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Effects of computer game experiences on children's spatial abilities

By

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Abstract

The purpose of this study is to determine the relationships among children's computer game experiences and their spatial abilities. The study was carried out by surveying 769 children between 11-13 years of age (6th, 7th, and 8th graders) to determine their game preferences (2D or 3D) in terms of gender and grade. Spatial ability test scores were compared in terms of gender, grade, game playing time, game practice, and game preferences. Results revealed that game preferences were differentiated significantly due to gender but not in terms of grade level. Results indicated no significant difference in spatial ability test scores due to gender, playing time, or game preferences; however, grade levels and game practice did indicate significant differences in scores.

Keywords: *Spatial ability, mental rotation, computer games, game experiences*

1. Introduction

Day by day, the rate of computer ownership is growing; consequently, the average introductory age for computer usage is decreasing, while time spent on digital devices is increasing. According to the results of TUIK (Turkish Statistical Institute), among Turkish 11–15 year olds, the average age for starting to use a computer is 10 and 11 for having a mobile phone. Computer, Internet, and mobile phone usage by children in the same group was 73.1%, 65.1%, and 37.9%, respectively. Among children aged 6–15, 24.4% own personal computers. Moreover, cell phones are used for gaming by 62.9% of children aged 6-10 and 29.4% of children aged 11–15. Among the 6–15 year olds, on a weekly basis, 38.2% accessed the Internet for almost two hours; 47.4 %, 3–10 hours; and 11.8%, 11–24 hours. The rest reported accessing the Internet for more than 24 hours in a week, and 79.5% of the children reported using the Internet for gaming (TUIK, 2013).

In the United States of America, the Economics and Statistics Administration and the National Telecommunications and Information Administration (2011) reported that the percentage of children between 6 and 17 years of age who have access to the Internet is very high. Around 86% have home computers, and 78% have broadband Internet access at home. According to another report about Internet risks and safety in Europe, 60% of 9–16 year old users access the Internet every day or almost every day, and 83% of those children are using it to play games (Livingstone, Haddon, Görzig, & Ólafsson, 2011).

In addition, some researchers have found that boys play computer games more than girls (Cherney & London, 2006; Greenberg, Sherry, Lachlan, Lucas, & Holmstrom, 2010; Homer, Hayward, Frye, & Plass, 2012; İnal & Çağıltay, 2005; Lowrie & Jorgensen, 2011; Onay, Tufekci, & Cagiltay, 2005) and that boys prefer to play fantasy, violence, sports, action, and adventure games, while girls prefer entertainment, adventure, action, and educational games (Cherney & London, 2006). Homer et al. (2012) stated that the favorite game genre for the majority of middle school-aged boys was the FPS or first person shooter; girls' favorites featured virtual worlds. Vermeulen, Van Looy, De Grove, and Courtois (2011) stated that females have a tendency to prefer abstract, short, and easy to control games such as casual and social network games, but boys have the tendency to play core games, generally with higher quality 3D graphics.

With increases in the number of computer and Internet users, the effect of these technologies on children has become a popular issue. Despite commonly known consequences of computers and the Internet on children's activities and development, possible positive results also deserve recognition. Computer usage can alter children' cognitive skills from verbal to visual, and video or computer games especially can prepare children to understand the visual processes of science and technology (Subrahmanyam, Kraut, Greenfield, & Gross, 2001). Moreover, the goal-oriented nature of computer games may explain a change in cognitive skills of players (Greenfield, 1996). Some studies have shown that activities like computer games might be connected to spatial skill development, as well (Weckbacher & Okamoto, 2012; Quaiser-Pohl et al., 2006). The relationship between children's spatial abilities and their computer game preferences will be examined in this study.

