Journal of Education and Future
year: 2025, issue: 28, 31-44
DOI: 10.30786/jef.1641336

Development of a Quadrilaterals Test for Seventh-Grade Students: A Validity and Reliability Study*

Article Type	Received Date	Accepted Date
Research	17.02.2025	07.03.2025

Feyzullah Orman[**] **Sevim Sevgi**[***]

Abstract

This study is aimed at developing an achievement test on quadrilaterals for seventh-grade students. For this purpose, a test consisting of multiple choice questions was developed by conducting validity and reliability studies. Survey design, one of the quantitative research methods, was used. The sample of the study consisted of 300 seventh-grade students enrolled in a middle school in Melikgazi district of Kayseri, Turkey. Within the scope of validity, item analysis and construct validity analyses were conducted. In addition, exploratory and confirmatory factor analyses were conducted for construct validity. As a result of the reliability analysis, the KR-20 reliability coefficient of the scores obtained from the test was calculated as 0.928. The CFA analysis confirmed the one-factor structure determined by the EFA. The average item difficulty index of the scale was found to be 0.51, and the average item discrimination index was found to be 0.64. As a result, a valid and reliable quadrilateral test was obtained. For future studies, this test, which has high discrimination, can be accepted as a criterion test, and items can be prepared for similar purposes.

Keywords: Quadrilaterals, mathematics education, test development, validity, reliability.

[*] This research extends a doctoral dissertation at Erciyes University, Institute of Educational Sciences, Kayseri, Turkey, of the first author under the supervision of second author. Erciyes University Scientific Research Projects Unit supported this study with the project code SDK-2024-13237. This study was supported by TUBITAK 2211-A General Domestic PhD Scholarship Program.
[**] Erciyes University, Institute of Educational Sciences, Department of Mathematics and Science Education, Mathematics Education, Türkiye. E-mail: feyzullahorman@gmail.com, https://orcid.org/0000-0001-5954-0894
[***] *Corresponding Author:* Assoc. Prof. Dr., Erciyes University, Faculty of Education, Mathematics and Science Education Department, Mathematics Education, Türkiye. E-mail: sevimsevgi@erciyes.edu.tr, https://orcid.org/0000-0002-6611-5543

Yedinci Sınıf Öğrencileri için Dörtgenler Testi Geliştirme: Geçerlik ve Güvenirlik Çalışması*

Makale Türü	Başvuru Tarihi	Kabul Tarihi
Araştırma	17.02.2025	7.03.2025

Feyzullah Orman** **Sevim Sevgi*****

Öz

Bu çalışmada 7. sınıf öğrencileri için dörtgenler konusunda bir başarı testi geliştirilmesi amaçlanmıştır. Bu amaç doğrultusunda geçerlik ve güvenirlik çalışmaları yapılarak çoktan seçmeli sorulardan oluşan bir test geliştirilmiştir. Nicel araştırma yöntemlerinden biri olan anket tasarımı kullanılmıştır. Çalışmanın örneklemini Türkiye'nin Kayseri ili Melikgazi ilçesindeki bir ortaokulda öğrenim gören 300 yedinci sınıf öğrencisi oluşturmuştur. Geçerlik kapsamında madde analizi ve yapı geçerliliği analizleri yapılmıştır. Ayrıca yapı geçerliliği için açımlayıcı faktör analizi ve doğrulayıcı faktör analizi yapılmıştır. Yapılan güvenirlik analizi sonucunda testten elde edilen puanların KR-20 güvenirlik katsayısı 0,928 olarak hesaplanmıştır. DFA analizi, AFA'nın belirlediği tek faktörlü yapıyı doğrulamıştır. Ölçeğin ortalama madde güçlük indeksi 0,51, ortalama madde ayırt edicilik indeksi ise 0,64 olarak bulunmuştur. Sonuç olarak geçerli ve güvenilir bir dörtgenler testi elde edilmiştir. İleride yapılacak çalışmalarda yüksek ayırt ediciliğe sahip bu test bir ölçüt test olarak kabul edilebilir ve benzer amaçlar için maddeler hazırlanabilir.

Anahtar Sözcükler: Dörtgenler, matematik eğitimi, test geliştirme, geçerlik, güvenirlik.

* Bu çalışma birinci yazarın, Erciyes Üniversitesi Eğitim Bilimleri Enstitüsü Kayseri, Türkiye'de, ikinci yazarın danışmanlığında yürütülen doktora tezinden üretilmiştir. Bu çalışma Erciyes Üniversitesi Bilimsel Araştırma Projeleri Birimi tarafından SDK-2024-13237 proje kodu ile desteklenmiştir. Bu çalışma TÜBİTAK 2211-A Genel Yurt İçi Doktora Burs Programı kapsamında desteklenmiştir.

** Erciyes Üniversitesi, Eğitim Bilimleri Enstitüsü, Matematik ve Fen Bilimleri Eğitimi Ana Bilim Dalı, Matematik Eğitimi Bilim Dalı, Türkiye. E-posta: feyzullahorman@gmail.com, https://orcid.org/0000-0001-5954-0894

*** *Sorumlu Yazar:* Doç. Dr., Erciyes Üniversitesi, Eğitim Fakültesi, Matematik ve Fen Bilimleri Eğitimi Bölümü, İlköğretim Matematik Eğitimi Ana Bilim Dalı, Türkiye. E-posta: sevimsevgi@erciyes.edu.tr, https://orcid.org/0000-0002-6611-5543

Introduction

Geometry teaching has been included in the curriculum due to various requirements. These include being able to use entities made up of geometric shapes effectively, understanding how shapes relate to their functions, recognizing space and applying spatial skills, and employing basic geometry knowledge and skills to solve everyday life problems (Aslaner, 2018). In the math curriculum, geometry is taught to help students learn how to think mathematically and logically, to show how things fit into the real world by looking at their spatial properties, and to give students the geometry skills they need in everyday life (González & Herbst, 2006). The development of geometric thinking enhances mathematical thinking.

