument valid for measuring statistical literacy construct for undergraduate students in a public university where the medium of instruction is English?

6.1.1. Confirming Evidence of Content Validity

Content validity refers the systematic examination of the test content to determine whether it covers a representative sample of the behavior domain to be measured (Anastasi and Urbina, 1997). To start with, the cognitive engagements necessary for being statistically literate were clarified from the synthesis of literature. They constituted the behavior domain of statistical literacy. The cognitive engagements were knowing, interpretation, and critical interpretation. Knowing a definition of a statistics concept is not a useful skill in everyday life, but a prerequisite for interpreting statistical information encountered in everyday life, the weight of the instrument was given to interpretation and critical interpretation. This way, it was believed that the focus of the instrument was

zoomed out technical knowledge but focused on everyday life skills by not taking technical knowledge in the center of the study.

In addition to the cognitive levels, the statistics topics covered in the instrument are also an important dimension for content validity. To clarify the statistics topics in the instrument experts were recruited. Eleven scholars who taught statistics or research methods courses at the university in which this study was done responded to Content Rating Forms which was asking the necessity of statistics topics for helping undergraduate students to be statistically literate. Their answers were used in clarifying the content of SLS. Although some topics were eliminated from the content of SLS in revisions, it can be seen that scholars did not agree upon the necessity of these topics, expert ratings were partitioned to neither necessary nor unnecessary and essential categories. Moreover, all the statistics that experts agreed to be necessary were seen as included in the final instrument.

The match and dispersion between statistics topics included in the scale and the cognitive dimensions measured by the scale can be seen the test plan of SLS. The distribution of questions to the cognitive dimensions can be seen in the Appendix E and the intended measurement outcome for each question can be seen in Appendix F. These evidences can constitute confirming evidence regarding the sub question 1.1, about having content validity for this instrument.

In addition, the content covered in SLS is within the statistics topics covered in related assessment studies (see Appendix A, Table A.1). It can be observed that topics covered in SLS were within the range of the content covered in related assessment studies except the topic of “frequency”. Frequency was not included in previous assessment studies, adding the frequency topic to the range of statistics topics in an assessment study can be thought as a contribution of this study.

Moreover, statistics topics in SLS can be seen within the range of the content covered in statistical literacy instruction studies (Schild, 2003; Wilson, 1994) which can be seen in Appendix A, Table A.3. In addition to the instruction studies, important statistics as proposed by authors (see Appendix A, Table A.4.) can be a comparison for the suitability of the content of SLS. For example, among the topics Scheaffer, Watkins, and

Landwehr (1998, as cited in Gal, 2004) suggested that the following aspects of statistics were included in the SLS: interpreting tables and graphs, what constitutes a good sample, summarizing key features with summary statistics, confidence intervals, and hypothesis testing. Moreover, Garfield and Ben-Zvi (2005) suggested that topics about data, distribution, association, samples and sampling, and inference. Among the ideas that Utts (2003) suggested as necessary for every citizen the following ideas can be thought as covered in SLS: when it can be concluded that a relationship is a cause and effect type of relationship and when it is not, the difference between finding “no effect” or “no difference” and statistical significance of the findings, common sources of bias that can occur in surveys or experiments, confusion of statements with its inverse statements when talking about conditional events, understanding of the idea that variability is natural and “normal” is not the same as “average”. Lastly among Schield’s (1999) suggestions, distinguishing statements of association from statements of causation, and interpreting what a statistic means can be said to be included in SLS. As it can be compared with Appendix D, the ratio of topics included in SLS within statistical ideas that were seen as necessary by authors is high. Therefore, it can be said that SLS covers most of the statistical ideas that were seen as necessary by authors. This can be thought as a support for suitability of the content of SLS as a supporting the content validity of SLS.

6.1.2. Confirming Evidence of Construct Validity

Construct validity is an indispensable property of scales. There are two ways of understanding construct validity. One way of seeing validity is as proposed by Cronbach and Meehl in 1955. According to this understanding, construct validity is involved whenever a test is to be interpreted as a measure of some attribute or quality. Moreover, the possible validation procedures include correlation matrices and factor analysis and studies of internal structure. Studies of internal structure propose that situations represented by the specific items have the power to reflect general quality of the test.

Another understanding of construct validity was proposed by Messick (1989) as a unified construct validity framework. According to him the definition of validity was defined as (Messick, 1989):

“Validity is an integrated evaluative judgment of the degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness of inferences and actions based on test scores and other modes of assessment. (p.13)”

According to Messick (1995), validity becomes a unified concept where the unifying force is the meaningfulness or trustworthy interpretability of the test scores and their action implications, which can be understood as the construct validity. Messick (1995) also reveals that construct validity subsumes content relevance and representativeness because such information about the range and limits of content coverage and about specific criterion behaviors predicted by the test scores contributes to score interpretation. Moreover, to ensure validity it is necessary to come up with a compelling argument that the available evidence justifies the test interpretation and use. Hence, from this perspective it can be deduced that evidences for content validity and other evidences contribute to the construct validity.

Both perspectives of construct validity can be employed in analyzing construct validity of SLS. From Cronbach and Meehl’s perspective, correlation matrices and factor analysis were ways of examining construct validity. The factor analysis and related correlation matrices revealed that the construct measured in SLS cannot be divided into meaningful sub constructs. Even if the statistics topics were thought as the sub constructs of SLS, it could explain only the 23 % of scores (see Table 5.33, Table 5.34, and Table 5.35).

In addition to quantitative evidences gathered from factor analysis and correlation matrices qualitative evidences can also contribute to the exploration of construct of validity of SLS. For this purpose, expert ideas on items that are collected by Item Rating Form can be sources of examination of items. In Item Rating Form, experts were asked to voice their opinion on whether each question measures the intended outcome. In this form, experts were also asked whether each question should be included in the SLS. Only the questions, which experts stated that the questions do measure the intended outcome were included in the study. No item which experts suggested to be eliminated from the scale was included in the SLS. Similarly, no item that experts agreed that should stay in the scale was eliminated even after the revisions.

From another perspective of construct validity, Messick (1995) states that arguments about the content, cognitive dimensions, test scores, and interpretation of test scores should be given for assuring construct validity. Evidences of suitability of the content and cognitive dimensions for measuring statistical literacy of undergraduate students were stated under content validity. In addition to evidences supplied in content validity part, participants' reflections that were collected in researchers' journal about the content of the SLS can be another source of evidence.

For example, in the administration done in 16th of November, one participant stated that

“I exactly understood why we took statistics courses and learned statistics, the questions were related with daily life, and [the test] was fun.”

Moreover, for some instances participants stated that they could not have completed the test if they did not take statistics course before. These excerpts reveal that, SLS has close relationship both with daily life experiences and statistics instruction.

The instances provided signal that scores gained from SLS are aligned with year of study at university, dealing with quantitative information, and understanding statistics in daily life. These instances can be counted as confirming evidences of validity. Since the relationship between the content and items of the test, and the test itself, and the statistical literacy construct can be claimed as a strong relationship, these also strengthen the argument of construct validity of SLS.