2. Background of the Study

In the literature, spatial ability and skills have been explained by researchers from different points of view. Linn and Petersen (1985) defined spatial ability as the mental process to perceive, store, recall, edit, and communicate spatial images based on three factors, mental rotation, spatial visualization, and spatial perception. Similarly, Contero, Naya, Company, Saorin, and Conesa (2005) mentioned three components to spatial abilities: relationships, visualizations, and orientations. Moreover, Olkun (2003) also identified spatial relations and visualization as key elements. In short, spatial cognitive skills make it possible for human beings to imagine mental representations of real life objects from different perspectives. Thus, spatial ability is important in fields such as science, technology, engineering, mathematics, psychology, and education (Wai, Lubinski, & Benbow, 2009).

In their study, Maeda and Yoon (2013) investigated the impact of gender difference on spatial ability performance. Out of a pool of 181 studies, they culled their results from 40 that met designated criteria, finding that males consistently outperformed females on spatial ability performance tests. Studies about grade differences have also shown that students in upper grades have better spatial abilities than their peers (Neuburger, Jansen, Heil, & Quaiser-Pohl, 2011).

According to some researchers, spatial abilities can be developed by video games (de Aguilera & Mendiz, 2003; Greenfield, 1993; Okagaki & Frensch, 1994; De Lisi & Wolford, 2002) and computer-supported activities (Greenfield, 1993; Guven & Kosa, 2008). One cognitive study showed that computer games can teach children to picture and interpret objects by tracking them in 3D space (Subrahmanyam, Kraut, Greenfield, & Gross, 2000). Moreover, 2D and 3D games could also be used to develop the spatial skills of children with learning disabilities (Masendorf, 1995). Meanwhile, Nordvik and Amponsah's (1998) study results showed that computer games featuring tasks such as knitting and jigsaw puzzles correlated positively with spatial skills, and Green and Bavelier (2003) stated that 3D computer games increase players' spatial abilities, like attentional and visual skills.

Some studies about spatial abilities have been specific to a single platform, style, or game. In a study by Gagnon (1985), two different games (one 2D and one 3D) were played by groups, and the scores were examined and found to correlate with spatial test scores. Males and females earned equivalent scores after five hours of game play, but males were better in the beginning. In other words, the females improved their spatial skills (Gagnon, 1985). Another study stated that playing computer games can minimize gender differences in spatial attention, which is necessary for higher levels of spatial cognition (Feng, Spence, & Pratt, 2007). Moreover, it has been suggested that experienced game players have better spatial skills than inexperienced game players (Gagnon, 1985). Similarly, visual spatial skills of experienced video game players are superior to those of non-players (Quaiser-Pohl et al., 2006; Sims & Mayer, 2002). De Lisi and Wolford (2002) stated that playing computer games had a positive effect on third graders' spatial skills (specifically, mental rotation skills) after 11 separate 30 minute sessions. Although boys scored higher grades on the pretest, the children with lower spatial skills improved after playing (De Lisi & Wolford, 2002).

When the frequency of children playing computer games increases, the scores of their spatial abilities (spatial visualization and relationships) also increase (Turgut, 2007). In their study, Greenfield, Brannon, and Lohr (1994) examined whether playing a 3D computer game had an effect on spatial skills, which was assessed by a mental paper folding test. After the first experiment, researchers found a correlation between the game and the test scores of experienced players. According to the results of the second experiment, short term game experience had no effect on spatial skills scores, unlike the beneficial effects of long term experience.

In their study, Subrahmanyam and Greenfield (1994) examined the effects of video games on the spatial abilities of 10 and 11 year old children. Results showed that playing a 3D action game did affect children's spatial performances, while a computerized word game did not. They also stated that game practice could be more beneficial for those who begin with relatively poor spatial skills and that games might be useful in adjusting imbalanced spatial skill performance stemming from gender differences (Subrahmanyam & Greenfield, 1994).

Quaiser-Pohl et al. (2006) also investigated the relationship between computer game preferences and spatial skills (mental rotation) of females and males, finding a difference in favor of males. In addition, non-player males had lower scores than game player males, and females' computer game preferences were not relevant to their spatial skill performances.

