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What is the Predictive Power of Visual Mathematics Literacy Perception and Its Sub-dimensions for Geometry Success?

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ABSTRACT

Purpose: In this study, it was aimed to examine the relationship between the visual mathematics literacy perceptions and its sub-dimension for geometry success levels of prospective teachers. It was also aimed to examine to what extent visual mathematics literacy perception and its sub-dimensions predicted geometry success.

Research Methods: This study was designed in accordance with a qualitative, scanning model. The research was carried out with 232 (97 males and 135 females) prospective teachers who studied in Mathematics Education Program at Firat University, Education Faculty, and were selected by simple random sampling method. "Visual Mathematics Literacy Perception Scale" and "Geometry Success Test" were employed in this study as data collection tools. Correlation analysis and multiple regression analysis were used for analyzing the data.

Findings: After the data were analyzed, it was determined that there was a positive relationship between the visual mathematics literacy perception and geometry success of prospective teachers. It was also determined that visual mathematics literacy perception is a meaningful predictor of geometry success.

Implications for research and practice: Providing trainings on these concepts in the direction of the results, to investigate the concept of perception on other learning areas of mathematics and conducting experimental studies on the perception of visual mathematics literacy are suggested.

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Introduction

The standards put forward by the National Council of Teachers of Mathematics (NCTM) in the USA aim to train prospective teachers as mathematics literate, while one of the primary goals of mathematics education in primary school mathematics curriculum published by the Turkish Ministry of National Education (MoNE) in 2013 is to achieve this (Ministry of National Education [MoNE], 2013). Traditionally, mathematics education has been very procedure-based. Over the past decade, international mathematics reform has placed more emphasis on literacy competencies and their links with mathematics learning. This shift, which has influenced both pedagogy and curriculum expectations, has increased the overlap between literacy skills and mathematics learning in instructional practice (Ontario Ministry of Education [OME], 2004). Children's and teens' ability to learn mathematics, and their awareness of mathematical thoughts may only be achieved by verbal, numerical, visual, symbolic and written communication in mathematics. In fact, "mathematics for everyone", "mathematics literacy perception" and "improvement in mathematics" have gone beyond being just slogans, and become one of the primary goals, and this constituted a field of education and research that every community should invest it.

Mathematics Literacy

Literacy was described by Karunaratne (2000) as the individuals' ability to maintain their life in their community, having enough reading-writing skills to communicate within the community, and being able to apply basic mathematical operations. It is seen that the concept of literacy is related to the area of mathematics by its definition. Therefore, the concept of literacy has gained a place in the mathematics literature.

Mathematics literacy is described as individuals' awareness and understanding of the role of mathematics in the real world, and having judgements based on solid foundations and usage of mathematics to meet their needs as a sensitive citizen (MoNE, 2013). In that case, it can be said that mathematical literacy is not only knowing mathematical concepts and solving routine problems, but also identifying oneself with mathematics (Colak, 2006). It was aimed that students should be trained as mathematically literate by standards asserted by NCTM of America and main objectives of mathematics education in the 2005 Primary Education Mathematics Education Program (NCTM, 2000). Individuals with mathematical literacy competence can keep the mathematical concepts in mind, transfer mathematical skills into daily life, and use the mathematical information in analysis and synthesis situations. In this view, for individuals to have mathematical literacy competence, some basic competency and skills about mathematics should be gained (Bekdemir & Duran, 2012). Mathematical literacy is closely related to literacy. While literacy is the foundation for all learning, mathematical literacy is also necessary if we are to fully understand information that surrounds us in modern society (OME, 2004, p. 23). Mathematics learning cannot occur without a strong literacy background. Early recognition of written and spoken letters and numbers are important stepping-stones for later development of math abilities (Cappelli, 2015). In this context, mathematical literacy can be defined as a type of literacy that involves the use of critical thinking, reasoning, and mathematical thinking skills in solving real-life problems and strengthening the individual in mathematics field. When the literature is examined, it is possible to come across studies that indicate the importance of mathematics literacy for teaching processes and learners. Gatabi, Stacey and Gooya (2012) see mathematical modelling as the key process in mathematical literacy. In some of the studies conducted in the field of mathematics literacy, researchers focused on mathematics literacy levels of mathematics teachers (Demir & Altun, 2018; Tekin & Tekin, 2004). In other studies, the effect of mathematics literacy on variables such as gender (OECD, 2004; Ozgen & Bindak, 2011) or academic achievement (Kocaarslan & Celikturk, 2013; Tat, 2018) was examined.

Math and Visual Perceptions

Visual perception is the ability to notice visual stimulants, distinguish them and decipher these stimulants by associating them with previous experiences (Frostig, 1968). According to Kavale (1982), visual perception is related to the ability of the individual to organize his/her skills and interpret them. When visual perception skills are analyzed, it is seen that they are generally divided into sub-categories such as visual discrimination, visual figure ground, visual closure and visual memory (National Educational Psychological Service [NEPS], 2015). Additionally, it is seen that other skill types such as establishing spatial relationships as well as visual memory and visual discrimination are in a strong relationship with mathematics skills (Olkun, Altun & Deryakulu, 2009). According to Coley and Gelman, perceptual stability, which is closely related to both mathematical and visual perception, is a subject that is important throughout the lives of human beings. This is because human beings are faced with a constantly changing perspective. When we get closer to objects, the size and shape of the objects change according to the changes in our position. When we turn or raise our head, our harmony with our environment also changes. Our eye movements cause similar changes, but the environment is perceived as stable thanks to perceptual stability. The information that a triangle is a triangle, even if its location or position is changed, is related to both mathematical and visual perception. When mathematical skills are analyzed, it is seen that visual perception processes are necessary for usage and improvement of many skills (Erden & Akman, 1995; Sigmundsson, Anholt, & Talcott, 2010).