6.1.3. Confirming Evidence of Curricular Validity

As supportive evidence for content related validity, curricular validity which is the extent to which the content of the test matches the objectives of a specific curriculum can be evaluated. The match between the content covered in statistics courses in a university (see Appendix A, Table A.5) and high school (9-12) mathematics and research methods curricula (see Appendix A, Table A.6) can be a way to examine curricular validity of SLS. To start with, the match between the content covered in SLS and the common topics in statistics course in a university as shown in Table 2.5 previously. From the table it was

shown that the following topics were mostly common in statistics courses offered by different departments: Data representation, descriptive statistics, basic probability, probability distributions, estimation, sampling, testing of hypothesis, hypothesis testing for two population parameters, correlation, correlation analysis, and regression. Among these common topics, the SLS can be claimed to cover all the topics except correlation analysis and regression. Since the correlation analysis was not done in everyday life circumstances and only interpretation of correlation was included in SLS, the exclusion of correlation analysis from the content of SLS can be acceptable. Moreover, referring to Şahin's (2011b) study about pre-service teachers' ideas on necessity of statistics topics for being statistically literate, regression can be thought as peripheral to the university students' everyday experiences. Therefore, it can be possible to state that excluding the topic regression from SLS can be legitimate, and a great deal of the common topics in statistics courses was included in SLS. Conversely, it can be also said that all the statistics content covered in SLS were included in the common topics in statistics courses offered at university. To sum, there is a significant match with the common statistics topics in university statistics courses which ensures curricular validity for the university level statistics curriculum.

To have an insight on participants' background, statistics topics in mathematics and related courses in grades 6-12 curricula were analyzed (see Appendix A, Table A.6). It can be seen that the content of 6-12 mathematics curricula was included in the content of SLS which cover the content measured in 12 of the 17 questions in SLS. The statistics topics that were included in SLS but not included in the grades 6-12 mathematics curricula are outliers, normal distribution, hypothesis testing, confidence intervals, and correlation. Since participants' knowledge on outliers were not directly checked using separate questions but checked indirectly with questions asking the change in mean and median in case of existence of outliers, it can be thought that participants can make educated guess for outliers by using their knowledge in median and mean. It can also be stated that many participants did not encounter normal distribution, hypothesis testing, confidence intervals, and correlation during their high school years. These topics were covered in statistics courses offered at university level. That's why, it is reasonable that some participants stated that they could not complete SLS, if they had not taken statistics course at the university. Conversely, there is no topic that was not covered in any statistics or related

course. Therefore, it can be said that SLS is valid for statistics curricula covered in high school and university.

6.1.4. Disconfirming Evidence of Validity

In addition to the confirming evidences related to validity, disconfirming evidences should also be mentioned. The disconfirming evidences can be related to the language and the content of SLS.

Some disconfirming evidences related to the language of SLS can be given. Some participants requested the test to be in Turkish. Those participants were usually from quantitative majors. As a more common reflection, in most administrations participants asked the meaning of the words, “bias” and some asked “rush”. Some declared that although they did not know the word itself, they could understand the meaning from the context. To have a general understanding about the effect of the language of the scale, the differences and correlations between Turkish and English versions of the scale will be informative. The results of paired sample t- test showed that there was a significant difference between total scores gained from English and Turkish versions of SLS in favor of Turkish version. However, it is not possible to differentiate the effect of language of SLS from other factors that may affect higher performance in the Turkish version of the SLS. For example, taking the SLS twice, familiarity with the questions, and completing a statistics course between the administrations of the two versions of SLS, losing some of the participants because of not being able to match their student ID information supplied in taking the two versions of SLS could have affected participants’ performance. All things considered, it can be said that taking the Turkish version of SLS can be advantageous for the participants’ performance.

Another issue about the validity of SLS can be related to the content of the scale. Some participants declared that they found the test partially hard, especially last questions in the instrument. As mentioned before, some of the participants also stated that they could not complete the test, if they had not taken statistics course before. This can be due to difference between taking or not taking any statistics course before and the content of the statistics course if taken. In many departments at the university statistics related courses are

compulsory and some of the undergraduate statistics courses and their content were given in the literature review part. However, as it was stated before, there are differences between even the common content of the statistics courses depending on the departments offering the courses. Therefore, it may be the case that some participants found the content related to both their life and statistics courses they took, but some found that content of some questions were related to the statistics courses they took but not to their life. That's why, it can be inferred that some topics in the test could be perceived as hard, only related to statistics courses but not related to everyday experiences for participants from different majors. Since there is variation between statistics courses and experiences of participants, it was not possible to come up with a statistical literacy instrument that includes statistics topics that are common for undergraduate students from all departments and is sufficient to measure statistical literacy at the same time.

6.2. Evidence about Reliability

Cronbach and Meehl (1955) stated that internal consistency is an important aspect of instruments and item-test correlations and certain reliability formulas are ways of obtaining evidence related to internal consistency.

6.2.1. Confirming Evidence of Reliability

To be informed about the reliability of the instrument, Cronbach's alpha coefficient was calculated from the scores taken from each administration. It was seen that the Cronbach's alpha coefficient was seen increased between first and second administrations. The reliability Cronbach alpha was calculated in .568 in the first administration and as .604 in the second administration. Moreover, for the second administration, Cronbach's alpha based on standardized items was revealed as .572. In the third administration, Cronbach's alpha was revealed as .532 and Cronbach's alpha based on standardized items were revealed as .531. According to Thorndike (2005), it is possible to appraise reliability comparing with other available instrument serving the same function.

Moreover, it is seen that the difference in Cronbach's alpha and Cronbach's alpha based on standardized items decreased and became insignificant through the third

administration. Since Cronbach's alpha based on standardized items was used when the scoring of the items are not equal, it can be thought that the scoring two items differently may not have affected the reliability of the SLS in the third administration phase.

6.2.2. Disconfirming Evidence of Reliability

Although the Cronbach alpha coefficient for the third administration was sufficient, a decrease in Cronbach alpha coefficient is seen between the second and third administrations. The reason for the decrease in this reliability coefficient can be because of having a more heterogeneous profile of participants in terms of having university students from different programs as participants.

Moreover, Cronbach's alpha based on standardized items is not high enough for many of the items. From this information, it can be said that many items had significant contributions to the reliability of SLS, but the contribution may not be aligned with other items.

7. LIMITATIONS

7.1. Limitations about Participants

The selection of participants depended on the courses they were taking. The courses were chosen depending on the year and department of the students taking the courses. Permission to announce the study was taken from the instructor of the course. The purpose of the study was explained to the students at the very beginning of the class time, and the students who volunteered to take the scale participated in the study. Therefore, the selection of the participants was not random. However, the number of the participants was kept as large as possible to avoid any bias or effect of possible extraneous variables. The sample size of the participants in administrations is even greater than the necessary sample size (423 or alternatively 257) deduced after computations.

Another limitation about the participants is the general academic proficiency of participants. The university chosen for conducting this study is a top-ranked university in Turkey. The students of this university performed high on the nationwide university entrance exams to be admitted to the university. Although participants were from different departments, it can be said that they all had already proven their ability in understanding a written text and test taking. When the instrument is to be delivered to students whose capabilities in understanding written texts and test taking, this can be a limitation.