In light of the literature, it can be said that the computer games preferred by children might have an effect on their spatial abilities. Studies about spatial abilities mostly depend on computer game genres; on the other hand, limited studies have examined spatial ability and computer game preferences. This study aimed to fill that gap by determining the relationship between children's computer game preferences and their spatial ability performances. The following research questions will be examined:

Is there a significant difference between students' 2D or 3D game preferences in terms of
- gender (male vs. female) or
- grade level (6th, 7th, and 8th)?

Is there a significant difference between students' spatial ability performances in terms of
- gender (male vs. female),
- grade level (6th, 7th, and 8th),
- play time per week,
- years spent playing computer games, or
- game preferences (2D or 3D)?

3. Method

The goal of the study was to investigate factors that may affect student game preferences and spatial ability performances. This study was survey-based and carried out during the 2012–2013 academic year in three secondary schools.

Participants

A total of 769 students from three schools in Istanbul completed the survey and spatial ability test. The study took place during the 2013 spring term, and the sample was approximately half boys (51%, N = 390) and half girls (49%, N = 379). See Table 1 for more demographic information.

Table 1. Descriptive results of participants

School	Gender		Grade			Total
	Female	Male	6th	7th	8th	
School A	216	216	141	154	137	432
School B	70	77	39	69	39	147
School C	93	97	75	51	64	190
Total	379	390	255	274	240	769

Data Collection Tools
In order to determine children's characteristics, a survey was conducted with questions about children's grade, gender, computer game experiences, preferences of computer games, and time spent playing games per week. A Spatial Ability Test (SAT) adapted to Turkish by Turgut (2007) was also administered. The reliability value of the SAT was found to be 0.83 in Turgut's study. In the present study, a reliability test was conducted with 114 students, and Cronbach's alpha was found to be 0.81. The test consists of 29 multiple-choice questions about images of 3D objects viewed from different perspectives, such as how many cubes were used to build constructions.

Statistical Analysis
The survey data were analyzed via descriptive statistics, and a chi-squared test was conducted to determine the relationships between gender and game preferences and between grade levels and game preferences. Since the participants' spatial ability scores were not normally distributed, nonparametric tests were used for comparison. The Mann-Whitney U test was used to assess the differences between participants' spatial ability scores in terms of computer game preferences (2D or 3D) and gender. The Kruskal-Wallis test was used to determine the differences between participants' spatial ability scores in terms of grade level, game playing time, and game experience. Lastly, according to Cohen (1988), the effect sizes of results were interpreted as small (r = 0.10), medium (r = 0.30) and large (r = 0.50).

4. Results

According to the survey results, 90% (N = 690) of the children had computers in their homes. A total of 17% of the children had their first computer game experience before the age of five, 68% between 5 and 10, and the rest (15%) between 11 and 15. Moreover, 15% of them had been playing computer games for one to two years, 33% for three to five years, 36% for six to eight years, and 16% for more than nine years. Among the 769 children, 697 stated that they had played computer games in the last year. The mean values of the spatial ability test scores were calculated for these 697 children with respect to their game preferences.

Game Preferences in Terms of Gender
Chi-squared test results showing the differences between students' game preferences (2D or 3D) in terms of gender are given in Table 2.

Table 2. Game preferences in terms of gender

Genders	Game Platforms		Total	$\chi 2$	p	ϕ
	2D Games	3D Games				
Females	253	70	323			
Males	39	335	374	328.256	.000	0.686
Total	292	405	697			

According to the test results, 2D or 3D game preference is dependent on gender ($\chi 2_{(1,697)}$ = 328.256; $p < 0.05$; ϕ = 0.686; see Table 2). Females (78% 2D players; 22% 3D players) were less likely to show interest in 3D games than males (10% 2D players; 90% 3D players). The phi-coefficient was 0.686, indicating that the strength of association was high.

Game Preferences in Terms of Grade
This study included students from 6th, 7th, and 8th grades. A chi-squared test was performed to examine the relation between game preferences of participants and their grade levels (see Table 3).

Table 3. Game preferences in terms of grade levels

Grades	Game Platforms		Total	$\chi 2$	*p*
	2D Games	3D Games			
6th grade	96	138	234		
7th grade	108	141	249	.349	0.840
8th grade	88	126	214		
Total	292	405	697		

According to the test results, the relation between these variables was not significant ($\chi^2_{(2,697)}$ = .349; $p >$ 0.05).