Geometry Learning Field

Although geometry is one of the primary fields of mathematical learning, the cognitive processes underlying the academic success in geometry are not examined in detail. Visual literacy and visual mathematics literacy concepts have emerged as a result of the relationship between the geometry learning area and cognitive literacy skills. Beauchamp, Braden and Baca (1994) argue that visual literacy is the fourth element of the general education in the modern world following reading, writing and arithmetic. Additionally, the reason why visual literacy is of great importance in terms of general education is explained in four items: First, the concept of visual literacy requires using the right hemisphere of the brain, which is of great importance for the development of human beings. Thus, usage of both hemispheres of the brain in thinking process reinforces holistic thinking. Second, the concept of visual literacy makes it possible to understand abstract thoughts in the left hemisphere of the brain better by making them alive, persuasive, intense and known. Third, visual literacy provides the ability to process the same ideas in different ways. Finally, visual literacy enables individuals to read and understand the visual environment around them, so that they can make their own decisions instead of being influenced by the natural and man-made environment around them. Beauchamp et al. (1994) argue that students should be trained in three different aspects within the scope of visual literacy and geometry education: visualization through imagery, reading and interpreting visual elements, and designing visual materials. Although there is not a unity and solidarity in visual literacy, which improves rapidly and has a wide scope, it is seen that visual literacy education is necessary in the 21st century, in which people are bombarded with visuals. Geometry education to be planned in this regard should help students maximize the benefits of the visual materials among the course materials.

Visual communication and visual learning can be observed in many learning fields, especially in the geometry learning field. The use of visual materials for enriching learning processes is a teaching technique approved by educators. According to Dwyer (1978), visuals (such as TV, images, slide presentations, diagrams, graphics, etc.) are influential on teaching the facts and concepts and using valid methods. Levie (1987) argues that visuals materialize the abstract information, make them thinkable in an imaginative way, and are useful in cooperative reasoning (analogical reasoning). The abilities of teachers and other training personnel related to visual literacy and other literacy types have direct influence on education services. Visual literacy skills are highly influential on teaching materials designed by teachers, timely and effective use of teaching materials with appropriate methods and techniques, and being able to organize the message to be conveyed to the student visually (for example being able to make simple schemes and drawings).

Visual mathematics literacy has indispensable meaning and importance in both daily life and mathematics education. This is because mathematics visualized in constructs makes is easier to understand the relationships among objects (Ayguner, 2016). For some students, visual representations are obligatory to learn mathematics. The reason for some students to fail in mathematics is the inadequacy of visual elements and helpers used in mathematics education. Visual regulations for such students will increase the success of the students, and therefore, their interest in the subject and participation in the classroom (Tutkun, Erdogan & Ozturk, 2014). According to Tekin and Tekin (2004), individuals who are visually literate in mathematics have the quality of recognizing and analyzing experiences based on shapes, space, time and movement using all senses, and the representations of the concepts.

Spatial Thinking

The concept of dimension, which constitutes the basis for understanding space geometry, has a significant role in the development of mathematical thinking (Manin, 2006). Dimension concept has taken place in the primary and secondary school curricula in recent years. In order to understand the subjects in geometry, the concepts of point, line, plane and volume should be understood well. Dimensions of these concepts should be mentioned when they are introduced. In this regard, it is possible to say that geometry may be shaped by the concept of dimension. On the other hand, spatial thinking is the ability of creating the objects and status quo in one's mind. Drawing explanatory figures when solving problems, being able to transfer verbal problems into tables and graphics, and being able to understand the relationships among geometrical figures show that this skill can be improved (Turgut, 2010). Subject in the learning field of geometry play an important role in improving students' skills of objective and critical thinking, establishment of causality relationships, and numerical thinking (Oral & Ilhan, 2012). Therefore, the use of spatial skills through visualizing geometrical concepts and spatial situations constitutes the basis for spatial thinking. Improving spatial skill will also make it possible to understand mathematical and geometric subjects better. However, many studies are concerned with finding the methods that improve spatial skill the most. NCTM states that geometry will lead students to analyze the properties of geometric shapes by using spatial thinking and geometrical modelling in solutions of problems, and express geometric relationships mathematically. Accordingly, it was emphasized that the reasoning and justification skills of students will be improved by geometry, which is a natural field in mathematics (NCTM, 2000).

Visual Math Literacy

Visual literacy emerged as a result of the fact that human beings used visuals on the walls of caves, visuals are integrated into the education process, and visuals concepts increase the permanence of mental processes by materializing them. Visual literacy was described by Hortin (1980) as "readership of visual elements, the ability to think and learn with visual elements, and interpretation capacity that is, thinking visually." In this regard, the concept of visual mathematics literacy perception was described as "being able to perceive, express, interpret, assess and use the problems faced in daily life as visual and spatial, and similarly, being able to perceive, express, interpret, assess and use visual and spatial information in a mathematical sense" (Duran & Bekdemir, 2012).

According to NCTM, one of the primary goals of the process of learning geometry is the visual awareness of students as visually literate individuals. Many studies were conducted on this concept in the USA and Israeli, and even technology assisted computer programs were developed. The Visual Mathematics Institute was found in California, USA in 1975 to conduct studies on visual mathematics literacy perception. This institute, which aims to popularize mathematics among individuals, continues to carry on its duty at the University of California for visual mathematics research involving computer graphics and interactive environments (Marcolin & Abraham, 2006). On the other hand, visual mathematics literacy perception is also a research subject of the Education Technologies Department of the University of Haifa in Israel. One of the teams conducting studies in this department developed a computer program named Visual Math in the beginning of 1990s (Devraj, Butler, Gupchup & Poirier, 2010). When the software steps were examined, wide range of features of the software representing mathematical aspects of contextual problems drew attention (Yerushalmy, 2006). Students studying in 7th-12th grades improved their knowledge in geometry with a critical approach thanks to this software, which was based on geometry designs. The primary goal of Visual Math is to help students improve their algebra skills and ensure that they learn graphical reading techniques (Devraj, Butler, Gupchup & Poirier, 2010).