Geometry develops five important skills in students: visual, verbal (use of terminology), drawing, and logical skills (distinguishing classification patterns, forming and testing hypotheses, and making inferences). Hoffer (1981) defines geometry as the application of knowledge to daily life. Understanding geometry not only prepares students for higher-level thinking but also establishes a foundation for various mathematical subjects such as measurement, arithmetic, and problem-solving (Gravemeijer et al., 2016). The K–12 math curriculum aims to teach students how to: use transformation geometry and symmetry to solve mathematical problems; figure out where things are and how they relate to each other using analytic geometry and other representation systems; and think mathematically about the properties of two-dimensional and three-dimensional geometric shapes and objects and how they relate to each other mathematically (National Council of Teachers of Mathematics [NCTM], 2000). It utilizes visualization, spatial reasoning, and geometric modeling to address the problem.

Geometry involves three cognitive processes that develop in synergy with one another: visualization, structure building, and evidence processing (Duval, 1998). Visualization involves describing an expression, making its hidden parts visible, and describing the object's two- and three-dimensional relationships and gestalt in a way that makes it easier to understand. It includes summarizing or subjectively questioning the problem, as well as constructing structures. This phase involves creating a mathematical model that expresses actions and observed results using tools such as rulers, compasses, or dynamic geometry software. Proof demonstrates the truth of the propositions reached through reasoning processes.

Teaching geometry aims to build theoretical and spatial knowledge together. When students encounter new geometry problems, they must see, understand, predict, and prove the connection between their theoretical knowledge and the representation of these concepts in space (Laborde et al., 2006). It is possible to approach a geometry problem from various perspectives and arrive at different solutions. This diversity and richness should enhance geometry teaching. Flexible instruction should integrate different visualization methods and types of reasoning (Duval, 1998). Vinner (1991) outlined key considerations for defining and organizing mathematical concepts as follows. Students primarily acquire concepts through their definitions. They use definitions to solve problems and mathematically prove theorems when necessary. Descriptions should be concise and contain minimal information.

Quadrilaterals

Quadrilaterals are defined as: If A, B, C, and D are four non-linear planar points, then [AB], [BC], [CD], and [DA], which are made up of four line segments that only meet at their ends, are called a *quadrilateral* (Hızarcı et al., 2009). This is a simple definition of quadrilaterals, including concave and convex quadrilaterals whose sides intersect only at the vertices. Grade level allows for changes in definitions and an increase in properties. For example, while all diagonals of convex polygons intersect at a common point, not all diagonals of concave polygons intersect at a common point (Graumann, 2005). De Villiers (1994) defined a more complex quadrilateral (i.e., crossed quadrilateral) according to which both sides of a quadrilateral can intersect each other at a point other than the corners.

Special quadrilaterals can be classified according to the properties of their angles and sides. A *square*, *rectangle*, *rhombus*, *parallelogram*, *trapezoid*, and *deltoid* are special quadrilaterals, but the deltoid is not included in the middle school mathematics curriculum (Ministry of National Education [MoNE], 2018). Special quadrilaterals are defined in two ways. The relationships and coverage of these quadrilaterals determine whether definitions are hierarchical or exclude relationships.

The hierarchical ordering of quadrilaterals can benefit from reasoning, and it is important to focus on certain features (Graumann, 2005). It is important to pay attention to the following features: sides of the same length, parallel sides, opposite angles of the same measure, special angles, angles that add up to the same number, diagonals of the same length, orthogonal (crossing perpendicularly) diagonals, diagonals that average each other, one diagonal that averages the other, and axes of symmetry. We classify these definitions as either inclusive or exclusive (Ulusoy, 2022). In an inclusive definition, the classification of any set of concepts is hierarchically dependent on the definition. The most general special quadrilateral is considered a trapezoid, and the definition is made as a quadrilateral with at least one pair of opposite sides parallel. On the other hand, the exclusionary approach defines the trapezoid as a quadrilateral with only one pair of opposite sides parallel (De Villiers, 1994). The Turkish MoNE (2018) middle school mathematics curriculum accepts the inclusive definition in teaching quadrilaterals. The definitions of quadrilaterals are:

A *trapezoid* is a quadrilateral with at least one pair of parallel sides (MoNE, 2018). The definition of a trapezoid is expressed with a hierarchical and inclusive approach. In the next step, students are expected to establish a relationship between a trapezoid and a parallelogram and conceptualize a trapezoid with two pairs of parallel sides as a parallelogram (Çalık Uzun, 2020). A *parallelogram* has two pairs of parallel sides, or a quadrilateral whose opposite sides are parallel and of equal length. Since the two pairs of sides of a quadrilateral are parallel, their opposite sides must also be equal, so there is no need to state this equality (Çalık Uzun, 2020). The sides of a parallelogram are equal because the opposite sides are parallel; the lengths of diagonals are different, but they center each other. Its opposite angles are equal, and consecutive interior angles are supplementary.

A *rhombus* is a parallelogram with all sides of equal length. In addition to the properties of a parallelogram, it has some special angle-side relationships. All sides of a rhombus are the same length, and its diagonals are orthogonal; that is, they are not parallel to each other. The bisector is the point where the diagonals meet at the corners (Çalık Uzun, 2020). Since the side lengths are equal and the diagonals are bisectors, these diagonals divide the rhombus into four equal triangles (Danişman, 2020). A *rectangle* is a parallelogram with a 90-degree angle. In addition to all the properties of the parallelogram, all its interior angles are 90 degree, and the lengths of both diagonals are equal (Çalık Uzun, 2020). A rectangle is a special case of a parallelogram, and it has same properties as a parallelogram. In addition to parallelogram properties, rectangle diagonals are equal in length and bisect.