Spatial Ability Performance in Terms of Gender

The Mann-Whitney U test was employed to investigate differences in results obtained from the participants' spatial ability test scores (see Table 4). Results did not reveal a significant difference between female and male test scores (U = 55637.50, p = .07) at the .05 level.

Table 4. Spatial ability performance in terms of gender

Genders	*N*	Mean Rank	Sum of Ranks	*U*	*p*
Females	323	363.75	117490.50		
Males	374	336.26	125762.50	55637.500	.072
Total	697				

Spatial Ability Performance in Terms of Grade Levels

The data were obtained from 6th, 7th, and 8th graders. As table 5 indicates, a Kruskal-Wallis test was used to examine the difference in findings obtained from the spatial ability test scores of each grade. The results of the analysis indicate a significant difference in the medians ($\chi^2_{(2,\ 697)}$ = 99.66; p = .00).

Table 5. Spatial ability performance in terms of grade levels

Grades	*N*	Mean Rank	*df*	χ^2	*p*
6th grade	234	262.76			
7th grade	249	341.41	2	99.66	0.00
8th grade	214	452.12			
Total	697				

Because the overall test value showed significance, pairwise comparisons among the three groups were completed using the Mann-Whitney U test. Results demonstrated significant differences between 6th and 7th graders (U = 22799.000; p = .00); the calculated effect size was 0.19, which is considered small. The results also showed significant differences between 7th and 8th graders (U = 18420.000; p = .00) at a small effect size of 0.27. Moreover, between 6th and 8th graders, there were significant differences (U = 11193.000; p = .00), and the calculated effect size was 0.48, which is almost considered large. It can be concluded that the 8th graders' spatial ability test scores were statistically significantly higher than those of both the 7th and 6th graders and that the 7th graders' spatial ability test scores were statistically significantly higher than those of the 6th graders.

Spatial Ability Performance in Terms of Playing Time per Week

A Kruskal-Wallis test was used to examine the difference in the spatial ability test scores of players in terms of time invested in gameplay (see Table 6).

Table 6. Spatial ability performance in terms of playing time per week

Time Spent Playing Games	*N*	Mean Rank	*df*	χ^2	*p*
1-5 h per w	231	349,58	4	8.272	0.082
6-10 h per w	225	352,78			
11-15 h per w	102	385,46			
16-20 h per w	53	335,81			
>20 h per w	86	302,44			
Total	697				

Descriptive statistical results showed that 33% of players spent 1–5 hours per week on computer games, 32% spent 6–10 hours per week, 15% spent 11–15 hours per week, 8% spent 16–20 hours per week, and 12% spent more than 20 hours per week. Analysis of the Kruskal-Wallis test revealed no statistically significant difference between these variables ($\chi^2_{(4, 697)} = 8.272$; $p = .082$).

Spatial Ability Performance in Terms of Playing Experience

A Kruskal-Wallis test was used to examine differences in spatial ability performance in terms of how many years participants had been playing computer games (see Table 7). According to the descriptive statistics results, 13% of participants had played games in the last two years, 33% had played in the last five years, 38% had played in the last eight years, and 16% had played in the last nine years. The results of the Kruskal-Wallis test indicated a significant difference in the medians ($\chi^2_{(3, 697)} = 12.161$; $p = .007$).

Table 7. Spatial ability performance in terms of playing experience

Playing experience	*N*	Mean Rank	*df*	χ^2	*p*
0-2 years	91	310,47	3	12.161	0.007
3-5years	229	332,36			
6-8 years	266	355,47			
> 9 years	111	399,41			
Total	697				

The Mann-Whitney U test was conducted to complete pairwise comparisons among the four groups. According to the results, there were only significant differences between 0–2 years and more than 9 years of playing experience ($U = 3798.500$; $p = .002$; $r = 0.21$) and between 3–5 years and more than 9 years playing experience ($U = 10179.000$; $p = .003$; $r = 0.16$). Both calculated effect sizes were small.

