RPGE
unesp

ATTITUDES TOWARD AUGMENTED REALITY TECHNOLOGIES AND SPATIAL INTELLIGENCE AMONG GIFTED STUDENTS

ATITUDES EM RELAÇÃO ÀS TECNOLOGIAS DE REALIDADE AUMENTADA E À INTELIGÊNCIA ESPACIAL ENTRE ESTUDANTES SUPERDOTADOS

ACTITUDES HACIA LAS TECNOLOGÍAS DE REALIDAD AUMENTADA Y LA INTELIGENCIA ESPACIAL EN ESTUDIANTES SUPERDOTADOS

Duran KÜÇÜKLER[1]
e-mail: dkucukler@dogus.edu.tr

Ali Batuhan YILDIZ[2]
e-mail: batuhanyildiz@mersin.edu.tr

Zahide BILGEN BUCAK[3]
e-mail: zahidebbicak@gmail.com

Ali GÖK[4]
e-mail: gokali@mersin.edu.tr

Gülsüm GÖK[5]
e-mail: gulsumgok@mersin.edu.tr

How to reference this paper:

Küçükler, D., Yildiz, A. B., Bilgen Bucak, Z., Gök, A., & Gök, G. (2026). Attitudes toward augmented reality technologies and spatial intelligence among gifted students. *Revista on line de Política e Gestão Educacional*, *30*, e026040. https://doi.org/10.22633/rpge.v30i00.20998

| **Submitted**: 11/03/2026
| **Revisions required**: 10/04/2026
| **Approved**: 30/04/2026
| **Published**: 08/05/2026

Editor: Prof. Dr. Sebastião de Souza Lemes
Deputy Executive Editor: Prof. Dr. José Anderson Santos Cruz

[1] Doğuş University. İstanbul – Türkiye. Lecturer at Doğuş University, Vocational School, Internet and Network Technologies Program.
[2] Mersin University. Mersin – Türkiye. Lecturer at Mersin University, Mut Vocational School, Department of Computer Technologies.
[3] Ministry of National Education. Mersin – Türkiye. Teacher at the Ministry of National Education.
[4] Mersin University. Mersin – Türkiye. Assistant Prof. Dr. at Mersin University, Faculty of Education, Department of Computer Education and Instructional Technology.
[5] Mersin University. Mersin – Türkiye. Assistant Prof. Dr. Mersin University, Faculty of Education, Department of Mathematics and Science Education.

ABSTRACT: This study employed a survey model to examine the relationship between gifted middle school students' attitudes toward Augmented Reality (AR) technologies and their spatial intelligence, and to determine whether these variables differ according to gender, daily technology use, and parents' educational levels. The sample consisted of 72 gifted middle school students. The findings showed that students have high levels of both attitudes toward AR technologies and spatial intelligence. A statistically significant relationship was found between spatial intelligence and AR use satisfaction. Independent samples t-tests revealed significant differences in attitudes toward AR technologies, particularly in AR use intention, satisfaction, and anxiety, across class levels and daily technology use groups. The results suggest that integrating AR technologies into educational environments may support spatial skill development and enrich learning experiences for gifted learners.

KEYWORDS: Augmented Reality. Attitude toward AR. Spatial intelligence. Gifted students.

RESUMO*: Este estudo utilizou um modelo de survey para examinar a relação entre as atitudes de estudantes superdotados do ensino fundamental em relação às tecnologias de Realidade Aumentada (RA) e sua inteligência espacial, bem como verificar se essas variáveis diferem segundo o gênero, o uso diário de tecnologia e o nível educacional dos pais. A amostra foi composta por 72 estudantes superdotados. Os resultados indicaram que os estudantes apresentam níveis elevados tanto de atitudes em relação às tecnologias de RA quanto de inteligência espacial. Foi identificada uma relação estatisticamente significativa entre inteligência espacial e satisfação com o uso da RA. Testes t para amostras independentes revelaram diferenças significativas nas atitudes em relação às tecnologias de RA, especialmente na intenção de uso, satisfação e ansiedade, entre diferentes níveis escolares e grupos de uso diário de tecnologia. Os resultados sugerem que a integração de tecnologias de RA em ambientes educacionais pode apoiar o desenvolvimento de habilidades espaciais e enriquecer as experiências de aprendizagem de estudantes superdotados.*