A *square* is a special case of a rectangle with all sides of equal length. The lengths of the diagonals are equal; they are bisectors, and each of these angles is 45^0. The diagonals bisect each other orthogonally, dividing the square into four equal triangular regions (Danişman, 2020). A square is a special kind of trapezoid, parallelogram, rhombus, or rectangular square (Çalık Uzun, 2020). Zazkis and Leikin (2008) said that a square is a regular quadrilateral with all interior angles and side lengths being the same, a quadrilateral with all sides being the same and one angle being 90 degrees, a rhombus with equal interior angles and diagonal lengths, and a parallelogram with equal length and an orthogonal diagonal. It is defined as a quadrilateral with four axes of symmetry.

Students’ Misconceptions and Difficulties in Quadrilaterals

Students may experience problems when they do not consider the relational properties of quadrilaterals and focus only on the shapes of these concepts (Çalık Uzun, 2020). Middle school students had misconceptions about trapezoids and thought that some special quadrilaterals, such as squares, rectangles, and parallelograms, were not trapezoids (Dogan et al., 2012). Seventh-grade students had misconceptions regarding the classification and definition of special quadrilaterals and the determination of the relationships between them (Ay & Başbay, 2017; Özkan & Bal, 2017). Ubuz (2017) found that the formal definitions used to set up hierarchical relationships between special quadrilaterals and students' concept images were not the same. She suggested using shapes that encompass everyone to create the correct concept image.

In this study, we aimed to develop a valid and reliable method for a seventh-grade geometry test based on quadrilaterals. We developed the geometry test to identify students' misconceptions and achievements in quadrilaterals. This test, developed following the mathematics curriculum, can be used by middle school teachers to determine students' misconceptions and achievements in quadrilaterals.

Method

Study Design

We used a survey design, a type of quantitative research method. In a survey design, the qualities, such as interests, skills, opinions, and abilities, of the participants regarding a subject or event are revealed (Fraenkel & Wallen, 2006). This study aimed to develop a reliable and valid achievement test to determine the achievement levels of 7^{th}-grade middle school students on quadrilaterals.

Population and Sample

The accessible population for the study includes 7^{th}-grade students in Melikgazi, Kayseri, during the 2022-2023 academic year. The sample consists of 300 students enrolled in 7th grade at a middle school in Melikgazi, Kayseri. The study utilized cluster sampling. The sample size must be at least five times the number of questions (Büyüköztürk, 2002). This study also adheres to the ten-fold rule. We initially composed the achievement test with 25 questions but later reduced it to 17 through analysis, leading to the establishment of the final version. The final version of the quadrilaterals test is in the Appendix. Orman (2025) administered the Turkish version of the quadrilateral test.

Data Collection Tools

We aimed to develop a quadrilaterals test as a data collection tool. We provided the quadrilaterals test in Orman (2025). We conducted validity and reliability studies while creating the quadrilaterals test. The related section presents the findings.

Data Analysis

We conducted the necessary reliability and validity studies using SPSS 22 during the test development phase. A value of 1 was assigned to students' correct answers and 0 to their blank or wrong answers. To ensure content validity, the purpose and objectives of the study were determined, a question pool was created, a specification table was created, and expert evaluation was conducted. Difficulty and discrimination indexes were examined to ensure the validity of the test. In addition, exploratory and confirmatory factor analyses were conducted for construct validity. Then, the KR-20 reliability coefficient was calculated. Since the study was carried out by following the achievement test development steps, detailed information about the analysis is given in the findings section.

Ethical Procedures

The Human Sciences Ethics Committee of the corresponding Erciyes University approved the research protocol on 25 / 10 / 2022 with the research number 445. The data were obtained from students. For this reason, we informed the participating students and their families about the study's content. We obtained consent forms from the families of each student. The research was based on voluntary participation.

Results

Validity Study for Achievement Test

Validity is the degree to which a test prepared for a purpose serves it (Fraenkel & Wallen, 1996). Within the scope of the validity study, findings related to content and construct validity were included.

Content Validity of Quadrilaterals Test

We examined the Mathematics Curriculum before creating the quadrilaterals test (MoNE, 2018). The curriculum includes quadrilaterals under the subheading of polygons in the Geometry and Measurement Learning Area. Table 1 provides the objectives regarding quadrilaterals in the mathematics curriculum. There are three objectives for quadrilaterals in the curriculum. First, the researcher considered these objectives, conducted a literature review, and created an item pool consisting of 60 items. This item pool was reduced to 25 items by obtaining the opinions of five experts, including a Turkish teacher, three mathematics teachers, and a faculty member working in the department of middle school mathematics teaching. The first item was included in the 2022 7th-grade Scholarship Exam. The third item was included in the 2010 7^{th}-grade SBS Exam. Item 17 was included in the 2008 7th-grade SBS Exam. The 8th item was included in the 2007 7th-grade Scholarship Exam. Inspired by scholarship exams and expert opinions, the researcher prepared the other items using 7th-grade mathematics textbooks. Table 1 displays the relationship between 25 items and the objectives.

Table 1. *Distribution of objectives (O)*

O	An Explanation of Objectives	Items
1	"Recognizes rectangle, parallelogram, trapezoid, and rhombus; determines the angle properties." (MoNE, 2018, p. 69) (Seven hours of teaching) a) "Along with the angles formed by the sides, the angles formed by the diagonals in rhombuses, squares, and rectangles are also examined." (MoNE, 2018, p. 69) b) "Square is considered a special case of rectangle and rhombus. In addition, rectangles and rhombuses are considered special cases of parallelograms. In addition, rectangle, rhombus and parallelogram are considered special cases of the trapezoid." (MoNE, 2018, p. 69)	3, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 23, 24, 25
2	"Creates area relations of rhombus and trapezoid, solves related problems." (MoNE, 2018, p. 69) (2 hours of teaching)	1, 2, 5, 17
3	"Solves area-related problems." (MoNE, 2018, p. 69) (3 hours of teaching) a) "Problems that require finding the areas of compound shapes consisting of triangles, rectangles, parallelograms, trapezoids, or rhombuses are included." (MoNE, 2018, p. 69). b) "Studies aimed at relating the perimeter and area of a rectangle are included. "The perimeters of different rectangles with the same area and the areas of different rectangles with the same perimeter are examined." (MoNE, 2018, p. 69).	4, 8, 22

Examining Table 1, we found that the first objective had the highest number of items. This is because it is a detailed learning outcome that examines the angle and diagonal properties of quadrilaterals and their relationships with each other. The first version of the quadrilaterals test, consisting of 25 items, was administered to 300 8th-grade students enrolled in the same school with 7th-grade students at the beginning of the 2022-2023 academic year. The reason why the first version of the quadrilaterals test was administered to 8th graders was that 7th graders had recently learned the quadrilaterals.