Spatial Ability Performance in Terms of Game Preferences

The Mann-Whitney U test was conducted to investigate differences in the results of participants' spatial ability performance in terms of 2D or 3D game preferences (see Table 8).

Table 8. Spatial ability performance in terms of game preference

Groups	*N*	Mean Rank	Sum of Ranks	*U*	*p*
2D players	292	349,78	102136,50		
3D players	405	348,44	141116,50	58901,500	.093
Total	697				

Preferring 3D computer games was more common among children 12 to 15 years old and especially among males. However, the test results did not reveal a significant difference between 2D and 3D players' test scores (*U* = 58901.500, *p* = .093) at the .05 level.

5. Discussion and Conclusion

This study aimed to answer questions about children's preferences and performances with regard to computer games. In order to achieve this aim, a Spatial Ability Test was administered to 769 elementary school children in Istanbul ranging from 12 to 15 years old. Among these children, 697 reported actively playing computer games in the last year.

The results showed that males were more likely to have an interest in 3D games (fantasy, action, sports, violence, etc.) than females, who preferred 2D computer games (board games, card games, etc.). This result could stem from different reasons. The literature has stated that, while females are more likely to play abstract, short, and easy to control games from the adventure, action, or educational genres, male players are more likely to choose fantasy, violence, sports, action, and adventure computer games with generally higher quality 3D graphics (Cherney & London, 2006; Vermeulen et al., 2011). Females may show a tendency towards playing primarily short-term casual games (board or card games); on the other hand, males have the potential to prefer longer 3D games. In future experimental studies investigating 2D or 3D preferences of players, game characteristics (genre, violence level, multiplayer options) should also be taken into consideration, as they may have an effect on selection.

Furthermore, no significant difference emerged between female and male spatial ability performance. Some previous studies (Maeda & Yoon, 2013; Quaiser-Pohl et al., 2006) have stated that males generally outperform females in spatial ability test scores. However, the present results support the study by De Lisi & Wolford (2002), which found no difference between females and males on test performance.

The present study also examined the relation between game preferences and grade levels. Results showed that differences between students' game preferences (2D or 3D) in terms of grade levels (6th, 7th, and 8th) were not significant. Since the ages of the children were so close, to determine the true effect on grade levels, a future study could be conducted with a wider age range of computer game players. Current findings did indicate a significant difference in the medians of spatial ability test scores across grades. The 8th graders were the most successful group, and 7th graders were more successful than 6th graders. This result could be related to their ages, and as they get older, they have the potential to earn higher scores. The result of the present study is consistent with Neuburger et al. (2011), who also observed that upper grade students scored higher than lower grade students.

Some studies have shown a relation between time invested and children's spatial ability scores. Turgut (2007) has stated that when the frequency of playing computer games increases, performance on the spatial ability test (spatial visualization and relations) also increases. In the current study, most children had been actively playing computer games in the last year, though with differences in weekly play time. However, test results showed no significant difference in spatial ability test scores with respect to game time. On the other hand, the results showed that computer game experience did have an effect on spatial ability performance, with more experienced players earning higher scores. This result is consistent with the literature (Gagnon, 1985; Greenfield et al., 1994; Quaiser-Pohl et al., 2006; Sims & Mayer, 2002).

Findings did not reveal a significant difference between 2D and 3D players' test scores, though the literature (Green & Bavelier, 2003; Subrahmanyam & Greenfield, 1994) has indicated that 3D computer games can affect players' spatial abilities. Other factors might affect computer game preferences like core or non-core games, game genre, length of game, or multiplayer functionality. By controlling these factors in future experimental studies, the true effects of playing 2D or 3D games on spatial abilities could be determined.

References

Cherney, I. D., & London, K. (2006). Gender-linked differences in the toys, television shows, computer games, and outdoor activities of 5- to 13-year-old children. *Sex Roles*, *54*(9/10), 717–726.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences.* Hillsdale,NJ: Erlbaum.

