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A Meta-Synthesis About the Studies on Spatial Skills in Turkey[1]

Research Article

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ABSTRACT

Spatial abilities encompass the abilities like to imagine different positions of two- and three-dimensional objects by way of turning and rotating them in mind. They are key to success in a lot of areas, especially mathematics, geometry. Various fields including engineering, architecture, and even medicine require spatial abilities. Thus, they are significant abilities that need to be improved in mathematics education. In this study, studies carried out in Turkey on spatial abilities were examined. Especially the studies performed in the last decade (between 2008-2018) were reviewed. The method of the study is meta-synthesis. Total of 48 studies, including articles, theses and dissertations were reviewed but only 43 of them were included in the study. They were examined through content analysis in terms of publication year, objective, method, sampling level, data collection tool, data analysis method, implementation duration, results and recommendations. Data analysis revealed that studies were mostly carried out in order to examine the effect of computer-aided education on the development of students' spatial abilities. In addition, studies were found to be quantitative to a great extent and carried out experimentally. At the end of the study, recommendations were provided for spatial abilities and future studies in this field.

Keywords:
Spatial Skills, Spatial Visualization, Spatial Orientation, Meta-Synthesis

Introduction

Spatial ability involves the ability to rotate objects in space and picture different positions of two- and three-dimensional objects by way of mentally turning and rotating them. There are various definitions of spatial abilities in the literature. According to Linn and Petersen (1985), spatial ability is representing, transforming, generating, and recalling symbolic, nonlinguistic information whereas Tartre (1990) defines it as the abilities concerning visual comprehension, manipulation, organization or interpretation of relations. Spatial abilities are also defined as the ability to generate, retain, retrieve, and transform well-structured visual images (Lohman, 1993). Technical fields including engineering, architecture and three-dimensional design

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require high spatial abilities. Absence of a well-developed spatial ability may cause serious problems affecting one's academic performance and profession (Rafi, Samsudin & Said, 2008). Moreover, spatial abilities are believed to be significant for higher-order thinking in science and mathematics, the ability to generate metaphors in language, and creativity in many fields although they were once considered as lower levels of concrete thought (Lohman, 1993).

Spatial abilities are crucial in mathematics, especially in geometry achievement. Thus, they need to be improved in mathematics education. Spatial ability and success in mathematics are closely related. Research results revealed that individuals with high mathematics anxiety reported higher spatial anxiety, general anxiety, lower sense of direction and, through regression analyses, spatial anxiety, general anxiety, and small-scale spatial ability have been shown to be the strongest predictors of mathematics anxiety (Ferguson, Maloney, Fugelsang & Risko, 2015). Moreover, Sarama and Clements (2004) asserts children are better prepared for all school tasks when they gain the competences of geometric and spatial abilities. Spatial abilities are among the achievements of the mathematics curriculum wherein the development thereof is particularly emphasized (Ministry of National Education [MoNE], 2018).

Different studies identified various factors of spatial abilities. For instance, according to McGee (1979), there are two factors of spatial ability: spatial orientation and spatial visualization. Spatial visualization is "the ability to mentally rotate, manipulate, and twist two- and three-dimensional stimulus objects" (McGee, 1979, p. 896). Spatial orientation, on the other hand, is "the comprehension of the arrangement of elements within a visual stimulus pattern, the aptitude to remain unconfused by the changing orientations in which a spatial configuration may be presented, and the ability to determine spatial orientation with respect to one's body" (McGee, 1979, p. 897). Michael, Guilford, Fruchter and Zimmerman (1957) classified spatial abilities as spatial relations and orientation, visualization, and kinesthetic imagery. Spatial relations and orientation factor are the comprehension of order of the objects within a visual stimulus pattern with respect to the body of a given person. Spatial visualization involves the manipulation which is rotating, twisting or flipping over the visual objects in mind within a certain sequence of movements. Kinesthetic imagery is associated with right-left differentiation with respect to one's bodily location. According to Pellegrino, Alderton and Shute (1984), spatial abilities consist of two factors, namely spatial relations and spatial visualization. Two-dimensional spatial rotation, cube comparison and three-dimensional spatial rotation constitute the spatial relation whereas spatial visualization consists of form-board, paper folding and surface development. Such ordering of sub-abilities represents an ordering from speed to power and simple to complex (Pellegrino, Alderton & Shute, 1984). Linn and Petersen (1985) suggest three aspects of spatial ability: spatial perception, mental rotation, and spatial visualization. Spatial perception is the identification of spatial relations with respect to individuals' own bodily orientation. Mental rotation involves mentally rotating the stimulus through a Gestalt-like process. Spatial visualization, on the other hand, requires a multi-step process (paper folding tests involving folding a paper, making holes in the folded paper, finding the pattern of the holes on the unfolded paper).