Visualization is the organization of data using visual elements (pictures, graphs, etc.) that can be easily perceived by the sense of seeing (Sevimli, Yildiz & Delice, 2008). As this concept is a different pathway in mathematical thinking than the thought of language and traditional algebra, it may be a strong and alternate resource for mathematical analyses of students (Konyalioglu, 2003). Usage of visualization in mathematics classes leads students to approach abstract concepts and constructs with different points of view. The mathematical relationships among visual objects are understood more easily with the help of visual mathematics literacy (Tutkun, Erdogan, & Ozturk, 2014). Considering the studies in the field of mathematics and geometry on visualization, it is seen that visualization is used intensively in geometrical processes (Nemirovsky & Noble, 1997). Visual literacy term is defined as the power of giving meaning to visual messages and composing message in a similar way (Alpan, 2008). In another definition for visual literacy is "the learned ability to interpret visual messages exactly and accurately, and to create such messages (Heinich, Molenda, Russell, & Smaldino, 1999, p. 64). Visual literacy is a required proficiency in education that requires teachers and instructors to be able to arrange, manipulate, and utilize graphics for the purpose of learning. By using their visual competency, they can enhance their students' learning and help them achieve academic success (Aisami, 2015).

There are a limited number of studies in the literature on visual mathematics literacy. Some of these studies were studies on developing a visual mathematics literacy scale. In this field, Bekdemir and Duran (2012) developed a visual mathematics scale for second grade students in elementary school education, and investigated the relationship between visual mathematics literacy and visual success in mathematics. Likewise, Authors (2016) developed a scale for determining the visual mathematics literacy of prospective teachers. Other studies focused on whether visual mathematics literacy levels and perception of self-efficacy changed based on variables such as perceived mathematics success, sex, and class level, and the relationships in this context. In a study by Tutkun, Erdogan and Ozturk, (2014), it was reported that the mathematics literacy levels and self-efficacy rates middle-school students were high, and these levels chanced based on sex, level of education and mathematics success. Ozdemir, Duran, and Kaptan (2016) detected a low-level and significant correlation between visual mathematics literacy and perception of self-efficacy, and reported that the visual mathematics literacy and self-efficacy perception of students differed significantly in favor of female students. Similarly, Duran, and Bekdemir (2013) found a positive, medium-level and significant relationship between visual mathematics literacy and perception of self-efficacy. They also determined that perception of self-efficacy in visual mathematics was a significant indicator of visual mathematics success.

It is thought that visual mathematics literacy perception of prospective teachers is an important factor in mathematics education as well as the visual mathematics literacy perception of students. In addition to these, as many visuals are included in the field of geometry, it is assumed that the success in this field is associated with visual mathematics literacy perception. Based on the literature review, it is considered to be appropriate in this study to examine the relationship between success in geometry and visual mathematics literacy perception of prospective elementary school mathematics teachers. In this regard, the present study aims at addressing the following questions:

RQ_1: What is the relationship level between geometry success and visual mathematics literacy perception and its sub-dimensions?

RQ_2: What is the predictive power of visual mathematics literacy perception and its sub-dimensions for geometry success?

Method

Research Design

A descriptive method was employed in this study. Descriptive studies attempt to describe a given situation comprehensively and in detail. Descriptive screening studies are commonly conducted on educational issues. This is because researchers conduct descriptive studies in order to summarize the characteristics of individuals, groups or physical environments (Buyukozturk, Kilic Cakmak, Akgun, Karadeniz & Demirel, 2012, p. 22). In this study, relational screening model was preferred in order to obtain the data indicating the relationship between visual mathematics literacy perception and geometry success. The relational screening model is a research model that aims at determining the coexistence or degree of relationship between two or more variables.

Research Sample

The population of the study consisted of prospective teachers in the field of Mathematics Education at the, Faculty of Education, Firat University in the fall semester of 2015-2016 academic year. The sample consisted of 232 volunteer prospective teachers, 97 (41.8%) were male and 135 (58.2%) were female selected through simple random sampling method. The number of students in this sample group were 72.5% of all students. The arithmetic mean of prospective teachers' age was 26.23. The reason for choosing the method of simple random sampling was that, in this method, all units constituting the population have the same possibility of being included in the sample (Can, 2013, p. 26).

Research Instruments and Procedures

The study used the Visual Mathematics Literacy Perception Scale and the Geometry Success Test (GST), which were developed by researchers as data collection tools. The primary assessment tool, the Visual Mathematics Literacy Perception Scale, was developed by Ilhan (2015) in order to determine the visual mathematics literacy perception levels of prospective teachers, and is a 5-point Likert-type scale consisting of 37 items. This scale consisted of five sub-dimensions: visual perception, geometric field, spatial intelligence, concretion, and create a pattern. Some items in the scale are as follows; "I can draw a three-dimensional shape from front to top view", "By breaking a three-dimensional object, I can obtain new three-dimensional objects", "I can find the general term from a shaped pattern with steps 3 and 5", "Modeling a decimal number to create the problem, I can solve it", "I can make geometric proof of Pythagoras" and "I can make geometric modeling of exponential numbers". Factor analysis studies were conducted to investigate the construct validity of the scale. Factor analysis methods used in the research were exploratory and confirmatory factor analyzes. With the exploratory factor analysis, it was tried to determine what factors were related to the scale. In order to ensure the validity of the scope, a pool of 60 items, which aimed to measure scale in specific dimensions, was formed as a result of the opinions of teacher candidates and the related literature review. The factor load of the scale ranged from 0.410 to 0.716. The internal consistency reliability coefficients of the scale were 0.820, 0.740, 0.891, 0.763 and 0.852 for the five sub-dimensions respectively, and the test-retest reliability coefficients were 0.764, 0.833, 0.856, 0.823 and 0.841 for the five sub-dimensions respectively. The Cronbach's Alpha reliability coefficient of the scale was 0.904. The Cronbach's Alpha reliability coefficient of the scale employed in this study was calculated as 0.889. If this coefficient is greater than 0.7, it is considered that the mean scores of the scale is reliable (Buyukozturk, 2018, p. 183).