Contero, M., Naya, F., Company, P., Saorin, J. L., & Conesa, J. (2005). Improving visualization skills in engineering education. *IEEE Comput. Graph. Appl.*, *25*(5), 24–31.

De Aguilera, M., & Mendiz, A. (2003). Video games and education: (Education in the face of a "parallel school"). *Comput. Entertain.*, *1*(1), 1–10.

De Lisi, R., & Wolford, J. L. (2002). Improving children's mental rotation accuracy with computer game playing. *The Journal of Genetic Psychology, 163*(3), 272–282.

Economics and Statistics Administration & National Telecommunications and Information Administration. (2011). *Exploring the digital nation: Computer and internet use at home*. US Department of Commerce. Retrieved from http://www.ntia.doc.gov/report/2011/ exploring-digital-nation-computer-and-internet-use-home

Feng, J., Spence, I., & Pratt, J. (2007). Playing an action video game reduces gender differences in spatial cognition. *Psychological Science*, *18*(10), 850–855.

Gagnon, D. (1985). Videogames and spatial skills: An exploratory study. *Educational Communication and Technology*, *33*(4), 263–75.

Green, C. S., & Bavelier, D. (2003). Action video game modifies visual selective attention. *Nature*, *423*(6939), 534–537.

Greenberg, B. S., Sherry, J., Lachlan, K., Lucas, K., & Holmstrom, A. (2010). Orientations to video games among gender and age groups. *Simulation & Gaming, 41*(2), 238–259.

Greenfield, P. M. (1993). Representation competence in shared symbol systems: Electronic media from radio to video games. In R. R. Cocking & K. A. Renninger (Eds.), *The Development And Meaning of Psychological Distance* (pp. 161–183). Hillsdale, NJ: Erlbaum.

Greenfield, P. M. (1996). Video games as cultural artifacts. In P. M. Greenfield & R. R. Cocking (Eds.), *Interacting with video* (pp. 85–94). Westport, CT: Ablex Publishing.

Greenfield, P. M., Brannon, C., & Lohr, D. (1994). Two-dimensional representation of movement through three- dimensional space: The role of video game expertise. *Journal of Applied Developmental Psychology*, *15*(1), 87–103.

Guven, B., & Kosa, T. (2008). The effect of dynamic geometry software on student mathematics teachers' spatial visualization skills. *The Turkish Online Journal of Educational Technology*, *7*(4), 100–107.

Homer, B. D., Hayward, E. O., Frye, J., & Plass, J. L. (2012). Gender and player characteristics in video game play of preadolescents. *Computers in Human Behavior*, *28*(5), 1782–1789.

İnal, Y., & Çağıltay, K. (2005). İlköğretim öğrencilerinin bilgisayar oyunu oynama alışkanlıkları ve oyun tercihlerini etkileyen faktörler [Elementary school students' computer game playing habits and the factors that affects their game preferences] (pp. 71–74). Presented at the Ankara Özel Tevfik Fikret Okulları, Eğitimde Yeni Yönelimler II Eğitimde Oyun Sempozyumu [New Trends In Education, 2nd Symposium On Game in Education], Ankara, Turkey.

Linn, M. C., & Petersen, A. C. (1985). Emergence and characterization of sex differences in spatial ability: A meta-analysis. *Child Development*, *56*(6), 1479–1498.

Livingstone, S., Haddon, L., Görzig, A., & Ólafsson, K. (2011). *Risks and safety on the internet: The perspective of European children: Full findings and policy implications from the EU Kids Online survey of 9-16 year olds and their parents in 25 countries.* London, UK: EU Kids Online. Available at http://www.eukidsonline.net/

Lowrie, T., & Jorgensen, R. (2011). Gender differences in students' mathematics game playing. *Computers & Education*, *57*(4), 2244–2248. doi: 10.1016/j.compedu.2011.06.010

Maeda, Y., & Yoon, S. Y. (2013). A meta-analysis on gender differences in mental rotation ability measured by the Purdue spatial visualization tests: Visualization of rotations (PSVT:R). *Educational Psychology Review*, *25*(1), 69–94. doi:10.1007/s10648-012-9215-x

Masendorf, F. (1995). Training learning-disabled children's spatial ability by computer games. *European Education*, *27*, 49–58.