Studies on spatial abilities have a long history (Lohman, 1979; Smith, 1964). Since a myriad of studies have been carried out in the field, there are a number of meta-analyses synthesizing the results thereof (Baenninger & Newcombe, 1989; Hyde & Linn, 1988; Linn & Petersen, 1985; Voyer, Voyer & Bryden, 1995). For instance, Linn and Petersen (1985) performed a meta-analysis of the relevant studies in order to examine the gender differences in terms of spatial abilities which revealed that there are gender differences with respect to some aspects of spatial abilities. The biggest gender difference was found to be in the mental rotation ability while the smallest in the spatial perception ability. In addition, various studies were carried out to examine the effects of various computer software programs on the development of spatial abilities (Gutierrez, Contero & Alcaniz, 2015; Gutierrez, Trujillo & Gonzalez, 2013; Hartatiana, Darhim & Nurlaelah, 2018; Merchant et al.

2013; Münzer, 2015; Yue, 2008); and the relationship between different variables such as spatial abilities, playing habits, and gender differences (Battista, Wheatley & Talsma, 1989; Guay & McDaniel, 1977; Lawton, 1994; Özcan, Akbay & Karakuş, 2016). Battista, Wheatley and Talsma (1989) investigated the relationship between the strategies used by pre-service elementary teachers in solving geometric problems and spatial visualization and reasoning. The results indicated that the two abilities are related to the problem-solving performance and the strategies that are utilized are related to the success in geometry course. Lawton (1994) investigated the differences in direction-finding strategies of female and male university students. Female students used a route strategy (following instructions to go from somewhere to another) more frequently while male students were more inclined to follow an orientation strategy (being aware of one's own location based on environmental reference points). In addition, when compared to males, females reported higher levels of spatial anxiety or anxiety about environmental navigation, which indicates a positive relationship between orientation strategy and spatial perception ability and negative relationship between orientation strategy and spatial anxiety.

This study aims to put forward a synthesis of studies carried out in Turkey on spatial abilities. Although there are meta-analyses about the studies on spatial skills, there is no meta-synthesis about the studies in Turkey. It is thought that this study will be useful for the literature about spatial skills and show the literature review of the studies in Turkey. Accordingly, the questions of the research can be listed as follows:

Considering the studies carried out on spatial abilities in Turkey between 2008-2018,

1. what is their distribution by years?
2. what are their objectives?
3. which methods do they use?
4. which designs do they use?
5. how do their sampling levels vary?
6. how does their number of samples vary?
7. how do their sample selection methods vary?
8. which data collection tools do they use?
9. which data analysis methods do they use?
10. what are the durations of implementations?
11. what kind of results do they reach?
12. what kind of recommendations do they make?

Method

Research Design

In the study, meta-synthesis method was used. Fraenkel, Wallen and Hyun (2011) states meta -analysis as a different type of research from quantitative, qualitative and mixed-method research methodologies and describes meta-analysis as *"an attempt to reduce the limitations of individual studies by trying to locate all of the studies on a particular topic and then using statistical means to synthesize the results of these studies"* (p. 16). DeWitt-Brinks and Rhodes (1992) defined meta-analysis as a method which is effective in reviewing, summarizing, and comparing existing research whereas in qualitative meta-analysis (meta-synthesis), the researcher uses descriptive narratives to describe and explain the findings of each study rather than using statistical methods. According to Sandelowski and Barroso (2003), the aim of meta-synthesis is not only collecting the research findings into one whole, but also interpreting them, which will result in a general understanding with respect to the nature of the phenomenon. In meta-synthesis, the data are reanalyzed through a new technique or a new question. It is a systematic approach where it encompasses a set of rules concerning selection of studies,

summary of findings, combination of opposite findings, and synthesis and interpretation of findings (Sandelowski & Barroso, 2003). In this meta-synthesis, the studies on spatial skills in Turkey were summarized and the results were presented by comparing the studies.

Data Collection Tools

Databases of Web of Science, Ebscohost, Google Scholar, National Thesis Center of the Council of Higher Education and the Turkish Academic Network and Information Centre of TUBITAK (ULAKBIM) were utilized in terms of literature review. Studies carried out in Turkey between 2008 and 2018 were included in the study. The key words "spatial ability", "spatial", "mental rotation", "spatial visualization", and "spatial orientation" were searched. Total of 48 studies were found. However, five of them consisting of theses and dissertations that are not open access, articles created from theses or dissertations, theoretical articles, and materials which are not allowed to full-text access were not included in the meta-synthesis. The remaining 43 articles and graduate theses and dissertations were included in the meta-synthesis. The studies are presented in appendix.

Data Analysis

The studies were examined through content analysis method and analyzed in terms of publication year, objective, method, design, sampling level, number of samples, sample selection method, data collection tool, data analysis method, implementation duration, results, and recommendations. First of all, content analysis was performed on the articles and tables were created based on the themes determined. The studies were interpreted based on their frequency. Their percent values were calculated and presented in the section of results. The articles were coded as S1, S2, ... (Study1: S1, Study2: S2, …) and given in the tables.

Findings

The results in Table 1 were obtained by examining the distribution of studies on spatial abilities by years.

Table 1. Distribution of Studies by Years

Year	f	%	Studies
2008	3	6,98	S13, S25, S31
2009	1	2,33	S32
2010	4	9,3	S1, S2, S14, S33
2011	4	9,3	S10, S15, S29, S34
2012	4	9,3	S3, S16, S30, S39
2013	6	14	S6, S9, S12, S19, S38, S40
2014	4	9,3	S7, S8, S11, S37
2015	2	4,65	S21, S24
2016	4	9,3	S5, S18, S23, S28
2017	7	16,3	S17, S22, S26, S27, S35, S42, S45
2018	4	9,3	S44, S46, S47, S48
Total	43	100	

As can be seen in Table 1, studies on spatial abilities were carried out each year between 2008 and 2018 and the most studies were carried out in 2013 (f=6) and 2017 (f=7).