PALAVRAS-CHAVE*: Realidade Aumentada. Atitude em relação à RA. Inteligência espacial. Estudantes superdotados.*

RESUMEN*: Este estudio empleó un modelo de encuesta para examinar la relación entre las actitudes de estudiantes superdotados de educación secundaria hacia las tecnologías de Realidad Aumentada (RA) y su inteligencia espacial, así como para determinar si estas variables difieren según el género, el uso diario de tecnología y el nivel educativo de los padres. La muestra estuvo compuesta por 72 estudiantes superdotados. Los resultados mostraron que los estudiantes presentan altos niveles tanto de actitudes hacia las tecnologías de RA como de inteligencia espacial. Se encontró una relación estadísticamente significativa entre la inteligencia espacial y la satisfacción con el uso de la RA. Las pruebas t para muestras independientes revelaron diferencias significativas en las actitudes hacia las tecnologías de RA, particularmente en la intención de uso, la satisfacción y la ansiedad, según el nivel de grado y los grupos de uso diario de tecnología. Los resultados sugieren que la integración de tecnologías de RA en entornos educativos puede apoyar el desarrollo de habilidades espaciales y enriquecer las experiencias de aprendizaje de estudiantes superdotados.*

PALABRAS CLAVE*: Realidad Aumentada. Actitud hacia la RA. Inteligencia espacial. Estudiantes superdotados.*

INTRODUCTION

Technological developments have continued to progress rapidly and expand over time. Among the contemporary technologies, Augmented Reality (AR) has emerged as a prominent innovation (Garzón et al., 2019). AR technology allows users to interact with materials in the physical environment through mobile devices such as smartphones and tablets, using embedded digital content (Dunleavy et al., 2009). Advances in information technology have made AR applications more accessible and practical (Wu et al., 2013). In particular, the increased processing power of mobile devices and the integration of AR software into smartphones in the 21st century have significantly contributed to the development of AR (Dunleavy et al., 2009; Azı, 2020).

AR scanner technologies now allow users to view educational materials and create AR content without requiring technical expertise. This technology overlays digital layers onto real objects using a camera, presenting enriched multimedia interfaces (Yılmaz & Batdı, 2016). These scanners have made AR content more accessible and easier to create, promoting wider use in educational settings. Moreover, AR has attracted increasing attention in educational research because it integrates digital elements with the real-world environment, allowing learners to interact with physical and virtual objects simultaneously (Nischelwitzer et al., 2007). Previous studies also indicate that AR is particularly effective for teaching abstract concepts, visualizing difficult phenomena, safely simulating hazardous situations, and enhancing the understanding of complex information (Walczak et al., 2006).

Lessons designed using AR technology can facilitate the teaching of abstract concepts, enabling students to visualize objects in three dimensions and understand them concretely (Azı, 2020). By supporting experiential and immersive learning environments, AR can enhance learners' motivation, engagement, and attention during the learning process (Singhal et al., 2012). AR technologies are known to play a significant role in promoting student motivation and fostering positive attitudes toward technology. Studies have shown that AR is particularly effective in sustaining attention and maintaining interest (Cai et al., 2017; Serio et al., 2013).

With the advancement of AR technologies, learning environments have become more supportive of constructivist approaches (Dunleavy & Dede, 2014). These technologies also facilitate collaborative learning, as multiple users can interact simultaneously on shared platforms (Singhal et al., 2012).

Nevertheless, the effective integration of AR technologies into educational environments largely depends on students' attitudes toward their use. Students' perceptions, acceptance, and willingness to engage with such technologies play a crucial role in determining whether AR can be successfully incorporated into learning processes. Negative attitudes or resistance to new technological tools may limit their pedagogical potential and hinder their adoption in classroom practices. Furthermore, students' attitudes toward AR may also be associated with their spatial intelligence, as many AR applications rely on interactive three-dimensional visualizations that require learners to interpret, manipulate, and understand spatial relationships. Therefore, examining the relationship between students' attitudes toward AR technologies and their spatial abilities may provide important insights into the effective use of AR-supported learning environments.