7.2. Limitations about the Content

The statistics content of the SLS was determined by compiling the content of similar measurement studies from the literature, statistics courses in the particular university the study was carried on, and ideas of experts who work in statistics or probability. Although the statistics topics covered in similar studies in the literature is quite similar to each other, the contents of the statistics course are not the same for all the courses from different departments. Similarly, there is not unique and common statistics content among the universities in the country. Scholars working in different fields from different universities

in the country can have different ideas on the statistics topics necessary for being statistically literate undergraduate students. If different sample of experts were recruited, the necessary topics for being statistically literate undergraduate students could be modified.

Although there can be differences in experts' ideas, no group of experts is solely capable of exactly determining necessary statistics topics. The requirements of understanding statistics in everyday life are affected from the necessities of the society and related daily life experiences. Experts who responded SLCRF in this study were working at the same university with the participants. This similarity can be thought as an advantage in terms of knowing the necessity and capability of participants in terms of understanding statistics in everyday life situations which is a central aim of statistical literacy. For further studies done in different universities, although small, there can be variations in experts' ideas on the suitability of set of necessary topics for being statistically literate.

8. DISCUSSIONS

Based on the limitations and the context of the study, reasons, interpretations and implications of the results will be given in the discussion part. The discussions will be analyzed as discussions related to participants, the content coverage, the questions used, validity of SLS, and reliability of SLS.

8.1. Participants

Year of study of the participants were an important aspect of participant selection. Second, third, fourth, and fifth year students were included in the study. Preparatory class and first year students were excluded in this sampling since they may not be adapted to the university environment and their statistical literacy levels may not be representative for an average undergraduate student.

English level of participants is considered to be well enough to follow the courses in English. Students need to pass the English proficiency exam to enroll the courses. Therefore, participants are expected to be able to read and understand written English materials in a proficient way. Nevertheless, it can be speculated that participants who are pursuing in quantitatively concentrated majors focused on quantitative information in the questions rather than the narrations within the questions. Similarly, participants who are pursuing majors in social sciences or language related fields could focus on the narrations but missed out the terminology. Comparisons done with MEDU and FLED students showed that MEDU students performed higher than FLED students in the English version of SLS, in spite of the assumption that FLED students have higher proficiency in English. Such evidences can indicate that the requirement of language proficiency for answering SLS does not dominate the statistical literacy requirement for performance of SLS.

8.2. Content of SLS

The statistics topics covered in SLCRF was mostly compiled from previous instruments done about statistics education research. Scholars' comments during the formation of SLCRF suggested including the topic "frequency" to the form and it can be seen that it is the first time that this topic was given place in an instrument about statistical literacy.

Since statistical literacy was defined within everyday life context, it is necessary to think the relatedness of the content of SLS with everyday life. As it was seen at the test plan of SLS (see Appendix E), it can be said that most of the topics included in SLS can be encountered in everyday life situations. Nevertheless, some topics included are not frequently encountered in everyday life such as histograms, hypothesis testing, and confidence intervals. It is observed that in the Turkish context, line charts and bar charts are more frequently used than histograms in everyday life such as newspapers, and on television broadcasts.

Moreover, a study done by Şahin (2011b) can give insight to the relationship between everyday life experiences of undergraduate students and the content of SLS. In that study, Şahin asked the most necessary and least necessary statistics topics required for being statistically literate undergraduate students to senior pre-service teachers in a public university using the same SLCRF used in this study. The results of that study reveal that the least necessary topics for being statistically literate according to senior year pre-service teachers were listed as box plots, stem and leaf plots, outliers, extremes, quartiles, modeling, regression, hypothesis testing, confidence intervals, confidence levels, and margin of error. The case of pre-service teachers can be an example of the situation that some statistics topics can be covered in the statistics courses but are not a part of their everyday life experiences of undergraduate students. For example, Q15 in the third administration was about "confidence intervals" which was not seen as a necessary topic by participants. Moreover, the Cronbach alpha if item deleted coefficient was the highest among all questions in SLS. It can be said that since confidence intervals do not seem to be a part of everyday life experiences of undergraduate students, their performance on this question may be relatively poorer than other questions in SLS. Likewise, there was

discrepancy between pre-service teachers' and scholars' ideas about the necessity of some other topics for being statistically literate such as outliers, extremes, quartiles, hypothesis testing, confidence intervals, confidence levels, and margin of error. Among them, hypothesis testing and extremes were also included in SLS because answers of scholars who responded SLCRF in this study indicated that these topics should be included in SLS. It can be speculated that the conflict between undergraduate pre-service teachers and university scholars in terms of the statistics topics required for statistical literacy in Şahin's (2011b) study can be due to scholars' prescriptive attitude in responding SLCRF. Prescribing for what should be in terms of statistical literacy capacity was not the central aim for this study at the beginning of this study. However, it was seen that the high school curricula for mathematics and research methods courses were insufficient for enhancing statistical literacy for these grades and scholars who responded to SLCRF were motivated to provide information about what undergraduate students should know about statistics and probability. It turned out that the statistical literacy scale that is meant to be constructed for this study should also have prescriptive property in addition to descriptive property.

In 2011, the national high school mathematics curriculum in Turkey was revised and chapter on statistics was included in 11th grade rather than 10th grade as it was in the curriculum established in 2005. New topics were added to the unit on statistics and probability. These new topics are scatter plots, box plots, measures of central tendency (minimum, maximum, mean, median, mod, range), measures of dispersion (standard deviation), correlation, and z-scores (TMoE, 2011). Among these topics added to the topics covered in previous curriculum, the topics minimum, maximum, mean, median, mod, range, standard deviation, and correlation were seen necessary by the experts who responded to SLCRF employed in this study and covered in SLS. This fact makes the claim of the prescriptive property of SLS. Moreover, box plots were not seen as necessary neither by experts nor students who responded to SLCRF. It is expected that since box plots will be in students' academic life, later studies using SLCRF can conclude that box plots is a required topic for statistical literacy.

As a summary of evidences collected, it can be said that the SLS is both descriptive and prescriptive in nature in terms of the content coverage for statistical literacy. Other

properties like validity and reliability of SLS should be evaluated by taking into account prescriptive property.

8.3. Questions

The questions were multiple choice questions mostly compiled from other instruments. Version of the questions in other instruments mostly had selected response type of questions. The number of options in each question varied. Since participants were accustomed to taking test, it was easier for them if there were three or less options for a question. Therefore, the number of the options for each questions were tried to be kept at maximum. Moreover, participants' previous experiences in taking test having multiple choice questions can make guessing the keyed responses possible for them without knowing the correct answer. Hence, the number of options for each question was fixed not to give any clue of the keyed response to participants.

Another possible discussion on the question can be about the type of the questions. Select response type of questions were employed in the scale because this type of questions were mostly used in previous instruments, it was practical to administer and score select response type of questions especially for high number of participants. Hence, it can be said that using select response, namely multiple choice items were helpful in making the instrument more practical. The duration of the administrations was 15-20 minutes for 17 questions with the help of multiple choice questions. Some criticism of using multiple choice questions can be about decreasing the gap between interpretation and critical interpretation of statistical information giving in the question. Since possible interpretations and criticisms of interpretations were given in the options, a participant can select the keyed response for a question asking for interpretation by criticizing the interpretations given hence critically interpreting the information. Nevertheless, using multiple choice questions made it harder to classify the questions into interpretation and critical interpretation categories.