Item Analysis

We examined item difficulty and discrimination indexes in addition to content validity studies. These indexes are statistical procedures that will also increase the validity of the test. In the quadrilateral test, items can be multiple-choice. In the quadrilateral test, one point was given to those who answered each question correctly, and zero points were given to those who answered incorrectly or left the question blank. In this way, both the item-based and total scores of 300 students were calculated. Students were ranked from highest to lowest according to their scores. Since 27% of 300 were 81, the 81 students with the highest score formed the upper group, and the 81 students with the lowest score formed the lower group. The item analysis method was applied to the lower and upper groups.

The item difficulty index of each question was calculated by dividing the sum of the number of students who answered each question correctly in the upper and lower groups by the sum of the number of students in the upper and lower groups, which is 162. Then, the number of students who answered each question correctly in the upper group was subtracted from the number of students who answered it correctly in the lower group. We determined the item discrimination index for each question by dividing this difference by the total number of students in each group, which is 81. These calculated index values are shown in Table 2.

If the item difficulty index is close to 1, the item is easy; if it is close to 0, the item is difficult (Büyüköztürk, 2011). This value is generally expected to be close to 0.5. However, preparing each item with a difficulty index of 0.5 is not desirable. Instead, items with easy, medium, and difficult difficulty should be included in the test. As a result, the average item difficulty index of the test should be close to 0.5 (Büyüköztürk, 2011; Hasançebi et al., 2020). As seen in Table 2, the item difficulty index of each question varies between 0.19 and 0.69. The average item difficulty index of the test was calculated as 0.47.

Table 2. *Difficulty and Discrimination Indexes of Items in the Achievement Test*

Item	Item difficulty index	Item discrimination index	Item	Item difficulty index	Item discrimination index
1	0.49	0.36	14	0.66	0.63
2	0.65	0.59	15	0.59	0.60
3	0.32	0.44	16	0.51	0.65
4	0.44	0.60	17	0.54	0.79
5	0.48	0.77	18	0.59	0.32
6	0.41	0.63	19	0.62	0.54
7	0.69	0.36	20	0.36	0.33
8	0.49	0.74	21	0.24	0.38
9	0.34	0.21	22	0.49	0.68
10	0.41	0.59	23	0.60	0.57
11	0.41	0.65	24	0.50	0.70
12	0.19	0.05	25	0.53	0.64
13	0.22	0.21			

We use item discrimination as an index to differentiate between individuals who possess the relevant item and those who do not. This index takes a value between +1 and -1. If this value is close to 1, it is interpreted as high discrimination in the upper and lower groups for the relevant item, and if it is close to 0, it is interpreted as low discrimination. A negative value means that the number of correct answers in the lower group is higher than in the upper group (Hasançebi et al., 2020). Büyüköztürk (2011) states that for the item discrimination index range, "If it is less than 0.20, the relevant item is weak and should be removed from the test; in the range of 0.20 – 0.29, the relevant item should be corrected and reviewed; in the range of 0.30 – 0.39, the relevant item is quite good; and if it is 0.40 and above, it is a very good item."

Examining Table 2 reveals that the item discrimination index values range from 0.05 to 0.77. The average item discrimination index of the test was calculated as 0.52. Items 1, 7, 9, 12, 13, 18, 20, and 21, whose item discrimination index was less than 0.40, were removed from the test after receiving expert opinions. Therefore, we found that each item's item discrimination index exceeded 0.40. After the relevant items were removed from the test, the average item difficulty index of the remaining 17 items was found to be 0.51, and the average item discrimination index was 0.64.

Exploratory Factor Analysis (EFA) for Construct Validity

Construct validity refers to how well the test demonstrates the theoretical framework for measurement (Çepni et al., 2012). We performed an EFA, as shown in Table 3, to address this. To perform factor analysis, it is recommended that Bartlett's test be significant (Pallant, 2016) and the KMO index be greater than the minimum value of 0.6 (Tabachnick & Fidell, 2013). When Table 3 is examined, the KMO value is 0.885. Therefore, since the KMO value is greater than 0.6, EFA can be performed.

Table 3. *KMO Value for the Quadrilaterals Test*

Kaiser-Meyer-Olkin Measure of Sampling Adequacy	.885
Approx. Chi-Square	1041.963
df	136
p	.000

Table 4 displays the total variance after the statistical analysis. Factors with eigenvalues greater than 1 are given in Table 4. Components with eigenvalues of 1 or more are taken into account to decide how many factors to extract (Pallant, 2016). The quadrilaterals test was grouped under one factor. We grouped the quadrilaterals test under a single factor due to the interrelated nature of its objectives. These factors cover 24.245% of the test items. However, the explained variance table alone cannot determine the factor structure in the test.

Table 4. *Total Variance Values for the Quadrilaterals Test*

Factor	Total	% of Variance	Cumulative %
1	4.122	24.245	24.245

A scree plot graph is an important tool for determining the number of factors (Seçer, 2013). Figure 1 shows the Scree Plot graph of the quadrilaterals test. Figure 1 shows that the slope flattens after the second factor. After this point, the contribution of the factors to the variance is considered low (Çokluk et al., 2010). Therefore, the Scree Plot graph shows a single factor.