Spatial intelligence refers to the cognitive capacity to mentally represent, manipulate, and transform objects and their spatial relationships (Herawati & Hariyani, 2024). It encompasses skills such as spatial visualization, mental rotation, and spatial orientation, which play a significant role in understanding mathematical concepts, particularly in geometry. Beyond academic contexts, spatial intelligence also contributes to everyday problem-solving tasks, including interpreting maps, navigating environments, and describing the relative positions of objects. Spatial intelligence can be enhanced through various instructional approaches, including computer-assisted learning environments, AR applications, and hands-on activities such as model building, all of which have been shown to support the development of spatial reasoning skills (Radianti et al., 2020). Previous research has also indicated that spatial ability tends to be more advanced among gifted students compared to their peers (Mann, 2004). Gifted learners often demonstrate stronger skills in spatial visualization, mental rotation, and complex problem solving, which are considered important components of spatial thinking. Therefore, investigating the relationship between spatial ability and attitudes toward emerging technologies such as augmented reality may be particularly meaningful within gifted populations. Considering that many AR applications rely on three-dimensional representations and spatial interactions, examining these variables among gifted students may provide valuable insights into how spatial strengths relate to the acceptance and effective use of AR-supported learning environments.

Science and Art Centers (BİLSEM), established in Türkiye in 1995, were designed as educational institutions that provide out-of-school support to students identified as gifted in the areas of general intellectual ability, visual arts, and music, enabling them to further develop their talents (Özer, 2021). As of 2026, a total of 362 BİLSEMs continue their educational activities across all 81 provinces of the country. While gifted students attend their formal schooling, they also receive additional education related to their talents at BİLSEM institutions operating under the Ministry of National Education outside regular school hours. The identification of gifted individuals is conducted through certain intelligence tests administered at Guidance and Research Centers (RAM) based on referrals from classroom teachers. Within these assessments, students respond to items designed to measure spatial intelligence abilities. Since the entrance examinations used for the identification of gifted students already provide an indication of their spatial intelligence levels, the present study aims to explore the relationship between students' spatial intelligence and their attitudes toward AR-technologies. Accordingly, this study seeks to examine the relationship between middle school students' attitudes toward AR-technologies and their spatial intelligence, as well as to compare these variables across several factors. In line with this purpose, the following research questions were addressed.

Research questions

1. What are the levels of participants' attitudes toward AR-technologies and their spatial intelligence?
2. Is there a significant relationship between participants' attitudes toward AR-technologies and their spatial intelligence?
3. Do participants' attitudes toward AR-technologies and their spatial intelligence differ significantly according to various variables?
    a) Is there a significant difference in participants' attitudes toward AR-technologies based on gender?
    b) Is there a significant difference in participants' spatial intelligence based on gender?
    c) Is there a significant difference in participants' attitudes toward AR-technologies based on their technology usage duration?
    d) Is there a significant difference in participants' spatial intelligence based on their technology usage duration?
    e) Is there a significant difference in participants' attitudes toward AR-technologies based on their parents' education level?
    f) Is there a significant difference in participants' spatial intelligence based on their parents' education level?

METHOD

This study investigates the relationship between middle school gifted students' attitudes toward augmented reality technology and their spatial intelligence, as well as the effects of gender, grade level, technology usage duration, and parental education level on these variables. The research was conducted using a survey model. Relational studies aim to describe and analyze the relationships between two or more variables in depth (Fraenkel et al., 2011). In this study, no intervention was applied to the participants; instead, the existing situation was examined descriptively. Gifted students' attitudes toward augmented reality technologies and their spatial intelligence skills were considered as dependent variables, while gender, technology usage duration, and parental education level were treated as independent variables.