Results in Table 2 were obtained by examining the studies in terms of their objectives.

Table 2. Distribution of Studies by Objectives

Objectives	f	%	Studies
The effects of Computer Aided Education (CAE) on the development of spatial abilities	29	67,4	S3, S5, S7, S8, S9, S10, S11, S12, S14, S15, S16, S17, S18, S19, S21, S22, S24, S25, S27, S28, S29, S30, S31, S32, S33, S34, S38, S39, S40
Examining the relationship between spatial abilities and different variables	7	16,3	S23, S26, S37, S44, S45, S46, S48
Both examining the relationship between spatial abilities and different variables and identifying the effect of CAE on the development of spatial abilities	2	4,65	S2, S47
Examining spatial abilities of the sample based on different variables	2	4,65	S6, S42
Identifying the effect of activities (other than CAE) performed to improve spatial abilities on the development of spatial abilities	2	4,65	S1, S13
Spatial self-assessment	1	2,33	S35
Total	43	100	

As seen in Table 2, when studies on spatial abilities were classified based on their objectives, most of the studies examined the effect of computer aided education on the development of spatial abilities (f=29).

Results in Table 3 were obtained by examining the studies in terms of their method.

Table 3. Distribution of Studies by Methods

Methods	f	%	Studies
Quantitative methods	35	81,4	S2, S3, S6, S7, S8, S10, S11, S12, S16, S18, S21, S22, S23, S24, S25, S26, S27, S28, S29, S30, S31, S32, S33, S34, S35, S37, S38, S39, S40, S42, S44, S45, S46, S47, S48
Mixed research methods	7	16,3	S5, S9, S13, S14, S15, S17, S19
Qualitative methods	1	2,33	S1
Total	43	100	

Table 3 has shown that studies on spatial abilities in Turkey were mostly carried out using quantitative methods (f=35).

Table 4 shows the distribution of studies by their designs.

Table 4. Distribution of Studies by Designs

Designs	f	%	Studies
Experimental	17	39,5	S3, S5, S10, S11, S12, S18, S27, S28, S29, S30, S31, S32, S33, S34, S38, S39, S40
Experimental + interviews	10	23,3	S7, S8, S13, S16, S17, S19, S21, S22, S24, S25
Relational screening	6	14	S23, S26, S37, S44, S46, S48
Causal-comparative	2	4,65	S35, S45
Action research	2	4,65	S1, S9
Relational + experimental	2	4,65	S2, S47
Time series	1	2,33	S6
Experimental + case study	1	2,33	S15
Experimental + action research	1	2,33	S14

Design was not indicated	1	2,33	S42
Total	43	100	

As can be seen in Table 4, the studies were mostly found to be experimental (f=17). Total number of the studies which utilized the experimental design is 31 (experimental f=17, combination of experimental design and interviews f=10, combination of relational and experimental designs f=2, combination of experimental and case study f=1, combination of experimental and action research f=1). Such studies outnumbered the other types of studies.

The distribution of studies on spatial abilities by their sample levels were presented in Table 5.

Table 5. Distribution of Studies by Sample Levels

Sample Levels	f	%	Studies
Secondary school students	18	41,9	S1, S7, S8, S10, S11, S13, S14, S16, S18, S19, S20, S22, S25, S29, S39, S40, S44, S47
Pre-service teachers	15	34,9	S2, S6, S12, S15, S24, S26, S28, S31, S32, S33, S34, S38, S42, S45, S46
University students	4	9,3	S5, S23, S27, S37
High school students	3	6,98	S3, S9, S21
Teachers	1	2,33	S35
Primary school students	1	2,33	S48
Preschool students	1	2,33	S37
Total	43	100	

As can be seen in Table 5, studies on spatial abilities were mostly performed with pre-service teachers (f=15) and secondary school students (f=18).

Results in Table 6 were obtained by examining the studies on spatial abilities with respect to the number of the participants.

Table 6. Distribution of Studies by Sample Size

Sample Size	f	%	Studies
11-100	33	76,7	S1, S3, S5, S6, S7, S8, S9, S11, S12, S13, S14, S15, S16, S17, S18, S19, S21, S22, S24, S25, S27, S28, S29, S30, S31, S32, S33, S34, S37, S38, S39, S40, S47
101-200	6	14	S10, S23, S26, S35, S46, S48
201-500	3	6,98	S2, S44, S45
More than 500	1	2,33	S42
Total	43	100	

According to Table 6, 33 of the studies (f=33) used 11-100 participants, which was the highest number of sample size.

Results in Table 7 were obtained by classifying the studies based on their sample selection method.