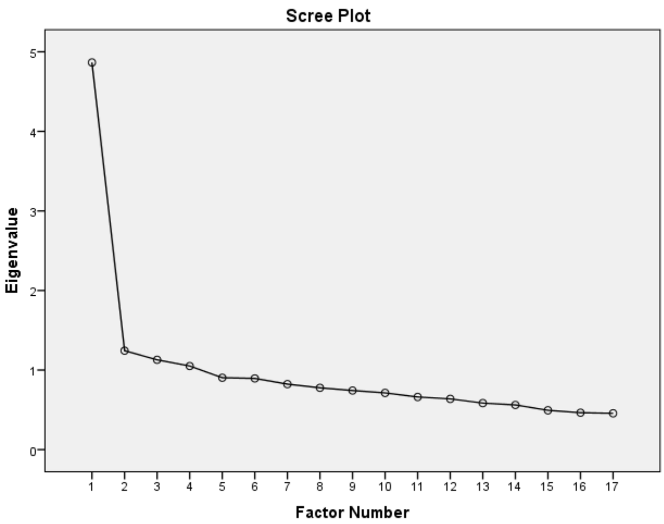


Figure 1. *Scree Plot for the Quadrilaterals Test*

The factor loadings and coefficients of the questions are given in Table 5. Following the test's factor analysis, the researcher examined each factor's questions. The examination revealed that the questions in Factor 1 were associated with the properties of quadrilaterals. The extraction method was principal axis factoring. We extracted one factor through three iterations.

Table 5. *Factor Loadings for the Quadrilaterals Test*

Item	Factor 1
item17	.586
item5	.561
item8	.555
item14	.532
item24	.525
item25	.524
item10	.524
item22	.520
item4	.499
item16	.498
item6	.469
item11	.461
item15	.454
item2	.450
item23	.412
item19	.386
item3	.348

Confirmatory Factor Analysis (CFA)

The CFA for the quadrilateral test developed in this study was conducted with the AMOS program. The CFA yielded a Chi-square with (201.860) degrees of freedom (119), and Hu & Bentler (1999) predicted a result below five. We took this ratio from the selected sample group, and according to Jöreskog & Sörbom (1993), a value below three indicates a perfect fit. The current study determined this result as 1.696, and Table 6 provides evidence of perfect fit in the data. The RMSEA value between 0.00-0.05 used in CFA is considered an acceptable fit, 0.08-0.10 is considered a moderate fit, and values greater than 0.10 are considered unacceptable (Schermelleh Engel et al., 2003). The RMSEA value of 0.048 obtained from this test indicates that the fit of this test is perfect. The CFA analysis confirmed the one-factor structure determined by EFA. The model is in Figure 2.

Table 6. *Confirmatory Factor Analysis Goodness of Fit Index Table*

Fit Measure	Perfect Fit	Acceptable Fit	Observed Value	Fit Status
χ^2/ sd	$0 \leq \chi^2$ / sd ≤ 2	$2 \leq \chi^2$ / sd ≤ 3	1.696	Perfect
p value	0,05 ≤ p ≤ 1,00	0,01 ≤ p ≤ 0,05	0,00	Perfect
RMSEA	0 ≤ RMSEA ≤ 0,05	0,05 ≤ RMSEA ≤ 0,08	0.048	Perfect
CFI	0,95 ≤ CFI ≤ 1,00	0,90 ≤ CFI ≤ 0,95	0.911	Acceptable
GFI	0,95 ≤ GFI ≤ 1,00	0,90 ≤ GFI ≤ 0,95	0.925	Acceptable
AGFI	0,90 ≤ AGFI ≤ 1,00	0,85 ≤ AGFI ≤ 0,90	0,903	Perfect

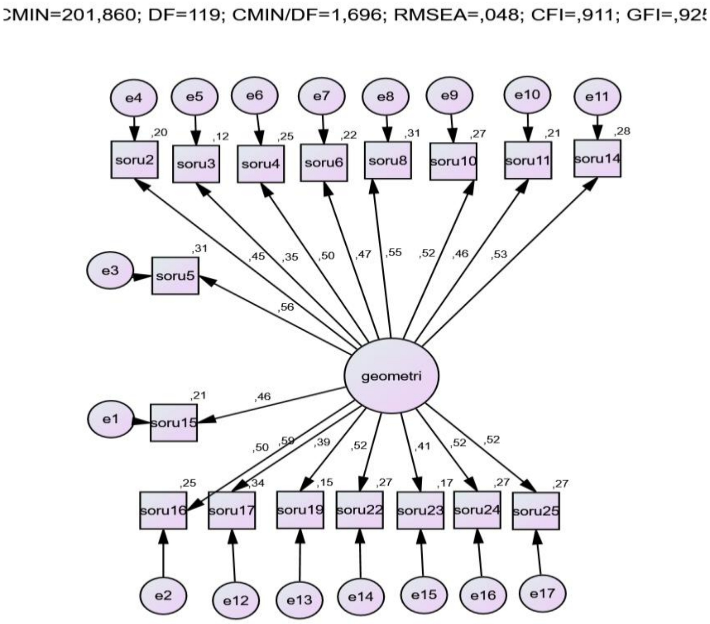


Figure 2. *Path Diagram*

Reliability Study for Achievement Test

The scale must be reliable for use (Pallant, 2016). Reliability is the consistency and stability of measurement results free from random errors (Çepni et al., 2012). For reliability, we use KR-20, KR-21, and Cronbach's alpha calculations. In general, Cronbach's alpha and KR-20 are preferred in tests where a zero value is used for a wrong answer and one value is used for the correct answer. In this study, we calculated the --20 value to evaluate the reliability of the students' quadrilateral tests.

We calculated the Kuder-Richardson-20 (KR-20) value to determine the internal consistency coefficient of the quadrilaterals test. The KR-20 value of 25 questions in the pilot quadrilateral test was calculated as 0.915. After removing eight items with a low item discrimination index, the KR-20 value of the remaining 17 items was calculated as 0.928. When the KR-20 value is 0.80 or above, the measurements obtained in the test are reliable (Secolsky & Denison, 2018). The item analysis and KR-20 analysis show that the quadrilateral test has very good discrimination, high reliability, and medium difficulty. Table 7 presents item-total statistics.