Compiling questions from different studies was considered advantageous in many cases. First of all, since the questions were tried out before, questions that may lead to problems have already been eliminated. Such questions were not frequently encountered.

Moreover, previous measurement studies reported results of administration of questions which made it possible for the researcher to identify questions working well while preparing the instrument in the first phase of the study. In addition to monitoring the quality of the questions, selecting among existing questions were advantageous in developing an instrument that is tailored to the desired construct. Since a special definition was used as the definition of statistical literacy for this study, questions that matched with this definition were selected. Therefore, choosing among existing questions and writing new questions when necessary was the strategy used in developing SLS. This way, it was possible to select the questions that are most relevant to the Turkish context.

On the other hand, selecting questions from previous instruments was disadvantageous in terms of language because there was no Turkish scale related to statistical literacy, all previous instruments were in English. Since some important nuances could be lost in translation, and participants were assumed to be proficient in English, it was preferred to use the questions in English in developing SLS. Since in Turkey, there are only few universities in which the medium of instruction is English, it was necessary to translate the instrument into Turkish to increase usability of the instrument in Turkish context SLS. Nevertheless, the instrument can be used in many other English speaking countries by making minor changes for cultural suitability.

8.4. Validity of SLS

Validity of the SLS was one of the central aims of this study. Construct validity, content validity, and curricular validity of SLS were examined.

Construct validity of SLS was explored from both Cronbach and Meehl's and Messick's perspectives. From both perspectives, evidences show that SLS has construct validity, content validity, and curricular validity for the undergraduate students in the given public university.

The analyses were carried out using CTT. Item Response Theory (IRT, see Baker, 2001) could also be used. In making the decision of using CTT or IRT, the nature of the construct was taken into account. At the initial preparation stage of SLS, it was foreseen

that there may be overlaps between statistical literacy, statistical reasoning, and statistical thinking as it was proposed by delMas (2002). However, IRT assumes that the construct to be measured should be uni-dimensional, i.e. consists of only one dimension. That's why, IRT was not used in exploring validity evidences for SLS. As it was calculated by factor analysis, after the third administration SLS turned out to be an instrument measuring a single dimension which is statistical literacy which paves the way for examining SLS using IRT for making shorter, tailor made versions of SLS for different purposes.

8.5. Reliability of SLS

The reliability of SLS turned out to be moderate. As it was stated before, for evaluating the reliability of an instrument, the reliability of existing instruments should be considered. Since, there was no other instrument measuring statistical literacy for undergraduate students in Turkey, the reliability of SLS can be suggested as acceptable. The reliability of SLS could be affected from the participants' language levels and experience with statistics. The reliability of SLS when it is administered to groups whose levels of statistics are different and who were given SLS in Turkish can be compared with the reliability of SLS as reported in this study.

It can be also said that the prescriptive nature of SLS was reflected in the reliability of the scale. For example, SLS covers content that may or may not have been covered in statistics courses such as confidence intervals, which is not among the common statistics topics covered in statistics courses in a public university as indicated Table 2.5. In addition to the content, it can be said that statistical literacy is not among the aims of statistics instruction. Therefore, participants answers can vary due to content coverage of the statistics courses they took or how much attention was given to interpretation of statistical information during the courses they took. Participants may not have given consistent answers throughout responding to the scale which may affected the reliability of SLS.

9. FURTHER RESEARCH

Results gained from this study indicate possible suggestions for further research. Measuring statistical literacy of undergraduate students was the aim of this study. The instrument developed for this study is expected to pave the way to many research studies about statistical literacy of undergraduate students.

First suggestion for further research can be administering the Turkish version of SLS to larger groups of undergraduate students. By monitoring the properties of the scale like validity, reliability, and practicality of the Turkish version of SLS will prepare the instrument to be used effectively and efficiently with a larger sample of undergraduate participants around Turkey.

Exploring for evidences of validity, such as criterion related validity can be possible for further studies. For example, comparing participants' scores from SLS with scores taken from statistics achievement instruments can be informative about criterion related validity of SLS. Moreover, it can be possible to monitor the effects of statistics instruction to statistical literacy levels of students. Scores gained from statistics courses can be compared with statistical literacy scores and the aims and effectiveness of statistics instruction in enhancing statistical literacy of undergraduate students can be questioned in detail.

Comparisons between statistical literacy performances of different groups can be also done such as comparing graduate students and undergraduates. With such comparisons, it can be possible to track the sort of experiences that can contribute to the enhancement of statistical literacy.

APPENDIX A: STATISTICS TOPICS IN RELATED STUDIES

Table A.1. Compilation of statistics topics in related assessment studies.

Artist Topic Scales (Garfield, delMas, and Chance, 2006)	CAOS (delMas, Garfield, Ooms, and Chance, 2006; delMas, Garfield, Ooms, and Chance, 2007)	SLAS (Schild,2008)	Test of Statistical Literacy (Wilson, 1994)	SCI (Allen, 2006)	SRA (Garfield, 2003) and QRQ (Sundre, 2003)
Data Collection Data Representation Measures of Center Measures of Spread Normal Distribution Probability Bivariate Quantitative Data Bivariate Categorical Data Sampling Distributions Confidence Intervals Significance Tests Type of variables Skewness Inter Quartile range	Data Collection and Design Descriptive Statistics Graphical Representations Boxplots Normal Distribution Bivariate Data Probability Sampling Variability Confidence Intervals Tests Of Significance	Bar charts Pie charts Correlation Conditional thinking Number sense Study design Bias Test of significance	Normal distribution Histogram Box plot Bar charts Correlation Median Mean Mode Probability (Dependent and independent events ; Interpretation of results) Stem and leaf plot Type of variables Correlation	Conditional probability Significance Tests Data collection Measures of spread Histogram Stem and Leaf Plot Median Outliers Measures of Center Confidence intervals Normal distribution p-values Correlation Sampling Distributions Sampling	Probability Independence Sampling variability Correlation Data representation Sampling

Table A2. Comparison of statistics topics in related assessment studies.

Subjects/ Tests	Artist Topic Scales (Garfield, delMas, and Chance, 2006)	CAOS (delMas, Garfield, Ooms, and Chance, 2006; delMas, Garfield, Ooms, and Chance, 2007)	SLAS (Schield,2008)	Test of Statistical Literacy (Wilson, 1994)
Data representation	*		*	*
Data collection	*		*	
Sampling variability	*	*		
Normal distribution	*			*
Confidence intervals	*	*		
Test of Significance	*	*	*	
Histogram	*	*		*
Box plot	*	*		*
Bar chart	*	*	*	*
Pie chart	*		*	
Stem and leaf plot				*
Randomization	*	*		
Correlation	*	*	*	*
Interpreting data		*		
Conditional thinking		*	*	
Regression	*	*		
Number sense			*	
Study design	*		*	
Bias			*	
Mean	*			*
Median	*			*
Mode	*			*
Inter quartile range	*			
Probability	*			*
Type of variables	*			*
Skewness	*			

Table A.3. Statistics topics in related instruction studies.