Table 7. Distribution of Studies by Sample Selection Methods

Sample Selection Methods	f	%	Studies
Sampling method was not indicated	32	74,4	S1, S2, S6, S7, S8, S10, S11, S12, S14, S15, S16, S18, S19, S21, S22, S24, S26, S27, S28, S29, S30, S31, S32, S33, S34, S35, S37, S38, S39, S40, S42, S47
Convenience sampling	4	9,3	S3, S9, S13, S25
Random sampling	3	6,98	S17, S23, S45
Criterion sampling	2	4,65	S44, S46
Purposive sampling	2	4,65	S5, S48
Total	43	100	

As can be seen in Table 7, sampling method was not indicated in the most of the studies (f=32).

Results in Table 8 were obtained by examining the studies on spatial abilities with respect to their data collection tools.

Table 8. Distribution of Studies by Data Collection Tools

Data Collection Tools	f	%	Studies
Spatial ability tests	41	45,1	S1, S2, S3, S5, S6, S8, S9, S10, S11, S12, S13, S14, S15, S16, S17, S18, S19, S20, S21, S22, S23, S25, S26, S27, S28, S29, S30, S31, S32, S33, S34, S36, S38, S39, S40, S42, S44, S45, S46, S47, S48
Alternative data collection tools	17	18,7	S2, S3, S5, S7, S14, S19, S20, S21, S24, S26, S29, S35, S37, S39, S44, S45, S47
Interview forms	16	17,6	S5, S7, S8, S9, S13, S15, S16, S17, S19, S21, S22, S24, S25, S36, S42, S43
Achievement tests	10	11	S2, S8, S9, S12, S16, S19, S21, S28, S34, S48
Scales	7	7,69	S7, S9, S13, S14, S18, S21, S25
Total	91	100	

Table 8 has revealed that 41 of the studies on spatial abilities (f=41) utilized spatial ability tests. So the studies were found to use mainly spatial ability tests.

Results in Table 9 were obtained by examining the studies in terms of their data analysis methods.

Table 9. Distribution of Studies by Data Analysis Methods

Analysis Methods	f	%	Studies
t test	20	24,4	S3, S8, S10, S12, S16, S17, S21, S22, S23, S24, S26, S27, S28, S30, S31, S32, S35, S40, S46, S47
Mann Whitney U	11	13,4	S2, S11, S14, S15, S17, S18, S19, S29, S33, S35, S48
ANOVA	10	12,2	S5, S6, S13, S21, S23, S35, S37, S42, S45, S46
Wilcoxon	8	9,76	S2, S15, S17, S18, S19, S29, S33, S38
ANCOVA/MANCOVA	7	8,54	S10, S21, S25, S28, S32, S39, S40
Correlation	6	7,32	S16, S23, S26, S37, S44, S47
Descriptive analysis	6	7,32	S1, S5, S9, S15, S16, S22
Content analysis	4	4,88	S13, S14, S19, S21
Regression	3	3,66	S7, S26, S28
Chi-squared test	3	3,66	S3, S26, S37
Kruskal-Wallis	2	2,44	S15, S39
Spearman Brown rank correlation coefficient	1	1,22	S48
Data mining	1	1,22	S7
Total	82	100	

As can be seen in Table 9, the studies on spatial abilities were analyzed by means of parametric and nonparametric methods. The studies predominantly adopted t test (f=20) as the data analysis tool.

Table 10 has presented the duration of studies carried out on spatial abilities.

Table 10. Distribution of Studies by Duration

Duration		**f**	**%**	**Studies**
Weeks	0-4 weeks	10	23,3	S2, S3, S5, S8, S17, S21, S25, S29, S38, S47
	5-8 weeks	9	20,9	S4, S7, S12, S15, S16, S27, S30, S31, S33
	9-12 weeks	5	11,6	S13, S22, S28, S32, S39
	14 weeks	1	2,33	S9
Hours	9-10 hours	2	4,65	S1, S19
	12-16 hours	2	4,65	S11, S14
One term		1	2,33	S34
The duration was not indicated		3	6,98	S10, S18, S24
Nonexperimental		10	23,3	S6, S23, S26, S35, S37, S42, S44, S45, S46, S48
Total		43	100	

Distribution of studies by their duration as shown in Table 10 revealed that 10 studies were nonexperimental (f=10) and a total of 10 studies were performed in 0-4 weeks.

The results obtained from the studies presented in Table 11.

Table 11. Distribution of Studies by Results

Results	**f**	**%**	**Studies**
Oriented towards intervention	30	69,8	S3, S5, S7, S8, S9, S10, S11, S12, S13, S14, S15, S16, S17, S18, S19, S21, S22, S24, S25, S27, S28, S29, S30, S31, S32, S33, S34, S38, S39, S40
Relational	6	14	S23, S26, S37, S 44, S45, S48
Oriented towards description	4	9,3	S1, S35, S42, S46
Oriented towards intervention + relational	2	4,65	S2, S47
Oriented towards description and Developing an assessment tool	1	2,33	S6
Total	43	100	

As can be seen in Table 11, the highest frequency of the results obtained from the studies were oriented towards intervention (f=30) and then relational (f=6). Since the studies were predominantly carried out experimentally, the results are mostly related to the effect of experimental intervention.

The analysis of the studies revealed that the recommendations were made for the headings presented in Table 12.