Table 7. *Item-total Statistics*

Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
item 2	8.01	29.453	.556	.925
item 3	8.35	30.066	.443	.928
item 4	8.23	29.022	.613	.924
item 5	8.19	28.475	.717	.921
item 6	8.25	28.886	.646	.923
item 10	8.26	28.926	.639	.923
item 11	8.25	28.985	.626	.924
item 14	8.01	29.012	.649	.923
item 15	8.08	29.180	.587	.925
item 16	8.15	28.889	.634	.923
item 17	8.12	28.295	.755	.920
item 19	8.05	29.501	.533	.926
item 22	8.18	28.744	.663	.923
item 23	8.06	29.288	.571	.925
item 24	8.17	28.587	.694	.922
item 25	8.14	28.863	.640	.923
item 8	8.17	28.343	.743	.921

Discussion, Conclusion and Recommendations

The study aims to prepare a valid and reliable quadrilaterals test. We conducted the necessary validity and reliability studies for the quadrilaterals test. First of all, the purpose of the study was determined. Next, we determined the content validity objectives and the items that align with these objectives. Experts in mathematics education continuously provided feedback to finalize the test before its administration. During this process, we tried to prepare the objectives, related items, and specification table appropriately. The test development processes in this study are parallel to the studies in the literature (Kılıç & Sağlam, 2009).

When the difficulty and discrimination indexes of the items were calculated, the difficulty indexes and discrimination indexes of questions 1, 7, 9, 12, 13, 18, 20, and 21 were found to be low. At the same time, the removal of these items increased the reliability of the test. We decided to remove these items from the test. Hazır Bıkmaz (2002) stated that some questions in the self-efficacy scale he developed had low discrimination and that the reliability coefficient increased when they were removed from the test. This result is similar to our study.

We performed EFA and CFA in this study to ensure construct validity. As a result of the exploratory factor analysis, it was decided that the test had one factor. A confirmatory factor analysis (CFA) was performed. The fit indices confirmed a good model. We conducted a reliability study for the quadrilateral test. In this context, the KR-20 reliability coefficient was found to be 0.928. In addition, the fact that the effect of each question on the reliability coefficient is greater than 0.60 means that the scores obtained from the test are reliable (Can, 2014). Considering all these evaluations, we developed a valid and reliable quadrilaterals test for the 7th-grade quadrilaterals subject.

This study aimed to create a valid and reliable quadrilaterals test. We determined a total of 17 items for the quadrilaterals test and proceeded with their application and analysis. We can conduct the study with a greater number of items to assess achievement. This approach will increase the likelihood of meeting the determined objectives. Orman and Sevgi (2025) administered the quadrilaterals test to determine the achievement of 7th-grade students' geometry achievement.

Experts assisted in determining the objectives. However, conducting interviews with students during the item determination process is also an option. We conducted the study with a total of 300 7th-grade students. This allows for an increase in the student population. We can provide open-ended questions to reveal students' advanced understanding of the objectives of the study. For future studies, this test with high discrimination can be accepted as a criterion test, and items can be prepared for similar objectives.

References

Aslaner, R. (2018). *Dinamik geometri öğretimi* [Dynamic geometry teaching]. Ankara: Anı Publishing.

Ay, Y., & Başbay, A. (2017). Çokgenlerle ilgili kavram yanılgıları ve olası nedenler [Misconceptions about polygons and their possible reasons]. *Ege Eğitim Dergisi [Ege Journal of Education], 18*(1), 83-104. https://doi.org/10.12984/egeefd.328377

Büyüköztürk, Ş. (2002). Faktör analizi: temel kavramlar ve ölçek geliştirmede kullanımı [Factor analysis: Basic concepts and using to development scale]. *Eğitim Yönetimi Dergisi, 32*(32), 470-483.

Büyüköztürk, Ş. (2011). *Sosyal bilimler için veri analizi el kitabı (17. basım)*. Ankara: Pegem A Publishing.

Can, A. (2014). *SPSS ile bilimsel araştırma sürecinde nicel veri analizi (2. Baskı)*. Ankara: Pegem A Publishing.

Çalık Uzun, S. (2020). Dörtgen kavramı ve öğretimi. In E. Ertekin & M. Ünlü (Editörs) *Geometri ve ölçme öğretimi tanımlar, kavramlar ve etkinlikler*, (pp. 217-249). Pegem A Publishing https://doi.org/10.14527/9786257880725.08

Çepni, S., Bayrakçeken, S., Yılmaz, A., Semerci, Ç., Köse, E., Sezgin, F., Demircioğlu, F., & Gündoğdu, K. (2012). *Ölçme Değerlendirme.* Pegem A Publishing, 5. edition, Editor: Emin Karip.

Çokluk, Ö., Şekercioğlu, G., & Büyüköztürk, Ş. (2010). *Sosyal bilimler için çok değişkenli istatistik: SPSS ve LISREL uygulamaları*. Ankara: Pegem A Publishing

Danişman, Ş. (2020). Özel dörtgenler ve öğretimi. In T. Ağırman Aydın, & B. Küçük Demir, (Ed). *Geometri ve Öğretimi*, (pp. 199-216). Ankara: Pegem Akademi. https://doi.org/10.14527/9786257052412.08

De Villiers, M. (1994). The role and function of a hierarchical classification of quadrilaterals. *For the Learning of Mathematics, 14*(1), 11-18.

Dogan, A., Özkan, K., Çakır, N. K., Baysal, D., & Gün, P. (2012). İlköğretim ikinci kademe öğrencilerinin yamuk kavramına ait yanılgıları ve bu yanılgıların sınıf seviyelerine göre değişimi [Students' misconceptions about trapezium through primary levels]. *Uşak Üniversitesi Sosyal Bilimler Dergisi, 5*(1), 103-115. https://doi.org/10.12780/UUSBD108

Duval, R. (1998). Geometry from a cognitive point of view. *Perspectives on the Teaching of Geometry for the 21st Century*, 37-52.