The second assessment tool, the GST, was developed by the researchers in order to determine the geometry success levels of the students. The geometry outcomes of the elementary school mathematics curriculum were examined before preparing the success test. A draft test form was prepared, consisting of 26 multiple-choice questions previously used in the Academic Personnel and Postgraduate Education Entrance Exams between the years of 2010-2015, which included these outcomes. These questions were submitted to two faculty members, experts in the field of mathematics education, for their opinions in terms of content. In line with the feedbacks of these expert faculty members, 6 questions were taken out and the final test was created, consisting of 20 questions. The highest score was determined as 20 (each of the question is 1 point) and the lowest score was determined as 1 for this specific test. The reliability coefficients of this test were examined using KR-20 reliability coefficients and split-half reliability. KR-20 reliability coefficient for a study examines whether all the questions in a scale constitutes a homogeneous structure or not (Kalayci, 2010, p. 405). In split-half reliability, the test is split into two pairs as singular-plural, first half-second half and neutral. Based on the relationships between the two halves, the correlation coefficient was calculated for the whole test by using Spearman Brown formula (Buyukozturk, 2018, p. 183). As a result of the analyses conducted, the KR-20 reliability coefficient of the GST was calculated as 0.794 and split-half reliability was calculated as 0.693. In this study, item difficulty and distinctiveness indices were calculated for each question. These indices are given in Table 1.

Table 1

Item Difficulty Index and Item Distinctiveness Index of GST

Item No	*Item Difficulty Index*	*Item Distinctiveness Index*
1	0.431	0.592
2	0.520	0.560
3	0.602	0.571
4	0.493	0.613
5	0.391	0.530
6	0.511	0.661
7	0.590	0.582
8	0.432	0.520
9	0.510	0.581
10	0.673	0.773
11	0.621	0.520
12	0.460	0.552
13	0.510	0.470
14	0.572	0.691
15	0.531	0.633
16	0.545	0.550
17	0.343	0.591
18	0.304	0.542
19	0.371	0.661
20	0.330	0.550
Total	0.493	0.589

The item difficulty index values of the substances found in a test vary between 0-1 and the items with difficulty indexes between 0.30 and 0.70 are considered as substances with an average difficulty level. In addition, substances with a substance difficulty index of less than 0.3 are found to be difficult and substances with a substance difficulty index of over 0.7 are considered to be difficult substances (Tekin, 1997; Yilmaz, 1998). The difficulties in the GST test (pj) ranged from 0.271 to 0.673. Therefore, it can be said that the majority of the substances in the test have a moderate difficulty. The overall difficulty index of the test was 0.493. In other words, it is possible to say that the test has moderate difficulty in general. The discriminant index (rjx) values ranged between -1 and +1, and a value of 0.40 and above indicated that the substances were very well distinguished. If this value is in the range of 0.30 to 0.39, the best substance should be corrected if it is in the range of 0.20 and 0.29, and if it is 0.19 and lower, it can be considered as the item to be removed from the test (Buyukozturk, 2018). When the discriminant index of GSAYB test items were examined, it was seen that the discrimination indexes of all items were greater than 0.40. That is to say, all items were suitable for testing in terms of discrimination.

During data collection, teacher candidates were informed about the application process. Forms were reproduced by foreseeing the number of samples. Pencil and eraser needs of teacher candidates were met. The implementation period lasted for two weeks. Visual mathematics literacy perception scale was administered in the first week, and in the second week, geometry achievement test was applied. In the application process, the classes of the related university were used. During the applications, attention was paid to keep the environment quiet and to offer individual solutions for the problems of the teacher candidates. Thus, the implementation process was completed without any problems.

Data Analysis

The relationship between the visual mathematics literacy perception and geometry success of prospective teachers was calculated using the Pearson Moments Multiplication Correlation Coefficient method, and the Multiple Regression Analysis method was used to examine whether visual mathematics literacy perception and its sub-dimensions were meaningful predictors of geometry success or not. Additionally, the mean and standard deviation values for visual mathematics literacy perception and sub-dimensions, its sub-dimensions and geometry success were also calculated. The visual mathematics literacy perception scale had 37 items and the items were scored in 5-point Likert-type. In the geometry achievement test, there were 20 items, and the items were scored as 1 for the correct answers and 0 for the wrong answers. In this direction, the visual mathematics literacy perception of students was taken as the independent (predictive) variable and geometry success was taken as the dependent (predicted) variable. Multiple Regression Analysis is a method related to the prediction of the dependent variable on the basis of two or more independent variables associated with the dependent variable (Buyukozturk, 2018, p. 98). The data were analyzed using SPSS (Statistical Package for Social Sciences) version 21.0.

Results

In this section of the study, we will discuss the findings related to the relationship between visual mathematics literacy perception, its sub-dimensions and geometry success of the prospective teachers; and then, findings will be presented in relation to determining the predictive power of visual mathematics literacy perceptions and, its sub-dimensions in terms of geometry success.

The relationship between visual mathematics literacy perception, its sub-dimensions and geometry success of the prospective teachers was calculated using correlation analysis. The results of the data analysis are shown in Table 2.