Table 12. Distribution of Studies by Recommendations

Recommendations	f	%	Studies
Recommendations for future research	26	60,5	S2, S3, S5, S6, S7, S8, S9, S10, S11, S13, S15, S16, S17, S18, S21, S22, S23, S26, S33, S38, S39, S40, S42, S46, S47, S48
Recommendations for implementation	12	27,9	S1, S12, S14, S24, S25, S27, S29, S30, S31, S34, S37, S44
Recommendations implementation + future research	5	11,6	S19, S28, S32, S35, S45
Total	43	100	

As can be seen in Table 12, recommendations were mostly included in the studies for future research (f=26).

Discussion and Conclusion

Spatial abilities include the abilities of imagining new states of objects by way of such processes as turning, rotating, unfolding or folding them in mind. Individuals should have these important abilities which are required by many professions. Thus, the students need to improve their spatial abilities from a young age. Myriad of studies have been carried out on spatial abilities. Differently, this study examines those conducted on spatial abilities over the past decade in Turkey. The results revealed that the studies in this field were mostly aimed at analysing the effect of computer aided education, especially the three-dimensional modeling software, on the development of spatial abilities. Rapid advancement in computer and communication technologies, increase in three-dimensional modeling softwares, and increase in the time of students spend on computers might be the reasons to this effort. In the age of technology, children spend time with computers from a very young age and it is very important to investigate the effects of computer applications in education. In this context, Yolcu and Kurtuluş (2010) attempted to improve the spatial visualization abilities of sixth grade students by means of concrete materials and computer applications, which revealed that both improved the students' abilities. Werthessen (1999) also found out that hands-on three-dimensional materials have a positive effect on the mental rotation, spatial visualization, and self-efficacy performances of primary school students. Accordingly, Olkun and Altun (2003) found that children who had a computer or got familiar with computers at a young age were more successful in geometry compared to those who did not. At the same time, these researchers didn't find significant difference between spatial and geometric thinking skills of students who do the activities like playing, drawing or play word processing on computers and don't do these activities. The authors attributed this situation to the lack of spatial content of such works on computers. Özcan, Akbay and Karakuş (2016) identified a positive correlation between spatial abilities and computer and game experiences. From these results, it is understood that playing computer games is important for the development of spatial skills, but the type of computer games play a significant role on spatial skills. Of course, more research is needed to investigate the effects of game types on spatial skills.

The studies carried out on spatial abilities were found to be mostly based on quantitative methods and experimental studies outnumbered those of other types. Although experimental design is important in terms of showing the effect of the adopted method on the development of spatial abilities; through qualitative methods, in-depth insights on the subject can be obtained and more detailed conclusions based on cause-effect relationship can be found with respect to mental development of students. In particular, the rareness of qualitative studies about this subject clearly suggests that future studies should focus on qualitative methods. At the end of the research, it was also found that most of the studies in this field were performed with secondary school students and pre-service teachers. Since spatial abilities need to be developed from an early age, it is important to increase the number of studies performed on smaller age groups, and even to monitor

the development of these abilities at all levels of education. Especially the studies that will be conducted in early education and primary education will develop the literature in this field.

Another finding obtained at the end of data analysis was that studies were highly performed in 2013 and 2017. Considering the wide range of areas where spatial abilities can be used, the number of studies is expected to increase year by year. However, studies were mainly carried out in 2013 and 2017 while there are less studies in other years, which is an unexpected situation. Spatial abilities need to be investigated due to its various aspects in every education level and the other areas of life. Researchers should introduce different perspectives to the field by performing various studies on the topic. In addition, sampling methods were not indicated in most of the studies. Researchers should pay special attention to indicate their sampling methods in their studies.

Since the studies were mostly experimental, they were carried out using small samples and mainly t test was utilized in data analysis. Thus, the results were mostly related to the effect of intervention. Such results were mainly caused by the adoption of a single type of research design (experimental design). Future studies to be carried out with different methods and designs will both contribute to the field and guide the scholars, teachers, programmers, and policy makers by broadening their horizons. Another issue to point out is that, various recommendations were made not only for new implementations but also for future research just based on a low number of studies. This is another point that should be taken into consideration by the researchers.

Recommendations

Some recommendations according to the results of the research are as follows;

1. The effect of different teaching materials except of computer applications on the development of spatial abilities needs to be explored.
2. Spatial abilities need to be investigated due to its various aspects by not only quantitative methods but also qualitative methods.
3. The studies that will be conducted in all education levels will develop the literature in this field.
4. Researchers should pay attention to the different parts of their studies; especially indicate their sampling methods. Recommendations should be made not only for new implementations but also for future research.