“Statistical Literacy” (Schield, 2003)	“A Brief Course in Statistical Literacy” Wilson (1994)	Numbers in Everyday Life (Hahn, Doganaksoy, Lewis, Oppenlander, Schmee, 2010)
Statistical literacy and critical thinking Reasoning with statistics Describing rates and percents Comparing count based data Confounding and standardizing Interpreting measurements Chance and probability Discrete random variables Estimation and statistical significance	What is statistics? Picturing data displays Describing distributions Normal distributions Normal calculations Models for growth Describing relationships Confidence intervals Significance tests	Some examples and basic concepts Public opinion polls and election forecasts Health studies Business and industrial applications Further examples and wrap-up

Table A.4. Important topics in statistics as proposed by authors.

Scheaffer, Watkins, and Landwehr (1998, as cited in Gal, 2004)	Garfield and Ben-Zvi (2005)	Utts (2003)	Schiold (1999)	Schiold (1999)
<p>Number sense Understanding variables Interpreting tables and graphs Aspect of planning a survey or experiment (what constitutes a good sample, methods of data collection, and questionnaire design) Data analysis processes (detecting patterns in univariate, two-way frequency data, summarizing key features with summary statistics) Relationships between probability and statistics, (determining characteristics of random samples) Background for significance testing (confidence intervals, hypothesis testing)</p>	<p>Data Distribution Trend Variability Models Association Samples and sampling Inference</p>	<p>1. When it can be concluded that a relationship is a cause and effect type of relationship and when it is not 2. The difference between statistical significance and practical importance 3. The difference between finding “no effect” or “no difference” and statistical significance of the findings 4. Common sources of bias that can occur in surveys or experiments 5. Coincidences and improbable events are not uncommon 6. Confusion of statements with its inverse statements when talking about conditional events 7. Understanding of the idea that variability is natural and “normal” is not the same as “average”</p>	<p>Association versus causation Sample versus population The quality of the test versus the power of the test.</p>	<p>1. Distinguish statements of association from statements of causation 2. Distinguish a sample statistic from a population parameter 3. Distinguish between the target population and the sampled population 4. Distinguish between the quality of a test from the predictive power of a test 5. Interpret what a statistic means 6. Distinguish an observational study from an experiment 7. Know the various sources of problems in interpreting a measurement or an association 8. Ask the following questions: Is this statistic true? Is this statistic representative? Is this association spurious?</p>

Table A.5. Content of statistics courses in a university.

Topic	Department				
	EC	CE	INTT	ME	MATH
Introduction and data collection	*		*		
Presenting data in tables and charts	*		*		*
Numerical descriptive measures	*	*	*		*
Sets, events		*			
Random variables		*		*	
Basic probability	*		*		*
Probability		*		*	
Probability distributions			*	*	
Discrete distributions	*	*	*	*	*
Continuous distributions	*	*	*	*	
The normal distribution	*				*
Sampling	*			*	*
Sampling distributions	*		*		
Confidence intervals	*				
Elementary concepts in hypothesis testing, review	*				
Testing of hypothesis		*	*	*	*
z- test, t- test, chi square -test					*
Analysis of variance			*	*	
Mathematical expectation		*		*	*
Correlation analysis		*	*		*
Correlation				*	*
Poisson process		*			
Introduction to reliability theory and failure		*			
Functions of random variables		*			
Introduction to estimation theory		*			
Estimation			*	*	*
Estimating single population parameters			*		
Estimation for population variances			*		
Introduction to linear regression			*		*
Regression					*
Simple regression		*		*	
Multiple regression		*	*		
The r.m.s. error for regression					*
Least squares		*			
Statistics of extreme events		*			
Model building			*		
Goodness of fit tests			*		
Contingency analysis			*		
Measurement error, Standard error					*
Chance errors in sampling					*
The accuracy of percentages and averages					*
The binomial formula					*
The law of averages					*
The normal approximation for data and probability histograms					*
Chance models in genetics					*
Civil engineering applications		*			

Table A.6. Statistics topics in related curricula in Turkey.

6-8 Curriculum (TMoE, 2009)	10 th Grade Curriculum (TMoE, 2005)	Elective Research Methods Courses for 10 th Grades (TMoE, 2010)	Common Statistics Courses in a Public University
Permutation Combination Experiment result Sample Random sampling Equal probability Probability of an event Joint and disjoint events Dependent and independent events Probability calculation of an event Experimental and theoretical probability Subjective probability Research question Suitable sampling Data collection Data representation Bar graphs Line charts Pie chart Pictorial graphs Histograms Data interpretation Mean Range Median Maximum Quartile ranks Standard deviation	Experiment result Sample Event Equal probability Joint and disjoint events Dependent and independent events Impossible event Certain events Probability calculation of an event Conditional probability	The need and importance of research Research problem Review of sources Hypothesis Aim and scope Significance Assumptions of research Limitations Definitions Method of research Sample and universe Sampling methods Data analysis and interpretation Findings and conclusion Parts of research reports Important points in writing research reports	Data representation Descriptive statistics Basic probability Probability distributions Estimation Sampling Testing Of Hypothesis Hypothesis testing for two population parameters Correlation Correlation analysis Regression

APPENDIX B: STATISTICAL LITERACY CONTENT RATING FORM

Değerli hocalarım,

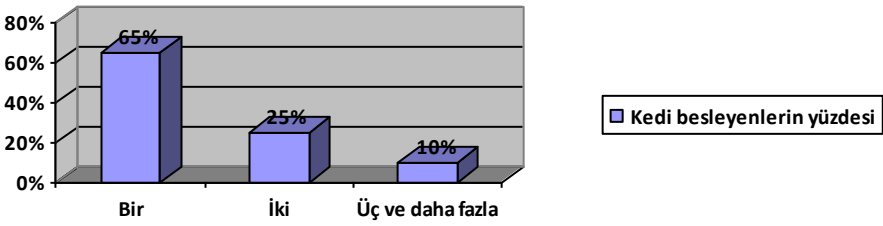
İstatistik okuryazarlığını ölçmek amacıyla bir master tezi çalışması yürütmekteyim. Okur yazarlık kapsamına girecek istatistik konularını belirlemede siz değerli hocalarımın bilgisine ve görüşüne ihtiyaç duyuyorum. Lisans öğrencilerinizi düşündüğünüzde istatistik okur yazarı olan bir öğrencinin , **günlük hayatında** verilen veriyi veya istatistiksel sonucu **anlayabilmesi, yorumlayabilmesi** ve verilen bir yorumla bu yorumun dayandığı veri veya istatistiksel sonuç arasındaki bağı **sorgulayabilmesi** beklenmektedir.

Aşağıda üç örnek verilmekte ve kontrol listesinden seçme yapmanız istenmektedir. Bu metin de dahil toplam 7 dakikada okuyup cevaplayarak yapacağınız katkı için şimdiden teşekkürlerimi sunarım.

Arş. Gör. Fusun Şahin

Fen Bilimleri Enstitüsü Yüksek Lisans Öğrencisi

Örnek 1: Verilen veriyi **anlama** becerisi

Uyaran	 <p style="text-align: center;">Katılımcıların yüzde kaçını iki veya daha fazla kedi beslemektedir?</p>	
	İstatistik okur-yazarı olan	İstatistik okur-yazarı olmayan
Tepki	% 35	<ul style="list-style-type: none"> • Kesin olarak bilemeyiz • % 10

Örnek 2: Verilen istatistiksel bilgiyi **yorumlama** becerisi

Uyaran	Ali ve Veli geçen 100 hafta boyunca birer piyango bileti aldılar. Ali şimdiye kadar hiç kazanmamış fakat Veli geçen hafta 20 lira kazandı. Bu hafta da ikisi birer bilet alacak. Sizce bu hafta kim ikramiye kazanabilir?	
	İstatistik okur-yazarı olan	İstatistik okur-yazarı olmayan
Tepki	İkisinin de eşit kazanma şansı vardır.	<ul style="list-style-type: none"> • Veli daha şanslıdır, bence Veli kazanır. • Veli geçen hafta kazandığı için bu hafta Ali'nin kazanma ihtimali daha yüksektir.