Fraenkel, J. K., & Wallen, N. E. (1996). *How to design and evaluate research in education* (third edition). New York: McGraw-Hill, Inc.

González, G., & Herbst, P. G. (2006). Competing arguments for the geometry course: Why were American high school students supposed to study geometry in the twentieth century? *International Journal for the History of Mathematics Education, 1*(1), 7-33.

Graumann, G. (2005). Investigating and ordering quadrilaterals and their analogies in space-problem fields with various aspects. *ZDM, 37,* 190-198. https://doi.org/10.1007/s11858-005-0008-2

Gravemeijer, K., Figueiredo, N., Feijs, E., Van Galen, F., Keijzer, R., & Munk, F. (2016). *Measurement and geometry in upper primary school*. Springer. https://doi.org/10.1007/978-94-6300-746-7

Hasançebi, B., Terzi, Y., & Küçük, Z. (2020). Madde güçlük indeksi ve madde ayırt edicilik indeksine dayalı çeldirici analizi [Distractor analysis based on item difficulty index and item discrimination index]. *Gümüşhane Üniversitesi Fen Bilimleri Dergisi [Gümüşhane University Journal of Science and Technology], 10*(1), 224-240. https://doi.org/10.17714/gumusfenbil.615465

Hazır Bıkmaz, F., (2002). Fen eğitiminde öz-yeterlik inancı ölçeği [Self-efficacy belief instrument in science teaching]. *Eğitim Bilimleri ve Uygulama, 1*(2), 197-210.

Hızarcı, S., Kaplan, A., İpek, A. S., Işık, C., & Elmas, S. (2009). *Düzlem geometri*. Ankara: Palme Publishing.

Hoffer, A. (1981). Geometry is more than proof. *The Mathematics Teacher, 74*(1), 11-18. https://doi.org/10.5951/MT.74.1.0011

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Structural Equation Modeling, 6,* 1-55. https://doi.org/10.1080/10705519909540118.

Jörekog, K., & Sörbom, D. (1993). *Lisrel 8: Structural equation modeling with the simplıs command language*. Scientific Software International. Inc.

Kılıç, D. & Sağlam N. (2009). Öğrencilerin mantıksal düşünme yeteneklerinin bazı değişkenler açısından incelenmesi [Investigating students' logical thinking abilities in terms of certain variables]. *Ege Eğitim Dergisi [Ege Journal of Education], 10*(2), 23-38.

Laborde, C., Kynigos, C., Hollebrands, K., & Strässer, R. (2006). Teaching and learning geometry with technology. *Handbook of research on the psychology of mathematics education*, 275-304. https://doi.org/10.1163/9789087901127_011

Ministry of National Education (MoNE) (2018). *Ortaokul matematik dersi (5, 6, 7 ve 8. Sınıflar) öğretim programı*. MoNE.

National Council of Teachers of Mathematics (NCTM) (2000). Principles and Standards for School Mathematics. Reston, VA: Author.

Orman, F. (2025). Teknoloji ile zenginleştirilmiş öğrenme ortamının dörtgenler konusunda yedinci sınıf öğrencilerinin akademik başarılarına etkisi [Effect of technology enriched learning environment on academic achievement of seventh grade students in quadrilaterals], Doctoral Thesis, Educational Sciences Institute, Erciyes University, Kayseri, Turkey (in Turkish)

Orman, F., & Sevgi, S. (2025). Effect of technology-enriched learning environment on academic achievement of seventh-grade students in quadrilaterals. Anadolu University Journal of Education Faculty, 9(1), 1-23. https://doi.org/10.34056/aujef.1490036

Özkan, M., & Bal, A. P. (2017). Analysis of the misconceptions of 7th grade students on polygons and specific quadrilaterals. *Eurasian Journal of Educational Research, 16*(67). http://dx.doi.org/10.14689/ejer.2017.67.10

Pallant J. (2016). *SPSS kullanma kılavuzu SPSS ile adım adım veri analizi.* (S.Balcı ve B.Ahi, Çeviri). Ankara: Anı Publishing.

Schermelleh Engel, K., Moosbrugger, H. ve Müller, H. (2003). Evaluating the fit of structural equation models: tests of significance and descriptive goodness-of-fit measures. *Methods of Psychological Research Online, 8*(2), 23-74.

Secolsky, C., & Denison, D. B. (2018). *Handbook on measurement, assessment, and evuluation in higher education* (2nd Ed.). Routledge. https://doi.org/10.4324/9781315709307

Seçer, İ. (2013). *SPSS ve LISREL ile pratik veri analizi: Analiz ve raporlaştırma*. Ankara: Anı Publishing.

Tabachnick, B.G., & Fidell, L. S. (2013). *Using multivariate statistics* (Sixth edition). New Jersey: Pearson Prentice Hall.

Ubuz, B. (2017). Dörtgenler arasındaki ilişkiler: 7. sınıf öğrencilerinin kavram imajları [Relations among quadrilaterals: 7th grade students' concept images]. *Yaşadıkça Eğitim [Journal of Education for Life], 31*(1), 55-68.

Ulusoy, F. (2022). Çokgenlerin öğretimi [Teaching of polygons]. In Z., Toluk-Uçar, R., Akkuş, B., Boz-Yaman, A., Duatepe-Paksu , & S. Bulut (Eds.) *Geometri Öğretim Bilgisi* [Knowledge of geometry teaching] (pp.134-177). Ankara: Pegem A Publishing

Vinner, S. (1991). The role of definitions in the teaching and learning of mathematics. In *Advanced mathematical thinking* (pp. 65-81). Dordrecht: Springer Netherlands. https://doi.org/10.1007/0-306-47203-1_5

Zazkis, R., & Leikin, R. (2008). Exemplifying definitions: a case of a square. *Educational Studies in Mathematics, 69*, 131-148. https://doi.org/10.1007/s10649-008-9131-7

Appendix
Quadrilaterals Test

1) Four friends with 36 cm long ropes create the following shapes on the table by using the ropes in their hands without cutting them.