Table 2

The Relationship Levels Between Visual Mathematics Literacy Perceptions and Sub-Dimensions with Geometry Success

Variables		*Mean*	*S.S.*	*G1*	*G2*	*G3*	*G4*	*G5*	*G6*
G1	Geometry Success	9.957	4.179	1					
G2	Visual Perception	2.967	0.739	0.076*	1				
G3	Geometric Field	4.044	0.653	0.175*	0.435*	1			
G4	Spatial Intelligence	3.366	0.313	0.259*	0.501*	0.479*	1		
G5	Concretion	4.359	0.680	0.196*	0.344*	0.421*	0.402*	1	
G6	Pattern	3.826	0.792	0.107*	0.485*	0.596*	0.434*	0.375*	1
G7	Visual Math Literacy	3.712	0.635	0.191*	0.062*	0.150*	0.249*	0.172*	0.077*

*p<0.01; n=232

When the data in Table 2 were examined, the mathematics teacher candidates' Visual Math Literacy Perception sub-dimension's highest mean belonged to Concretion dimension's ($\bar{X}$=4.359), and this dimension appeared to follow Geometric Field dimension's. Lowest mean belonged to Visual Perception dimension's ($\bar{X}$=2.957). Prospective teachers' geometric achievement scores were below mean ($\bar{X}$=9.957). All of the correlations between the sub-dimensions appeared to be significant. The relationship between Visual Math Literacy Perception with all sub-dimensions was meaningful at the level of $p<0.01$. Also, when the relation of geometry success to sub-dimensions was examined, Spatial Intelligence (Correlate=0.259) dimension had the highest mean. This was followed by Concretion dimension's mean (Correlate=0.196). Geometry success' correlation with Visual Math Literacy Perception was seen 0.191.

It has been assumed in the study that visual mathematical literacy and sub-dimensions significantly predict the geometric success. Regression analysis was performed in this direction, and the findings are given in Table 3.

Table 3

The Results of the Multiple Regression Analysis Regarding the Predictive Power of Visual Mathematics Literacy Perception and its Sub-Dimensions

Predictive Variables	*R*	*R^2*	*Change (R^2)*	*Std.β*	*t*	*F*	*p*
1. Visual Perception-Visual Perception	0.760	0.577	0.001	0,031 0.030	7.644 6.654	1.337	0.000
2. Visual Perception-Geometric Field	0.175	0.031	0.031	0.002 0.174	3.086 2.425	3.624	0.028
3. Visual Perception-Spatial Intelligence	0.268	0.072	0.064	- 0.034 - 0.084	4.980 4.040	8.873	0.000

Table 3 Continue

4. Visual Perception-Concretion	0.196	0.038	0.011	0.005 0.028	3.348 2.790	4.582	0.011
5. Geometric Field-Geometric Field	0.175	0.031	0.026	0.112 0.042	3.192 2.698	7.279	0.007
6. Geometric Field-Spatial Intelligence	0.265	0.070	0.067	0.043 0.046	2.585 3.124	8.658	0.000
7. Geometric Field-Concretion	0.219	0.048	0.110	0.070 0.046	2.029 2.041	5.773	0.004
8. Geometric Field-Pattern	0.175	0.031	0.175	0.112 0.053	3.114 2.129	3.624	0.028
9. Spatial Intelligence-Spatial Intelligence	0.259	0.067	0.029	0.064 0.010	5.041 4.059	16.475	0.000
10. Spatial Intelligence-Concretion	0.276	0.076	0.019	0.032 0.016	2.521 3.068	9.461	0.000
11. Spatial Intelligence-Pattern	0.259	0.067	0.020	0.032 0.021	3.903 3.686	8.203	0.000
12. Concretion-Concretion	0.196	0.038	0.099	0.017 0.001	3.709 3.029	9.176	0.003
13. Concretion-Pattern	0.200	0.040	0.077	0.222 0.085	2.906 2.611	4.778	0.009

When Table 3 was examined, the sub-dimensions of visual mathematics literacy perception such as visual perception, geometric field, spatial intelligence, concretion and pattern were used as the predictors of visual math literacy perceptions in the regression analysis (R=0.760, p=0.00<0.01). It was observed that the spatial intelligence and concretion sub-dimensions of visual mathematics literacy perception explained 7.6% of the data. The two best sub-dimensions of visual mathematics literacy perception were spatial intelligence (R=0.268, p=0.00<0.01) and concretion (R=0.196, p=0.00<0.01).

In this study, after predictive power of the sub-dimensions of the literacy perception was examined, predictive power of the geometric success of visual mathematics literacy perception sub-dimensions was investigated. The findings are given in Table 4.

Table 4

Predictive Power of the Geometric Success of the Visual Mathematics Literacy Perception Sub-Dimensions

Variables	***B***	***Standard Error***	***Beta***	***t***	***p***
Constant	4.975	1.712	-	2.906	0.004
Visual Perception	0.031	0.027	0.076	1.157	0.249
Geometric Field	0.112	0.042	0.175	2.698	0.007
Spatial Intelligence	0.260	0.064	0.259	4.059	0.000
Concretion	0.241	0.079	0.196	3.029	0.003
Pattern	0.189	0.115	0.107	1.635	0.103

When Table 4 was examined, it was seen that the highest ordering power was in the spatial intelligence sub-dimension with 0.259, followed by concretion dimension (0.196), geometric field (0.175), pattern (0.107); and these differences were statistically significant. On the other hand, the lowest ordering power was in the visual perception dimension with 0.076, but this was not significant. After determining the geometry success of the sub-dimensions, the overall power of the visual mathematical literacy perception was investigated in terms of eometric success. The findings are given in Table 5.