Örnek 3: Verilen yorum ile istatistiksel bilgi bağıni **sorgulama** becerisi

Uyaran	Çok sayıda öğrenci arasından rastgele seçilen bir gruba yemek masrafları için haftada ne kadar para harcadıklarını soran bir anket uygulanmıştır. Veriler incelendiğinde medyan değeri 30 lira olarak çıkmıştır. Medyan değerinden yola çıkılarak öğrencilerin çoğunun yemek masrafları için 30 lira harcadığı söylenebilir mi?	
	İstatistik okur-yazarı olan	İstatistik okur-yazarı olmayan
Tepki	<ul style="list-style-type: none"> • Söylenemez, medyan değeri grubun %50sinin 30 liradan çok ve diğer %50sinin de 30 liradan az harcadığını gösterir. 	<ul style="list-style-type: none"> • Söylenbilir, medyan değeri ortalama bir değerdir, ortalama değerden bu çıkarılabilir. • Söylenemez, öğrencilerin çoğu 30 liradan fazla harcamaktadır.

Aşağıdaki tabloda istatistik konuları verilmiştir. Çalışma İngilizce yürütüldüğü için konu adları İngilizce olarak verilmiştir. Bu konulardan bir istatistik ölçeğinde bulunmasını gerekli gördüklerinizi lütfen işaretler misiniz?

Checklist for Required Topics in Statistical Literacy

Statistics Content	Necessity		
	Not necessary	Neither necessary nor unnecessary	Essential
Study designs (observational, experimental)			
Hidden variables			
Random sample			
Bias in sampling			
Randomization			
Dependent and independent events			
Probability of events			
Conditional probability			
Estimation			
Types of variables			
Levels of measurement			
Line charts			
Pie charts			
Pictorial graphs			
Bar charts			
Histograms			
Box plots			
Stem and leaf plots			
Frequency			
Mean (sample mean/ population mean)			
Median			
Maximum			
Outlier			
Extremes			
Quartiles			
Standard deviation			
Probability distribution			
Normal distribution			
Modeling			
Regression			
Hypothesis testing			
Correlation			
Confidence intervals			
Confidence levels			
Margin of error			

APPENDIX C: EXPERTS' ANSWERS TO CONTENT RATING FORM

Table C.1. Experts' answers to content rating form.

Statistics Content	Necessity		
	Not necessary	Neither necessary nor unnecessary	Essential
Study designs (observational, experimental)	xx	xxxx	xxxxx
Hidden variables	xxxx	xxx	xxxx
Random sample		xxx	xxxxxxxx
Bias in sampling		xxxxx	xxxxxx
Randomization	x	xxx	xxxxxxxx
Dependent and independent events		xx	xxxxxxxxxx
Probability of events		x	xxxxxxxxxx
Conditional probability		xxxxx	xxxxxx
Estimation	xx	xx	xxxxxx
Types of variables		x	xxxxxxxxxx
Levels of measurement		x	xxxxxxxxxx
Line charts		Xxx	xxxxxxxx
Pie charts		Xxx	xxxxxxxx
Pictorial graphs		Xxxx	xxxxxx
Bar charts		Xxx	xxxxxxxx
Histograms		Xx	xxxxxxxx
Box plots	x	Xxxxxx	xxxx
Stem and leaf plots	xx	Xxxx	xxxxx
Frequency			xxxxxxxxxx
Mean (sample mean/ population mean)			xxxxxxxxxx
Median			xxxxxxxxxx
Maximum		Xxx	xxxxxx
Outlier		Xxx	xxxxxx
Extremes	x	Xxx	xxxxxx
Quartiles		Xxx	xxxxxx
Standard deviation		X	xxxxxxxxxx
Probability distribution		Xxxx	xxxxxx
Normal distribution	x	Xx	xxxxxx
Modeling	xxx	Xxxxx	xxx
Regression	xxx	Xxxxx	xxx
Hypothesis testing		Xx	xxxxxxxx
Correlation	xxx		xxxxxx
Confidence intervals	xx	Xxx	xxxxxx
Confidence levels	xx	Xxx	xxxxxx
Margin of error	xx	Xx	xxxxxx

APPENDIX D: FINAL TEST PLAN

Table D.1. Final test plan.

Content	Cognitive Level		
	Knowledge	Interpretation	Critical interpretation
Random sample, Bias in sampling, Randomization		1-(SCI27)	
Dependent and independent events		2- (TR5a, TR5b)	
Probability of events, Expectation		1 (QRQ2)	
Conditional probability			1 (SLS5)
Histograms			1 (SCI 28)
Frequency		1 (SLS6)	
Mean (sample mean/ population mean, outlier)		1 (A_MC 1)	1 (QRQ/SRA 1)
Median, Maximum, Outlier, Extremes			2 (A_MC 5, A_MC 6)
Standard deviation			1 (SCI 26)
Normal distribution			1 (A_ND 6)
Hypothesis testing		1 (CAOS 23)	
Confidence levels			2 (CAOS 29, CAOS 31)
Correlation			1 (CAOS 22)
Total		7	10

Note: The abbreviations stand for the questions in different instruments with the question number in instruments: SCI: Statistics Concept Inventory, TR: Test of Representativeness, QRQ: Quantitative Reasoning Quotient, SLS: Statistical Literacy Scale, SCI: Statistics Concept Inventory, A_MC: ARTIST Measures of Center, A_ND: ARTIST Normal Distribution, CAOS: Comprehensive Assessment of Outcomes for a first course in Statistics.

APPENDIX E: DETAILED TEST PLAN FOR SLS

Table E.1. Detailed test plan for SLS.

Item	Question	Content	Cognitive Level Measured		
			Knowledge	Interpretation	Critical interpretation
1	1-(SCI27)	Random sample, Bias in sampling, Randomization		X	
2	1-(TR5a)	Dependent and independent events		XX	
3	1-(TR5b)				
4	1 (QRQ2)	Probability of events, Expectation		X	
5	1 (SLS5)	Conditional probability			X
6	1 (SCI 28)	Histograms			X
7	1 (SLS6)	Frequency		X	
8	1 (A_MC 1)	Mean (sample mean/ population mean, outlier)		X	X
9	1 (QRQ/SRA 1)				
10	A (MC 5)	Median, Maximum, Outlier, Extremes			XX
11	A (MC 6)				
12	1 (SCI 26)	Standard deviation			X
13	1 (A_ND 6)	Normal distribution			X
14	1 (CAOS 23)	Hypothesis testing		X	
15	1 (CAOS 29)	Confidence levels, Confidence intervals			XX
16	1 (CAOS 31)				
17	1 (CAOS 22)	Correlation			X

Note: The abbreviations stand for the questions in different instruments with the question number in instruments: SCI: Statistics Concept Inventory, TR: Test of Representativeness, QRQ: Quantitative Reasoning Quotient, SLS: Statistical Literacy Scale, SCI: Statistics Concept Inventory, A_MC: ARTIST Measures of Center, A_ND: ARTIST Normal Distribution, CAOS: Comprehensive Assessment of Outcomes for a first course in Statistics.