Participants

The participants of the study comprised 72 gifted middle school students enrolled in BİLSEM in the Mersin district of Turkey in 2022. The sample was selected using the convenience sampling technique, a non-random sampling method (Fraenkel et al., 2011). The participants consisted of 38 girls (52.8%) and 34 boys (47.2%), with a mean age of 10 years. All participants had access to a computer or tablet at home. Prior to data collection, informed consent was obtained from both the participating students and their parents.

Procedure

The data for the study were collected in person by visiting the BİLSEM schools where the participating middle school gifted students. Data collection for each student took approximately 15 minutes, and the entire process was completed over a period of approximately four weeks. Descriptive and inferential statistical analyses were employed to analyze the data. Prior to analysis, assumptions regarding normality, homogeneity, and equality of variances were tested to ensure internal consistency. Descriptive analyses were conducted to determine the levels of students' attitudes toward AR-technologies and their spatial intelligence skills. Independent samples t-tests were used to examine whether gifted students' attitudes toward AR-technologies differed by gender. One-way analysis of variance (ANOVA) was conducted to assess differences in gifted students' attitudes based on technology use and parents' educational levels. Finally, correlation analysis was performed to examine the relationship between students' attitudes toward AR-technologies and their spatial intelligence skills.

Data collection tools

Augmented Reality Applications Attitude Scale: The Augmented Reality Applications Attitude Scale was developed by Küçük et al. (2014) and consists of 15 items rated on a 5-point Likert scale. The scale includes three sub-dimensions reflecting attitudes toward augmented reality technologies: “satisfaction of use,” “anxiety of use,” and “willingness to use.” The reliability of the scale was assessed using internal consistency, calculated with Cronbach’s Alpha. Küçük et al. (2014) reported a Cronbach’s Alpha coefficient of .83. In the present study, the analysis yielded a Cronbach’s Alpha coefficient of .74.

Spatial Intelligence Achievement Test: In the study, the Spatial Intelligence Achievement Test was administered to measure students’ levels of spatial intelligence skills. Developed by Özçakır (2017), the test consists of 14 items. The minimum score obtainable on the test is 0, while the maximum score is 14. Although the Spatial Intelligence Achievement Test was originally reported with a Cronbach’s Alpha of .73, the reliability obtained in the present study was .62.

RESULTS

Participants’ levels of attitudes toward AR-technologies and spatial intelligence

Table 1 presents the descriptive analysis results regarding the sample’s mean scores for spatial intelligence skills and attitudes toward AR-technologies. The findings indicate that the gifted students’ spatial intelligence skills are high. Additionally, considering that the attitude scale was developed on a 5-point Likert scale, it can be inferred that students who have experienced AR- technologies exhibit a positive attitude toward these technologies.

Table 1.
Participants’ attitudes toward AR-technologies and spatial ability levels

	n	Min.	Max.	X	SD
Spatial Intelligence	72	6.00	14	10.32	2.09
AR Use Satisfaction	72	2.86	5	4.17	.49
AR Use Intention	72	3.50	5	4.30	.39
AR Use Anxiety	72	1.00	2.50	1.66	.39

Note. Elaborated by the authors.

The relationship between participants' attitudes toward AR-technologies and spatial intelligence

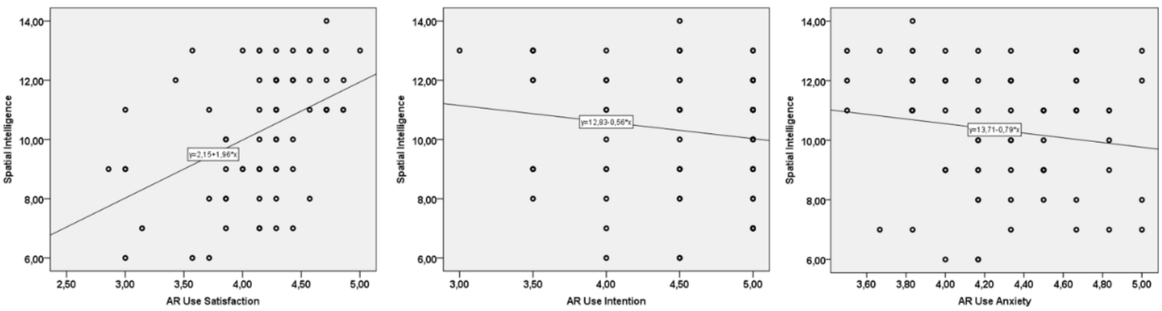
A Pearson product–moment correlation analysis was conducted to examine the relationship between participants' spatial intelligence and the sub-dimensions of their attitudes toward augmented reality (AR) technologies (Table 2). The results revealed a moderate, positive, and statistically significant correlation between spatial intelligence and AR Use Satisfaction ($r = .46$, $p < .05$), whereas no significant relationships were found with the other sub-dimensions. These findings indicate that higher levels of spatial intelligence are associated with greater satisfaction in using AR technologies among middle school gifted students. Figure 1 presents the scatter plot depicting the relationship between these two variables.