Table 5

Predictive Power of the Geometric Success of the Visual Mathematics Literacy Perception

Variance Source	*Sum of Squares*	*df*	*squares mean*	*F*	*p*	*R*
Regression	146.834	1	146.834	8.685	0.004	0.191
Error	388.735	230	16.908			
Total	4035.569	231				

When Table 5 was examined, it was seen that visual mathematics literacy perception had a significant effect on geometric success at the 0.01 level (F(1,230)=8.685; p=0.004). The regression coefficient between visual mathematical literacy perception and geometric success was calculated (R=0.191, p=0.00<0.01). It was observed that geometric success of visual mathematics literacy perception explained 1.91% of the data.

Discussion, Conclusion and Recommendations

Recently, visuals are gaining importance in all areas of the field of mathematics. Moreover, these visuals strengthen the relationship between mathematics and real life, and encourage permanent learning. While high visual mathematics literacy perception levels of students make it possible for them to understand the described mathematical concepts better, high visual mathematics literacy perception levels of teachers make it possible for them to create more useful and healthier visual materials, as well as facilitate permanent learning by creating more efficient teaching processes (MoNE, 2013).

In this study, the relationship levels of visual mathematics literacy perception and its sub-dimensions with each other and geometry success were examined, and then, the extent to which visual mathematics literacy perception and its sub-dimensions predicted geometry success was calculated. When the relationship of visual mathematics literacy perception and its sub-dimensions with geometry success was examined, it was determined that there was a statistically significant relationship with its sub-dimensions. All of the correlations between the sub-dimensions appeared significant. The relationship between Visual Math Literacy Perception with all its sub-dimensions was meaningful. Also, when the relation of geometry success to its sub-dimensions was examined, spatial intelligence dimension had the highest mean value, and the concretion dimension appeared to follow because visual mathematics literacy perception was closely related to spatial intelligence. In a study conducted by Bal

(2012), it was observed that prospective teachers had different geometric thinking levels, their attitudes towards geometry were high and there was a statistically significant, but a low-level of relationship, only in the dimension of 'anxiety' related to, geometric thinking levels and attitudes. Similarly, Gellert (2004) expressed that there was a statistically significant relationship between the concept of mathematics literacy perception and mathematics lessons where instructive materials were used. On the other hand, based on the literature review, it was seen that there were studies that found the relationship between visual mathematics literacy and geometry success on a medium or high level. In a study conducted by Kocaarslan and Celikturk (2013), it was determined that the visual literacy competence levels of the students in the faculty of education were generally high and there was a statistically significant and positive relationship between visual literacy levels and academic success. Another finding of this study was that geometric field was the most significant source that predicted geometry success. In other words, students who were more successful in geometry had higher visual mathematics perceptions based on the geometric field variable. Literature review showed that there are other studies supporting this finding. In parallel with these results, Duran and Bekdemir (2013) found a medium level, positive and statistically significant relationship between visual mathematics literacy self-efficacy perception and visual mathematics success.

Geometry success of prospective elementary school mathematics teachers in exams prepared by the Student Selection and Placement Center (SSPC), their performances in different selection and placement exams and their performances related to the field of geometry in their daily life constitute personal experiences in visual mathematics literacy perceptions. As a result of the positive and negative outcomes of these experiences, mathematical success of the students was associated with visual mathematical literacy. In Turkey, students answered 5.1 mathematics and geometry questions correct out of 40 in the Transition to Higher Education Examination in 2017; they answered 4.22 geometry questions correct out of 30 in the Undergraduate Placement Exam in 2016 (SSPC, 2017). According to studies in the literature, relationships among the sources were identified similarly, and their effects on geometry success was medium or low. In parallel to the findings of this study, Garderen determined in a study conducted in 2006 that students with visual-spatial impairment had deficiencies in understanding and differentiating information. Rapp (2009) expressed that students with visual-spatial intelligence were held back when teaching techniques were not supported by visuals in the classroom. Roblyer and Bennett (2001) propose that teachers will require skills that enable them to select appropriate materials for meaningful instruction, support the effective production of materials, design and teaching of specific activities that will facilitate deep learning as well as the ability to evaluate the level of student's visual literacy. Success in higher education is becoming more and more dependent on visual literacy skills (Nalinci & Yapici, 2015).

The findings of this study showed that there was a significant relationship between visual perception and geometry success. The sub-dimensions of visual mathematics literacy perception such as geometric field, spatial intelligence, concretion and pattern were used as the predictors of visual math literacy perceptions in the regression analysis. One of the sub-dimensions of visual mathematical literacy perception was visual perception. It is not possible to ignore the relationship of this source with visual math literacy perceptions. Literature review showed that visual perceptions are directly or indirectly associated with geometry success (Bekdemir & Duran, 2012; Hortin, 1980; Karunaratne, 2000). Again, as a result of the findings, it was determined that there was a low-level relationship between pattern sub-dimension, which was a source of visual mathematical literacy, and geometry success. According to the literature review, pattern sub-dimension is directly or indirectly associated with geometry success. In another study, Tanisli and Kose (2011) adopted a numerical approach in which the prospective teachers transformed a linear shape pattern into a visual and shape pattern with a focus on the shape structure when determining the rule of pattern and sustaining the pattern to a close/distant step, and they used 26 strategies in these approaches.