GENİŞLETİLMİŞ ÖZET

Türkiye'de Uzamsal Beceriler Alanında Yapılan Çalışmalarla İlgili Bir Metasentez

Giriş

Uzamsal yetenekler nesnelerin uzayda döndürülmesi, iki boyutlu ve üç boyutlu cisimlerin zihinde çevrilerek veya döndürülerek farklı konumlarının hayal edilmesi gibi becerileri içermektedir. Uzamsal yeteneği; sembolik ve dilsel olmayan bilginin temsili, dönüştürülmesi, oluşturulması ve yeniden çağrılması (Linn ve Petersen, 1985) veya ilişkileri görsel olarak anlama, manipüle etme, yeniden düzenleme veya yorumlama ile ilgili zihinsel beceriler (Tartre, 1990) olarak tanımlamak mümkündür. Teknik alanlar, mühendislik, mimari ve üç boyutlu tasarım gibi alanlar yüksek uzamsal beceri gerektirir. Gelişmemiş bir uzamsal yetenek kişinin akademik hayatı veya mesleğinde ciddi sorunlarla karşılaşmasına neden olabilir (Rafi, Samsudin ve Said 2008). McGee (1979) uzamsal yeteneğin uzamsal yönelim ve uzamsal görselleştirme olmak üzere iki alt boyuttan oluştuğunu ifade etmektedir. Uzamsal görselleştirme, iki ve üç boyutlu nesneleri zihinsel olarak çevirme, bükme ve manipüle etme yeteneğini; uzamsal yönelim ise, görsel bir uyaran örüntüsü içindeki nesnelerin düzenini kavrama, kişinin bedenine göre uzamsal yönelimi belirleyebilme yeteneğini içermektedir (McGee, 1979).

Uzamsal yetenekler alanındaki çalışmaların çeşitli bilgisayar programlarının uzamsal becerilerin gelişimine etkisinin incelenmesi (Hartatiana, Darhim ve Nurlaelah, 2018; Martin-Gutierrez ve diğ. 2010; Merchant ve diğ. 2013; Münzer, 2015; Yue, 2008); uzamsal beceriler ile oyun oynama alışkanlıkları, cinsiyet farklılıkları gibi farklı değişkenler arasındaki ilişkilerin incelenmesi (Battista, Wheatley ve Talsma, 1989; Guay ve McDaniel, 1977; Lawton, 1994; Özcan, Akbay ve Karakuş, 2016) gibi konularda yapıldığı görülmektedir. Bu çalışmada ise uzamsal becerilerle ilgili özellikle Türkiye'de yapılmış çalışmalardan bir sentez yapılması amaçlanmıştır. Bu amaç doğrultusunda, araştırmanın soruları şu şekilde sıralanabilir. 2008- 2018 yılları arasında Türkiye'de uzamsal becerilerle ilgili yapılan çalışmalar;

1. yıllara göre nasıl dağılmaktadır?
2. hangi amaçlarla yapılmıştır?
3. hangi yöntemlerle yapılmıştır?
4. hangi desenlerle yapılmıştır?
5. örneklem düzeyi nasıl değişmektedir?
6. örneklem sayısı nasıl değişmektedir?
7. örneklem seçim yöntemleri nasıl değişmektedir?
8. hangi veri toplama araçları kullanılmıştır?
9. hangi veri analiz yöntemleri kullanılmıştır?
10. yapılan uygulamaların süresi ne kadardır?
11. ne tür sonuçlara ulaşılmıştır?
12. ne tür öneriler sunulmuştur?

Yöntem

Çalışmada meta-sentez yöntemi kullanılmıştır. Son on yılda Türkiye'de uzamsal beceriler alanında yapılmış çalışmalar incelenerek metasentez yöntemiyle biraraya getirilmiştir. Çalışmalar taranırken Web of Science, Google Akademik, YÖK Ulusal Tez Merkezi, TÜBİTAK ULAKBİM, Ebscohost veritabanları

kullanılmıştır. Çalışmaya 2008-2018 yılları arasında Türkiye'de yapılan çalışmalar dahil edilmiştir. Taramalar "uzamsal beceri", "uzamsal", "zihinsel döndürme", "uzamsal görselleştirme", "uzamsal yönelim" ve İngilizce karşılıkları anahtar kelimeler olarak kullanılarak gerçekleştirilmiş ve toplam 48 adet çalışmaya ulaşılmış, ancak erişime açık olmayan tez, tezden yapılan makaleler, kuramsal makale ve tam metnine ulaşılamayan çalışmalar nedeniyle toplam 43 adet makale ve lisansüstü tezden oluşan çalışma metasenteze dahil edilmiştir. Çalışmalar içerik analizi yöntemiyle incelenmiş ve yayın yılı, amaç, yöntem, desen, örneklem düzeyi, örneklem sayısı, örneklem seçim yöntemi, veri toplama aracı, veri analiz yöntemi, uygulama süresi, sonuç ve öneri gibi başlıklar çerçevesinde analize tabi tutulmuştur. Öncelikle ulaşılan makalelere belirlenen temalar doğrultusunda içerik analizi yapılmış ve tablolar oluşturulmuştur. Bu çalışmalar frekansları doğrultusunda yorumlanmıştır.