Table 2.
Correlations between participants' attitudes toward AR-technologies and their spatial intelligence

		N	Pearson Correlation	*p*
Spatial Intelligence	AR Use Satisfaction	72	.46*	.00
	AR Use Intention	72	-.15	.19
	AR Use Anxiety	72	.12	.34

Caption: **p < 0.01.
Note. Elaborated by the authors.

Figure 1.
Scatterplots representing correlations between participants' attitudes toward AR-technologies and their spatial intelligence



Note. Elaborated by the authors.

Comparison of participants' attitudes toward AR-technologies and spatial intelligence according to gender, daily technology use, and parents' educational levels

T-Tests Results: Descriptive statistics for spatial intelligence and attitude toward AR-technologies variables across gender, class level, and daily technology usage are presented in Table 3. Mean scores revealed high spatial intelligence and attitudes toward AR-technologies in satisfaction and intention, as well as low anxiety in all categories. Preliminary analyses conducted to check assumptions of independent samples t-test. The results revealed the data distributed normally since skewness kurtosis values are between -1 and +1 and Normality tests were nonsignificant $p > .05$. Levene's Test results indicated that homogeneity of variance assumptions were also assumed $p > .05$.

Table 3.
Descriptive Statistics Results

Independent Variable 1	Independent Variable 2	Dependent Variable	*N*	$\bar{X}$	*SD*
Gender	Female	Spatial Intelligence	38	9.82	1.72
		AR Use Satisfaction		4.15	.47
		AR Use Intention		4.61	.48
		AR Use Anxiety		1.61	.38
	Male	Spatial Intelligence	34	10.88	2.35
		AR Use Satisfaction		4.20	.52
		AR Use Intention		4.34	.64
		AR Use Anxiety		1.72	.39
Class	1st year	Spatial Intelligence	49	10.16	2.15
		AR Use Satisfaction		4.09	.51
		AR Use Intention		4.35	.60
		AR Use Anxiety		1.76	.36
	2nd year	Spatial Intelligence	23	10.65	1.97
		AR Use Satisfaction		4.34	.41
		AR Use Intention		4.76	.40
		AR Use Anxiety		1.46	.37
Tech Using	Less than 5	Spatial Intelligence	26	10.58	2.04
		AR Use Satisfaction		4.01	.58
		AR Use Intention		4.27	.51
		AR Use Anxiety		1.78	.38
	5 and more	Spatial Intelligence	46	10.17	2.13
		AR Use Satisfaction		4.26	.41
		AR Use Intention		4.60	.57
		AR Use Anxiety		1.60	.38

Note. Elaborated by the authors.

As seen in the Table 4, Independent Samples t-Tests results revealed no statistically significant gender difference in spatial intelligence, $t(70) = -2.21$, $p = .30$, $d = 0.52$, indicating a medium effect size despite the non-significant result (Cohen, 1988). Similarly, no significant gender differences were found for AR Use Satisfaction, $t(70) = -0.40$, $p = .69$, $d = 0.10$, or AR Use Anxiety, $t(70) = -1.17$, $p = .25$, $d = 0.28$ with small effect sizes. A statistically significant gender difference was found for AR Use Intention, $t(70) = 2.02$, $p = .04$, $d = 0.48$, representing a medium effect size, with female students reporting higher intention to use AR.