Visual perception, geometric field and spatial intelligence sources were more effective on geometry success when compared to other sources. Each source explained approximately 7% of geometry success. Considering other sources, it was seen that the effect of spatial intelligence source was higher. Spatial intelligence, visual perception and geometric field sources should be improved in order to improve visual mathematical literacy of students. Furthermore, it is important to help students gain accurate, complete and successful experiences. Lastly, concretions and pattern sources were the fourth and fifth important sub-dimensions that affected geometry success. Each of these sub-dimensions explained approximately 4% of geometry success. When compared to other sub-dimensions, it was seen that the effect of concretions sub-dimension was lower. In line with the findings obtained as a result of this study, it is concluded that it is required to examine direct and indirect relationships between the sub-dimensions of visual mathematics literacy perception and geometry success. Duran and Bekdemir (2013) stated that visual mathematics literacy self–efficacy perception is a significant predictor of visual mathematics success. Bal (2012) claimed that teacher candidates they were located in different geometric levels, between a high level of attitude towards geometry and a low level of attitude with geometric thinking levels, but it was observed that the relationship was at a low level. Ozgen and Bindak (2011) determined in their study that the success scores in mathematics courses and the importance given to mathematics courses are significant predictors of mathematical literacy self – efficacy perceptions. In addition to these studies, there are other studies in literature that determined the factors predicting mathematics success (Dogan & Baris, 2010; Kayagil, 2010; Ozdemir, 2010; Ozer & Anil, 2011; Uredi & Uredi, 2005; Yilmaz, 2006). The finding that the predictive powers of the sub-dimensions of visual mathematics literacy perception are statistically meaningful brings the importance of this relationship to the forefront. Furthermore, it was also found that visual mathematics literacy perception had a significant effect on geometric success. The reason for this is that the research was conducted only at a university, or the number of samples was low. Another reason is that teacher candidates could not reflect their perception levels to their achievements. It is also assumed that the sample in the study reflected all the information on the test and the scale. The work to be done in the future in accordance with these limitations can include;

1. research on larger samples related to the subject,

2. investigation of the relationship between visual mathematical literacy perceptions and geometric successes of different parts,

3. similar practices on existing mathematics teachers,

4. trainings on these concepts in the direction of the results,

5. investigating the concept of perception related to other learning areas of mathematics,

6. conducting experimental studies on the perception of visual mathematics literacy,

7. conducting projects to gain visual perception of visual mathematics literacy.

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Görsel Matematik Okuryazarlığı Alt Boyutlarının Geometri Başarısını Yordama Gücü Nedir?

Atıf:

Ilhan, A., Tutak, T., & Celik, H. C. (2019). What is the predictive power of visual mathematics literacy perception and its sub-dimensions for geometry success? *Eurasian Journal of Educational Research, 80,* 1-24, DOI: 10.14689/ejer.2019.80.1

Özet

Problem Durumu: Okuryazarlık kavramı günümüzde şekillenen bir kavram olarak bilinmekle birlikte tarihsel sürecinin de çok eski olmadığını araştırmalar neticesinde görmek mümkündür. Ayrıca okuryazarlık kavramı çok genel bir kavramdır ve bu kavramla ilişkili yeni okuryazarlık türleri literatürde her geçen gün oluşturulmuş ve oluşturulmaktadır. İnsanların ilk çağlardan beri mağara duvarlarında görselleri kullanması, görsellerin eğitim sürecinin neredeyse tamamına entegre edilmesi ve görsel kavramların zihinsel süreçte somutlaştırmayı sağlayarak kalıcılığı artırması görsel okuryazarlık kavramını doğurmuştur. Görsel okuryazarlık, Hortin (1980) tarafından, "görsel elemanları okuma ve yorumlama kapasitesiyle beraber görsel öğeler ile düşünme ve öğrenme becerisi, yani görsel olarak düşünebilme" şeklinde tanımlanmıştır. Eğitim alanında farklı okuryazarlıklara dair ortak yanların bütünleşmesinden doğan sanatsal matematik veya görsel matematik okuryazarlığı gibi okuryazarlıkların tanımlanması ön plana çıkmıştır. Bu noktadan hareketle görsel matematik okuryazarlığı "günlük hayatta karşılaşılan problemleri görsel veya uzamsal, tersine görsel veya uzamsal bilgileri de matematiksel olarak algılayabilme, ifade edebilme, yorumlayabilme, değerlendirme ve kullanabilme yeterliğidir" (Duran ve Bekdemir, 2013). Görsel matematik okuryazarlığının günlük yaşamda ve matematik eğitiminde vazgeçilmez bir anlamı ve önemi vardır. Görsel okuryazarlık ve görsel matematik okuryazarlığı kavramları, geometri öğrenme alanı ile bilişsel okuryazarlık becerileri arasındaki ilişki sonucunda ortaya çıkmıştır. Geometri matematiksel öğrenmenin temel alanlarından biri olmasına rağmen, geometriyle ilgili akademik başarının altında yatan bilişsel süreçler detaylı bir şekilde incelenmiştir. Öğretmen adaylarının görsel matematik okuryazarlığı algılarının, matematik eğitiminde önemli bir faktör olduğu düşünülmektedir. Bunlara ek olarak, birçok görselin geometri alanına dâhil edilmesi nedeniyle, bu alandaki başarının görsel matematik okuryazarlığı algısı ile ilişkili olduğu düşünülmektedir. Dolayısıyla görsel matematik okuryazarlık algısı ve alt boyutları ile geometri başarısı arasındaki ilişkinin incelenmesinin alan yazına yararlı olacağı öngörülmektedir.

Araştırmanın Amacı: Bu araştırmanın amacı, öğretmen adaylarının görsel matematik okuryazarlığı ile geometri başarıları arasındaki ilişkiyi incelemektir.

Araştırmanın Yöntemi: Mevcut araştırma, betimsel nitelikli bir çalışmadır. Betimsel çalışmalar, verilen bir durumu olabildiğince tam ve dikkatli bir şekilde tanımlamaya çalışır. Eğitim alanındaki araştırmalarda, yaygın olarak betimsel yöntem tarama çalışmaları yapılmaktadır. Mevcut araştırmada görsel matematik okuryazarlığı ile geometri başarısı arasındaki ilişkiyi belirten verilerin elde edilmesi noktasında ilişkisel tarama modeli tercih edilmiştir. Araştırmanın çalışma grubunu, 2015-2016 öğretim yılı

güz döneminde, Fırat Üniversitesi, Eğitim Fakültesi, matematik eğitimi anabilim dalında okuyan matematik öğretmen adayları oluşturmaktadır. Örneklemde ise bu öğrencilerden basit rastgele örnekleme yöntemiyle seçilen 232 (97 erkek, 135 kadın) öğrenci yer almıştır.