APPENDIX F: STATISTICAL LITERACY SCALE- ENGLISH
VERSION¹

Student number (as a nickname)*:

GPA*:

Exchange student*: No / Yes

Department and Grade*:

*:Don't hesitate to write your information. This information will only be used for gathering demographic data about the participants. They are all confidential and will not be shared. Every question has only one true answer. If you don't know answer of a question, please leave it blank.

1. In order to determine the mean height of Boğaziçi University students, which sampling method would not introduce bias?

- a) You randomly select from the university basketball team.
- b) You use a random number table to select students based on their student ID.
- c) You roll a pair of dice to select from among your friends.
- d) None of the methods above will have bias.

2-3. A bag has 9 pieces of fruit: 3 apples, 3 pears, and 3 oranges. Four pieces of fruit are picked, one at a time. Each time a piece of fruit is picked, the type of fruit is recorded, and it is then put back in the bag.

2. If the first 3 pieces of fruit were apples, what is the fourth piece MOST LIKELY to be?

- a) A pear
- b) An apple
- c) An orange or a pear are both equally likely and more likely than an apple.
- d) An apple, orange, or pear are all equally likely.

3. Which of the following best describes the reason for your answer to the preceding question?

- a) This piece of fruit is just as likely as any other.
- b) The apples seem to be lucky.
- c) The picks are independent, so each fruit has an equally likely chance of being picked.
- d) The fourth piece of fruit won't be an apple because too many have already been picked.

¹ Some questions were erased because of copyright issues.

4. The following message is printed on a bottle of prescription medication:

WARNING: For application to skin areas there is a 15% chance of developing a rash. If a rash develops, consult your physician.

Which of the following is the best interpretation of this warning?

- a) Don't use the medication on your skin- there's a good chance of developing a rash.
- b) For application to the skin, apply only 15% of the recommended dose.
- c) If a rash develops, it will probably involve only 15% of the skin.
- d) About 15 of 100 people who use this medication develop a rash.

5. Here, information about musicians in a flute concert is given in the table below. Which of the following situations is more probable?

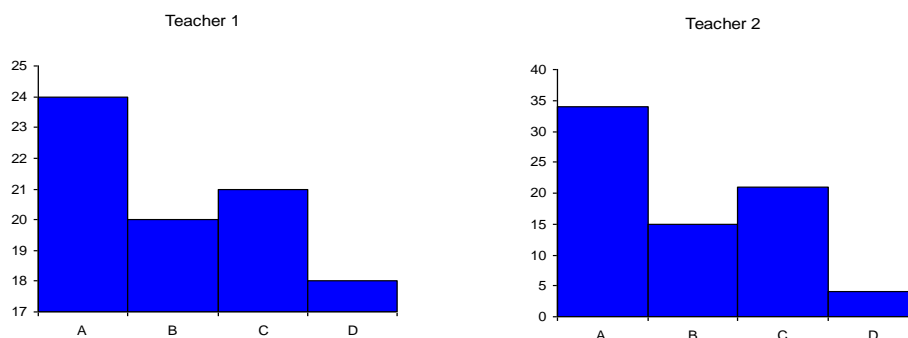
		Classical Music Player	
		Yes	No
Flutist	Yes	15	5
	No	10	8

- a) a flutist who plays classical music
- b) a musician who plays classical music and who is not a flutist
- c) a flutist who does not perform classical music
- d) a flutist among classical music players

6. In a sports center, the owner wants to throw away a machine in order to create some more space in the center without decreasing the member's interest and experience. He should choose the one that

- a) is used the least.
- b) enhances calorie loss.
- c) is the biggest in size.
- d) body builders don't use.

7. The following histograms show the number of students receiving each letter grade for two separate physics teachers. Which conclusion about the grades is valid?



- a) Teacher 1 gave more B's and C's but approximately the same number of A's and D's as Teacher 2
 b) Teacher 2 gave more A's and fewer D's than Teacher 1
 c) Teacher 2 gave more B's and C's than Teacher 1
 d) The overall grade distribution for the two Teachers is approximately equal

9. Nine students in a science class separately weighed a small object on the same scale. The weights (in grams) recorded by each student are shown below.

6.2 6.0 6.0 15.3 6.1 6.3 6.2 6.329 6.2

The students want to determine as accurately as they can the actual weight of this object. Of the following methods, which would you recommend they use?

- a) Use the most common number, which is 6.2.
 b) Use the 6.329 since it includes more decimal places.
 c) Add up the 9 numbers and divide by 9
 d) Throw out the 15.3, add up the other 8 numbers and divide by 8.

10-11. Students taking statistics course conducted a survey on how students spend their money. They collected data from a large randomly selected sample. They asked how much money they spent each week for food. The results are: mean = \$31.52; median = \$30.00; standard deviation = \$21.60; range = \$132.50.

10. A student states that the median food cost tells you that a majority of students in this sample spend about \$30 each week on food. How do you respond?

- a) Agree, the median is an average and that is what an average tells you.
- b) Agree, \$30 is representative of the data.
- c) Disagree, a majority of students spend more than \$30.
- d) Disagree, the median tells you only that 50% of the sample spent less than \$30 and 50% of the sample spent more.

11. The class determined that a mistake had been made and a value entered as 138 should have been entered as 38. They recalculate all of the statistics. Which of the following would be true?

- a) The value of the median decreases, the value of the mean stays the same.
- b) The values of the median and mean both decrease.
- c) The value of the median stays the same, the value of the mean decreases.
- d) The values of the median and mean both stay the same.

12. You have a set of 30 numbers. The standard deviation from these numbers is reported as zero. You can be certain that:

- a) Half of the numbers are above the mean.
- b) All of the numbers in the set are zero.
- c) All of the numbers in the set are equal.
- d) The numbers are evenly spaced on both sides of the mean.

APPENDIX G: İSTATİSTİK OKURYAZARLIĞI ÖLÇEĞİ- TÜRKÇE ÇEVİRİSİ²

Öğrenci numarası (Rumuz olarak):

Değişim öğrencisi: Evet /

Hayır

Bölüm ve Sınıf:

GNO:

Yukarıdaki bilgiler katılımcılar hakkında bilgi toplamak amaçlıdır. Gizli kalacak ve paylaşılmayacaktır. Soruların sadece bir doğru cevabı vardır. Eğer cevabı bilmiyorsanız soruyu boş bırakınız.

1. Bir üniversitede öğrenim gören öğrencilerin ortalama boyunu bulmak için kullanılacak örnekleme yöntemlerinden hangisi yanlılık oluşturmaz?

- a) Üniversitenin basketbol takımından rassal örnekleme yoluyla seçmek
- b) Öğrencilerin öğrenci numaraları içinden rassal sayılar tablosu kullanarak seçmek
- c) Üniversite öğrencisi arkadaşlarınız arasından bir çift zar atarak seçmek
- d) Yukarıdaki hiçbir yöntem yanlılık oluşturmaz.