Alp: Square shaped

Banu: Rectangular with a short side of 6 cm

Cem: Rectangular with a short side of 1 cm

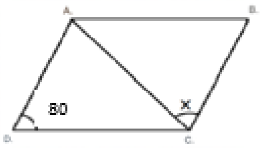
Laurel: Rhombus shaped with a height of 6 cm.

According to this, which one makes the shape on the table?

What is the largest area covered?

A) Alpine B) Banu C) Cem D) Laurel

2)



In the rhombus ABCD in the figure

If s($\widehat{ADC}$) =80 how many degrees is s($\widehat{ACB}$)?

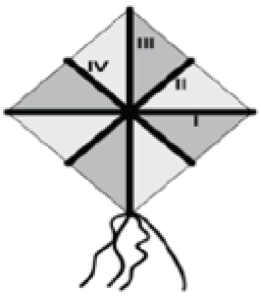
A) 80 B) 70 C) 60 D) 50

3) In which of the following quadrilaterals are the diagonals always equal in length?

A) Parallelogram and rectangle B) Rectangle and trapezoid
C) Square and rectangle D) Square and parallelogram

4)

The rhombic region-shaped kite on the side was created by combining the laths I, II, III and IV as shown in the figure.



In which of the following are the slats perpendicular to each other?

A) I and III B) II and III C) I and IV D) I and II

5) Which of the following quadrilaterals has equal diagonal lengths and angle bisectors?

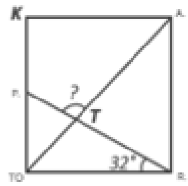
A) Square B) Trapezoid
C) Rectangle D) Parallelogram

6)
I. A parallelogram is a special case of a trapezoid.
II. Square is a special case of rectangle.
III. Rectangle is a special case of parallelogram.
IV. A rhombus is a special case of a parallelogram.

How many of the above information **<u>are incorrect?</u>**

A) 0 B) 1 C) 2 D) 3

7)

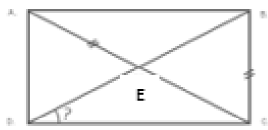


In the above SQUARE square, the PRE angle is 32°

What is the measure of angle PTA in degrees?

A) 64 B) 77 C) 103 D) 116

8)



In the rectangle ABCD above, diagonals [AC] and [BD] intersect at point E and |AE| = |BC|.

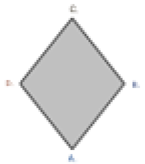
Accordingly, what is the measure of angle EDC in degrees?

A) 22,5 B) 30 C) 36 D) 45

9) Which of the following quadrilaterals has only one pair of opposite sides parallel?

A) Rectangle B) Parallelogram
C) Trapezoid D) Square

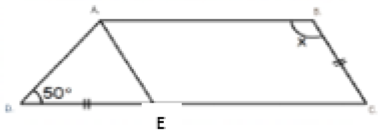
10)



A fountain will be placed at each corner of a rhombic garden as shown in the figure. The distance between the fountains at corners B and D is 8 m. If the area of the garden is 48 m², how many meters is the distance between fountains A and C?

A) 10 B) 12 C) 14 D) 16

11)



In the figure, ABCD is a trapezoid and ABCE is a parallelogram.

|| DE| = |BC| and s($\widehat{ADE}$) = 50°

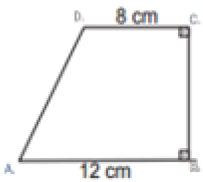
How many degrees is s($\widehat{ABC}$)?

A) 100 B) 130 C) 145 D) 160

12) Which of the following properties **is not a property of a rhombus?**

A) The diagonals are angle bisectors.
B) The diagonals bisect each other.
C) The diagonals intersect at right angles.
D) The diagonal lengths are equal.

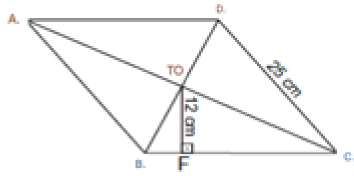
13)



In the right trapezium ABCD in the figure, if |AB| = 12 cm, |DC| = 8 cm and A(ABCD) = 100 cm², how many centimeters is BC?

A) 12 B) 10
C) 8 D) 6

14)



In the figure ABCD is a rhombus

Point F is on [BC], [EF] 1 [BC] and |DC| = 25 cm, | EF | = 12 cm.

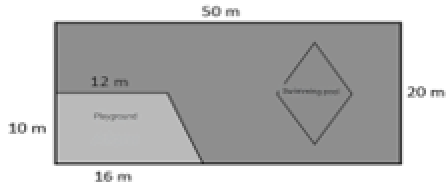
Accordingly, how many square centimeters is A(ABCD)?

A) 150 B) 300 C) 450 D) 600

15) The side lengths of a rectangle with an area of 80 square centimeters are natural numbers in centimeters. According to this, what is the maximum perimeter length of this rectangle in centimeters?

A) 162 B) 160 C) 80 D) 400

16)

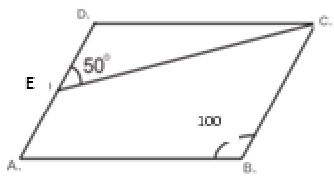


The plan of a rectangular park is given above. The diagonal lengths of the rhombus-shaped pool are 10 m and 16 m. The areas outside the trapezoid-shaped playground and the pool in the park are grassy.

Accordingly, what is the area of the grassy area in the park?

A) 560 B) 640 C) 700 D) 780

17)



In the figure, ABCD is a parallelogram, m($\widehat{ABC}$)

100 and m(DEC) = 50°, how many degrees is m(DCE)?

A) 30 B) 40 C) 50 D) 60

Answer Key: 1-A 2-B 3-C 4-A 5-A 6-A 7-C 8-B 9-C 10-B 11-A 12-D 13-B 14-D 15-A 16-D 17-A