Araştırmada, veri toplama araçları olarak araştırmacı tarafından geliştirilen ve öğretmen adaylarının görsel matematik okuryazarlık algı düzeylerini belirlemek amacıyla Görsel Matematik Okuryazarlığı Ölçeği ve geometri başarı düzeylerini incelemek için Geometri Başarı Testi kullanılmıştır. Araştırmada öğretmen adaylarının görsel matematik okuryazarlıkları ile geometri başarıları arasındaki ilişkinin hesaplanmasında Pearson Momentler Çarpım Korelâsyon Katsayısı yöntemi, görsel matematik okuryazarlığı algısı ve buna ait alt boyutların geometri başarısının yordayıcısı olup olmadığı Çoklu Regresyon Analizi yöntemiyle incelenmiştir.

Araştırmanın Bulguları: Çalışma bulguları dikkate alındığında görsel algı kaynağının geometri başarısı ile arasında düşük düzeyde ilişki tespit edilmiştir. Nitekim görsel matematik okuryazarlığının veri kaynaklarından biride görsel algıdır. Bu kaynağın geometri başarısı ile ilişkisini göz ardı etmek mümkün değildir. Literatür taraması yapıldığında görsel algıların geometri başarısı ile doğrudan veya dolaylı yönden ilişkili olduğu görülmektedir (Bekdemir ve Duran, 2012; Karunaratne, 2000). Yine bulgular neticesinde görsel matematik okuryazarlığının veri kaynaklarından biri olan örüntü oluşturma boyutunun geometri başarısı ile arasında düşük düzeyde ilişki tespit edilmiştir. Literatür taraması yapıldığında da örüntü boyutunun geometri başarısı ile doğrudan veya dolaylı yönden ilişkili olduğu görülmektedir. Tanışlı ve Köse (2011)'nin yapmış olduğu araştırmada, öğretmen adayları lineer şekil örüntüsünü yakın/uzak bir adıma devam ettirmede ve örüntünün kuralını belirlemede sadece şeklin yapısına odaklanılan görsel ve şekil örüntüsünün sayı örüntüsüne dönüştürüldüğü sayısal yaklaşımı benimsemişler, bu yaklaşımlar altında da toplam 26 strateji kullanmışlardır.

Araştırmanın Sonuçları ve Önerileri: Görsel algı, geometrik bilgi ve uzamsal zekâ kaynakları geometri başarısı üzerinde diğer kaynaklara göre daha fazla öneme sahiptir. Bu kaynaklar geometri başarısının yaklaşık %7'sini açıklamaktadır. Özellikle uzamsal zekâ kaynağının geometri başarısı üzerindeki etkisi diğer kaynaklar göz önünde bulundurulduğunda daha yüksek çıkmıştır. Öğrencilerin görsel matematik okuryazarlıklarını geliştirmek için öncelikle uzamsal zekâ kaynaklarıyla beraber görsel algı ve geometrik bilgi kaynakları geliştirilmelidir. Son olarak, somutlaştırma ve örüntü oluşturma kaynakları geometri başarısına etki eden dördüncü ve beşinci önemli boyutlardır. Bu boyutların her biri geometri başarısının yaklaşık %4'ünü açıklamaktadır. Özellikle somutlaştırma boyutunun geometri başarısı üzerindeki etkisi diğer boyutlar göz önünde bulundurulduğunda daha düşük çıkmıştır. Elde edilen bulgular doğrultusunda doğrudan ve dolaylı olarak görsel matematik okuryazarlığı algısı boyutlarının geometri başarısı ile arasındaki ilişkiyi incelemenin gerekli olduğu sonucuna ulaşılmıştır. Duran ve Bekdemir (2013), görsel matematik okuryazarlığı öz-yeterlik algısının, görsel matematik başarısının anlamlı bir yordayıcısı olduğunu söylemişlerdir. Özgen ve Bindak (2011) çalışmalarında matematik dersi başarı puanının ve matematik dersine verilen önemin, matematik okuryazarlığı öz-yeterlik inancına yönelik anlamlı birer yordayıcı olduklarını tespit etmişlerdir. Bu çalışmaların yanında matematik başarısını yordayan faktörlerin neler olduğunu belirleyen çalışmalar da literatürde mevcuttur (Doğan ve Barış, 2010; Kayagil, 2010). Genel anlamda görsel matematik okuryazarlığı alt boyutlarının geometri başarısını yordama gücü düşük çıksa da anlamlı olması ilişkinin önemini ön plana çıkarmaktadır. Sonucun böyle çıkmasının sebebi, araştırmanın yalnız bir üniversitede yapılmış olması veya örneklem sayısının düşük olması olabilir. Ayrıca araştırmada örneklemin teste ve ölçeğe tüm bilgilerini yansıttıkları varsayılmıştır. Bu sınırlılıklar doğrultusunda ileride yapılacak olan çalışmalara, konuyla ilgili daha büyük örneklemler üzerinde araştırmaların yapılması, farklı sayısal bölümlerin görsel matematik okuryazarlık algılarıyla geometri başarıları arasındaki ilişkilerinin incelenmesi hâlihazırda bulunan matematik öğretmenleri üzerinde benzer uygulamalar yapılması ve sonuçlar doğrultusunda bu kavramlar hakkında eğitimlerin verilmesi önerilmiştir.