Bulgular

Uzamsal beceriler alanında yapılan çalışmaların yıllara göre dağılımı incelendiğinde, 2008 ve 2018 yılları arasında her yıl uzamsal beceriler alanında çalışmalar yapıldığı görülmektedir. Ancak çalışmaların ağırlıklı olarak 2013 ve 2017 yıllarında yapıldığı görülmüştür. Amaçları açısından çalışmaların, Bilgisayar Destekli Öğretimin (BDÖ) uzamsal becerilerin gelişimine etkisi, uzamsal becerilerle farklı değişkenler arasındaki ilişkinin incelenmesi, hem uzamsal becerilerle farklı değişkenler arasındaki ilişkinin incelenmesi hem de BDÖ'nün uzamsal becerilerin gelişimine etkisi, uzamsal becerilerin çeşitli değişkenlere göre incelenmesi gibi başlıklarda toplandığı tespit edilmiştir. Ancak yapılan çalışmaların büyük çoğunluğunda bilgisayar destekli öğretimin uzamsal becerilerin gelişimine etkisinin incelendiği görülmüştür.

Çalışmalar yöntemlerine göre incelendiğinde, ağırlıklı olarak nicel yöntemler kullanılarak gerçekleştirildiği, ancak karma ve az da olsa nitel yöntemlerin uygulandığı çalışmaların da yapıldığı görülmüştür. Desenlerine göre, deneysel, deneysel ve görüşme, ilişkisel tarama, nedensel-karşılaştırmalı, aksiyon eylem araştırması, ilişkisel ve deneysel bir arada, zaman serileri gibi temalarda çalışmalar yapıldığı görülmüştür. Çalışmaların örneklem türleri incelendiğinde öğretmen adayları, ilkokul, okul öncesi, ortaokul, üniversite, lise öğrencileriyle, öğretmenlerle gerçekleştirildiği tespit edilmiştir. Ancak en fazla sayıda çalışma ortaokul öğrencileri ve öğretmen adaylarıyla yapılmıştır. Ancak araştırmaların büyük çoğunluğunda örneklem seçim yöntemi belirtilmemiştir. Çalışmalar veri toplama araçları açısından incelenmiş ve çalışmalarda en fazla sayıda uzamsal yetenek testlerinin kullanıldığı görülmüştür. Çalışmalar parametrik ve nonparametrik yöntemler kullanılarak analiz edilmiştir. Araştırmalarda en fazla kullanılan veri analiz yöntemi t testidir. Uygulama süresi açısından çalışmaların en fazla 0-4 hafta arasına gerçekleştirildiği ve çalışmalarda en fazla müdahaleye yönelik sonuçlara ulaşıldığı dikkat çekmiştir. Yapılan önerilerin ise yeni araştırmalara, uygulamaya ve hem uygulamaya hem de yeni araştırmalara yönelik olarak yapıldığı tespit edilmiştir.

Tartışma ve Sonuç

Uzamsal beceriler nesnelerin zihinde çevrilmesi, döndürülmesi, açılması ya da katlanması gibi işlemler sonucu yeni oluşacak hallerinin hayal edilmesi becerilerini kapsamaktadır ve birçok meslek dalının gerektirdiği, bireylerin sahip olması gereken önemli becerilerdir. Bu çalışmada Türkiye'de uzamsal beceriler alanında son on yılda yapılan çalışmalar incelenmiştir. Araştırma sonucunda ülkemizde bu alanda yapılan çalışmaların çoğunlukla bilgisayar destekli öğretimin, özellikle üç boyutlu modelleme programlarının, uzamsal becerilerin gelişimine etkisini incelemek amacıyla yapıldığı tespit edilmiştir. Bu durum üzerinde, bilgisayar ve iletişim teknolojileri alanında yaşanan hızlı gelişim, üç boyutlu modelleme programlarındaki artış ve öğrencilerin bilgisayar başında geçirdikleri vaktin artması etken olmuş olabilir. Nitekim Olkun ve Altun (2003) küçük yaşta bilgisayar sahibi olan veya bilgisayarla erken yaşta tanışan çocukların diğerlerine göre geometri başarılarının daha yüksek olduğunu bulmuşlardır. Uzamsal beceriler alanında yapılan çalışmaların ağırlıklı olarak nicel yöntemler kullanılarak gerçekleştirildiği, ayrıca yapılan deneysel

çalışmaların diğer tüm türlerden daha fazla sayıda olduğu anlaşılmıştır. Deneysel desen kullanılan yöntemin uzamsal becerinin gelişimi üzerindeki etkisini göstermesi bakımından önemli bir yöntemdir ancak aynı konu nitel yöntemlerle de incelenerek konuyla ilgili derinlemesine bilgi edinilebilir, öğrencilerin zihinsel gelişimi açısından daha ayrıntılı ve sebep-sonuç ilişkisine dayalı çıkarımlar yapılabilir. Özellikle yapılan araştırmalarda nitel çalışmanın azlığı bu alana yönelinmesi gerektiğini açıkça ortaya koymaktadır. Bu alanda en fazla sayıda çalışmanın ortaokul öğrencileri ve öğretmen adaylarıyla yapıldığı görülmüştür. Uzamsal beceriler küçük yaşlardan itibaren geliştirilmesi gereken beceriler olduğu için daha küçük yaş gruplarında da yapılan çalışmaların artırılması, hatta tüm eğitim seviyelerinde bu becerilerin gelişiminin takip edilmesi önemlidir. Farklı yöntem ve desenlerde gerçekleştirilecek araştırmalar hem alana katkı sağlayacak hem de bu konuda çalışan akademisyen, eğitimci, programcı ve politika yapıcılara yol gösterecek, yeni ufuklar açacaktır. Burada belirtilmesi gereken diğer bir nokta çok düşük sayıda araştırmadan sonra hem yeni uygulamalara yönelik hem de yeni araştırmalara yönelik önerilerin yapılmış olmasıdır. Araştırmacıların çalışmalarında bu konuya da dikkat etmesi yerinde olacaktır.