2-3. Bir torbanın içinde 3ü elma, 3ü armut, 3ü de portakal olmak üzere 9 adet meyve vardır. Her seferinde **bir tane** olmak üzere dört meyve seçilecektir. Her meyve seçildiğinde meyvenin cinsi kaydedilmekte ve tekrar torbaya atılmaktadır.

2. Eğer ilk 3 meyve elma ise, dördüncü meyve **en çok** hangisi olabilir?

- a) Armut
- b) Elma
- c) Portakal ve armut aynı ve elmadan daha yüksek bir olasılıkla
- d) Elma, portakal veya armut eşit olasılıkla

3. Aşağıdakilerden hangisi önceki soruya verdiğiniz cevabın nedenini en iyi anlatır?

- a) Bu meyve de diğerleriyle aynı derecede olasıdır.
- b) Elmalar daha şanslı görünüyor.
- c) Her seçim bağımsızdır, bu yüzden her meyvenin seçilme şansı eşittir.
- d) Dördüncü meyve elma alamaz çünkü yeterince elma zaten çekilmiştir.

² Some questions were erased because of copyright issues.

4. Reçeteli bir ilacın şişesinde aşağıdaki uyarı bulunmaktadır:

UYARI: Cilde uygulandığında % 15 olasılıkla kızarıklık yapma ihtimali vardır. Eğer kızarıklık oluşursa, doktorunuza

Aşağıdakilerden hangisi bu uyarının en iyi yorumudur?

- e) Bu ürünü kullanmayın, kızarıklık oluşma ihtimali oldukça yüksektir.
- f) Cilde uygulandığında önerilen dozun sadece %15'ini kullanın.
- g) Eğer kızarıklık oluşursa, muhtemelen cildin sadece %15'inde oluşur.
- h) Bu ilacı kullanan her 100 kişiden yaklaşık 15'inde kızarıklık oluşur.

5. Aşağıdaki tabloda bir flüt konserindeki müzisyenler hakkında bilgi verilmiştir. Hangi durum daha olasıdır?

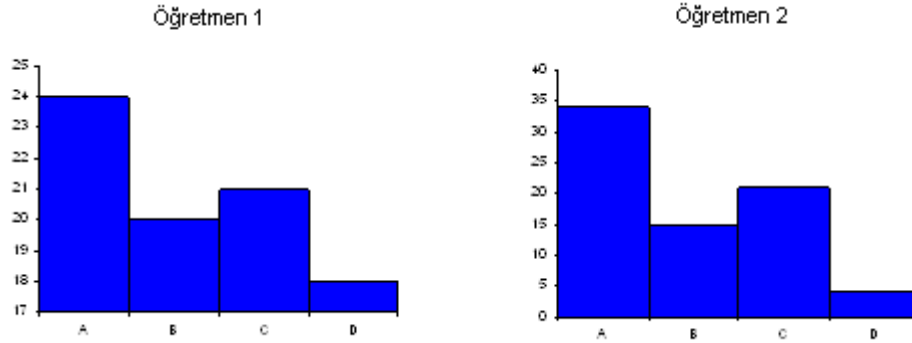
		Klasik Müzik Çalanlar	
		Evet	Hayır
Flütçüler	Evet	15	5
	Hayır	10	8

- e) klasik müzik çalan bir flütçü
- f) klasik müzik çalan ve flütçü olmayan bir müzisyen
- g) klasik müzik çalmayan bir flütçü
- h) klasik müzik çalanlar arasından bir flütçü

6. Bir spor merkezinde, merkezin sahibi üyelerin ilgisini ve çalışmalarını azaltmadan bir aleti atarak yer kazanmak istiyor. Hangi aleti atmalıdır?

- a) en az kullanılan
- b) kalori kaybını kolaylaştıran
- c) en büyük olan
- d) vücut geliştirenlerin kullanmadığı

7. Aşağıdaki histogramlar farklı iki fizik öğretmenin derslerinden alınan notları göstermektedir. Bu notlar hakkında yapılan çıkarımlardan hangisi geçerlidir?



1. öğretmen, 2. öğretmenden daha çok B ve C vermiş olup neredeyse 2. öğretmenle aynı sayıda A ve D vermiştir.
2. öğretmen 1. öğretmenden daha çok A ve daha az D vermiştir.
2. öğretmen 1. öğretmenden daha çok B ve C vermiştir.
- Her iki öğretmenin de not dağılımı yaklaşık olarak aynıdır.

9. Bir fen sınıfındaki dokuz öğrenci küçük bir cismin ağırlığını ayrı ayrı tartmaktadır. Ulaştıkları ağırlıklar gram cinsinden aşağıda belirtilmiştir.

6,2 6,0 6,0 15,3 6,1 6,3 6,2 6,329 6,2

Öğrenciler bu cismin ağırlığını olabildiğince doğru şekilde belirlemek istiyorlar. Aşağıdaki yöntemlerden hangisini kullanmalarını önerirsiniz?

- En sık karşılaşılan sayı olan 6,2'i kullansınlar.
- 6,329'u kullansınlar çünkü daha çok ondalık basamak içerir.
- 9 sayıyı da toplayıp 9'a bölsünler.
- 15,3'ü atıp, kalan 8 sayıyı toplayıp 8'e bölsünler.

10-11. İstatistik dersi alan öğrenciler, öğrencilerin paralarını nasıl harcadığıyla ilgili bir anket uyguluyorlar. Rassal olarak seçilmiş geniş bir örneklemden veri toplayıp yemek masraflarına haftalık ne kadar harcadıklarını soruyorlar. Sonuçlar: ortalama=31,52 TL; medyan= 30,00 TL; standart sapma =21,60 TL; açıklık=132,50 TL.

10. Bir öğrenci, yemek masrafının medyanının bu örneklemdeki öğrencilerin çoğunun yemek için haftalık 30 TL harcadığını söylediğini belirtiyor. Siz nasıl yanıtlarsınız?

- a) Katılıyorum, medyan ortalamadır ve söylediği ortalamadan çıkar.
- b) Katılıyorum, 30 TL veriyi temsil eder.
- c) Katılmıyorum, öğrencilerin çoğunluğu 30 TL'den daha fazla harcıyor.
- d) Katılmıyorum, medyan sadece örneklemin %50sinin 30 TL'den az ve %50 sinin de az harcadığını söyler.

11. Öğrenciler bir yanlışlık yapıp 138 olarak girmeleri gereken bir değeri yanlışlıkla 38 olarak girdiklerini fark ediyorlar. Hesaplamaları yeniden yapıyorlar. Aşağıdakilerden hangisi doğrudur?

- e) Medyan değeri azalır, ortalama değeri aynı kalır.
- a) Medyan ve ortalamanın ikisinin de değeri azalır.
- b) Medyan değeri aynı kalırken, ortalama değeri düşer.
- c) Medyan ve ortalamanın ikisinin de değeri aynı kalır.

12. Elinizde 30 tane sayı var. Bu sayıların standart sapması sıfır olarak bulunuyor. Siz eminsiniz ki:

- a) Sayıların yarısı ortalamanın üstündedir.
- b) Tüm sayılar sıfırdır.
- c) Tüm sayılar eşittir.
- d) Sayılar ortalamanın her iki tarafına da eşit aralıktadır.

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