Neuburger, S., Jansen, P., Heil, M., & Quaiser-Pohl, C. (2011). Gender differences in pre-adolescents' mental-rotation performance: Do they depend on grade and stimulus type? *Personality and Individual Differences*, *50*(8), 1238–1242. doi: 10.1016/ j.paid.2011.02.017

Nordvik, H., & Amponsah, B. (1998). Gender differences in spatial abilities and spatial activity among university students in an egalitarian educational system. *Sex Roles*, *38*(11-12), 1009–1023. doi: 10.1023/A:1018878610405

Okagaki, L., & Frensch, P. A. (1994). Effects of video game playing on measures of spatial performance: Gender effects in late adolescence. *Journal of Applied Developmental Psychology*, *15*(1), 33–58.

Olkun, S. (2003). Making connections: Improving spatial abilities with engineering drawing activities. *International Journal of Mathematics Teaching and Learning*, 1–10.

Onay, P., Tufekci, A., & Cagiltay, K. (2005). Türkiye'deki ögrencilerin bilgisayar oyunu oynama alışkanlıkları ve oyun tercihleri: ODTÜ ve Gazi üniversitesi öğrencileri arası karşılaştırmalı bir çalışma [A comparative study between METU and Gazi university students-game playing characteristics and game preferences of university students]. *Eurasian Journal of Educational Research*, *19*, 66–76.

Quaiser-Pohl, C., Geiser, C., & Lehmann, W. (2006). The relationship between computer-game preference, gender, and mental-rotation ability. *Personality and Individual Differences*, *40*(3), 609–619.

Sims, V. K., & Mayer, R. E. (2002). Domain specificity of spatial expertise: The case of video game players. *Applied Cognitive Psychology*, *16*(1), 97–115.

Subrahmanyam, K., & Greenfield, P. M. (1994). Effect of video game practice on spatial skills in girls and boys. *Journal of Applied Developmental Psychology*, *15*(1), 13–32.

Subrahmanyam, K., Kraut, R. E., Greenfield, P. M., & Gross, E. F. (2000). The impact of home computer use on children's activities and development. *Future Child*, *10*(2), 123–144.

Subrahmanyam, K., Kraut, R. E., Greenfield, P. M., & Gross, E. F. (2001). New forms of electronic media: The impact of interactive games and the internet on cognition, socialization, and behavior. In D. G. Singer & J. L. Singer (Eds.), *Handbook of children and the media* (pp. 73–99). Thousand Oaks, CA: Sage.

Turkish Statistical Institute (TUIK). (2013). *Use of information and communication technology and media by children aged 06-15*. Retrieved from http://www.turkstat.gov.tr/PreHaberBultenleri.do?id=15866

Turgut, M. (2007). *İlköğretim II. kademede öğrencilerin uzamsal yeteneklerinin incelenmesi* [Investigation of 6, 7 and 8. Grade Students' SpatialAbility] (Unpublished master's thesis). Dokuz Eylül Üniversitesi, İzmir, Turkey.

Vermeulen, L., Van Looy, J., De Grove, F., & Courtois, C. (2011). *You are what you play? A quantitative study into game design preferences across gender and their interaction with gaming habits.* Presented at the DiGRA 2011: Think, design, play, Digital Games Research Association (DiGRA), Utrecht, Netherlands.

Wai, J., Lubinski, D., & Benbow, C. P. (2009). Spatial ability for STEM domains: Aligning over 50 years of cumulative psychological knowledge solidifies its importance. *Journal of Educational Psychology*, *101*(4), 817–835. doi:10.1037/a0016127

Weckbacher, L. M., & Okamoto, Y. (2012). Spatial experiences of high academic achievers: Insights from a developmental perspective. *Journal for the Education of the Gifted*, *35*(1), 48–65.