Appendix. The studies used in the meta-synthesis

Symbol	Investigator	Description
S1	Yolcu & Kurtuluş (2010)	Developing the students' spatial visualization abilities
S2	Turğut (2010)	Examining the effect of technology based instruction on pre-service teachers' spatial abilities
S3	Yılmaz (2012)	The comparison of the effects of model – based and computer – based instruction on the students' spatial abilities
S5	Akkuş (2016)	Examining the effects of augmented reality applications on the spatial abilities
S6	Yüksel (2013)	Examining the effects of computer based applications on the spatial abilities
S7	Özlü (2014)	Analyzing the effects of the 3d virtual environment on the spatial abilities of the students
S8	Gün (2014)	Effects of augmented reality applications on students' spatial abilities
S9	Karaaslan (2013)	Searching for the effects of the computer-assisted activities on students' performances, spatial skills
S10	Yıldız & Tüzün (2011)	Effects of using three dimensional virtual environments and concrete manipulatives on spatial ability
S11	Şimşek & Yücekaya (2014)	The effect of the teaching by the dynamic geometry software on the students' spatial ability
S12	Akıllı & Seven (2014)	The effects of 3d computer models to academic achievement and spatial ability
S13	Bayrak (2008)	Investigation of effect of visual treatment on the student's spatial ability and attitude toward spatial ability problems
S14	Turhan (2010)	The effects of computer aided perspective drawings on the students' spatial ability
S15	Uygan (2011)	Examining the effects of Google SketchUp and concrete models (CM) on various skills within spatial ability
S16	Başaran Şimşek (2012)	The effect of utilizing the dynamic geometry software on the elemantary school students' spatial ability
S17	Parmaksız (2017)	Augmented reality activities for improving spatial skills
S18	Çalışkan (2016)	Researching the effects of instruction of the solid matters assisted with dynamic geometry softwares on the students' spatial thinking
S19	Uzun (2013)	The effect of using dynamic geometry software on student's spatial ability
S21	Akbay (2015)	The effect of designing in digital game environment on spatial ability of students
S22	Dere (2017)	the effects of using web based 3d design applications on spatial visualisation and mental rotation abilities
S23	Özcan, Akbay & Karakuş (2016)	The effects of gaming habits of students on their spatial skills
S24	Mumcu & Yıldız (2015)	Examining the effect of a web-based instructional material supporting spatial thinking
S25	Boyraz (2008)	The effects of computer based instruction on seventh grade students' spatial abilities
S26	Hacıömeroğlu & Hacıömeroğlu (2017)	Examining the relationship between spatial ability and different variables
S27	Karakus & Aydin (2017)	The effects of computer algebra system on the students' spatial visualization skills
S28	Kösa (2016)	The effects of using dynamic mathematics software on preservice mathematics teachers' spatial visualization skills

S29	Kurtuluş (2011)	The effect of computer-aided perspective drawings on spatial orientation and perspective drawing achievement
S30	Toptas, Çelik & Karaca (2012)	Improving spatial thinking abilities through a 3d modeling program
S31	Güven, B. & Kosa, T. (2008).	Examining the effect of dynamic geometry software on student teachers' spatial visualization skills
S32	Baki, Kosa & Guven (2011)	Comparing the effects of using dynamic geometry software and physical manipulatives on the spatial visualisation skills
S33	Kurtulus & Uygan (2010)	The effects of google sketchup based geometry activities and projects on spatial visualization ability
S34	Alkan & Erdem (2011)	A study on developing candidate teachers' spatial visualization and graphing abilities
S35	Yılmaz (2017)	Preservice mathematics teachers' self–report levels on spatial ability
S37	Yıldırım & Zengel (2014)	The impact of cognitive styles on design students' spatial knowledge from virtual environments
S38	Kurtuluş (2013)	Observing the relation between the cognitive style and spatial knowledge acquisition from virtual environment
S39	Yurt & Sünbül (2012)	The effect of modeling-based activities developed using virtual environments and concrete objects on spatial skills
S40	Erkoc, Gecu & Erkoc (2013)	The effects of using google sketchup on the mental rotation skills of students
S42	Erkek, Işıksal & Çakıroğlu (2017)	Investigating the pre-service teachers' spatial visualization ability and spatial anxiety levels with respect to their gender and undergraduate programs
S44	Gürbüz, Erdem & Gülburnu (2018)	The relationship between mathematical reasoning and spatial ability of the students
S45	Turgut, Yenilmez & Balbağ (2017)	Examining the prospective teachers' logical and spatial thinking skills according to various variables
S46	Abay, Tertemiz & Gökbulut (2018)	Examining the spatial skills according to several variables
S47	Kösa & Kalay (2018)	Evaluation of the learning environment designed for developing the spatial orientation skills
S48	Altıner (2018)	Examining the relationship between spatial thinking and puzzle games of the students

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