Considering the class effect, no significant difference was found in spatial intelligence between first- and second-year students, $t(70) = -0.92$, $p = .36$, $d = 0.24$. However, there was a significant mean difference between them with respect to AR Use Satisfaction, $t(70) = -2.06$,

p = .04, d = 0.51, AR Use Intention, t(70) = −3.03, p < .01, d = 0.80, and AR Use Anxiety, first-year students reported significantly higher anxiety, t(70) = 3.20, p < .01, d = 0.81, in favor of Second-year students. The significant results also represented medium and large effect sizes.

Based on daily technology use of gifted students, there was no significant difference in spatial intelligence t(70) = 0.78, p = .44, d = 0.2. On the other hand, a significant mean difference was found with respect to AR Use Satisfaction, t(70) = −2.08, p = .04, d = 0.52, and higher AR Use Intention, t(70) = −2.42, p = .02, d = 0.61 with medium effect sizes, in the favor of students who used technology 5 hours or more per day. Similarly, the difference in AR Use Anxiety approached significance, t(70) = 1.98, p = .05, d = 0.47, suggesting a small-to-medium effect size, with heavier technology users reporting lower anxiety. Overall, while some group differences were not statistically significant, several effects, particularly those related to class level and technology usage, demonstrated medium to large practical significance. Notably, AR Use Intention and Anxiety showed large effect sizes across grade levels, suggesting developmental or experiential influences on technology-related attitudes.

Table 4.
Independent samples t-test results

Independent Variable	**Dependent Variable**	***t***	***df***	***p***	**Mean Difference**	**Cohen's d**
Gender	Spatial İntelligence	-2.21	70	.30	-1.07	-.51
	AR Use Satisfaction	-.40		.69	-.05	-.09
	AR Use Intention	2.02		.04*	.28	.47
	AR Use Anxiety	-1.17		.25	-.11	-.27
Class	Spatial İntelligence	-,92	70	.36	-.49	-.23
	AR Use Satisfaction	-2.06		.04*	-.24	-.52
	AR Use Intention	-3.03		.00*	-.41	-.76
	AR Use Anxiety	3.20		.00*	.29	.80
Tech Using	Spatial İntelligence	.78	70	.44	.40	.19
	AR Use Satisfaction	-2.08		.04	-.24	-.50
	AR Use Intention	-2.42		.02*	-.33	-.58
	AR Use Anxiety	1.98		.05	.18	.48

Note. Elaborated by the authors.

One-Way ANOVA Results: Descriptive findings indicated that participants demonstrated relatively strong spatial intelligence and generally positive attitudes toward AR-technologies, characterized by high levels of satisfaction and intention to use, alongside low levels of anxiety across all groups (Table 5).

Table 5.
Descriptive Statistics Results

Variable		*N*	$\bar{X}$	*SD*
Spatial Intelligence	Middle school or below	9	10.00	2.50
	High School	19	10.16	2.34
	Undergraduate	29	10.38	1.86
	Graduate	15	10.60	2.13
	Total	72	10.32	2.10
AR Use Satisfaction	Middle school or below	9	4.03	0.63
	High School	19	4.14	0.58
	Undergraduate	29	4.17	0.38
	Graduate	15	4.30	0.47
	Total	72	4.17	0.49
AR Use Intention	Middle school or below	9	4.39	0.55
	High School	19	4.45	0.60
	Undergraduate	29	4.47	0.52
	Graduate	15	4.60	0.69
	Total	72	4.48	0.57
AR Use Anxiety	Middle school or below	9	1.74	0.28
	High School	19	1.72	0.49
	Undergraduate	29	1.60	0.35
	Graduate	15	1.67	0.37
	Total	72	1.66	0.39

Note. Elaborated by the authors.

One-way analyses of variance (ANOVA) were conducted to examine whether spatial intelligence and attitude toward AR-technologies differed according to educational level gifted students' parents (Middle School or Below, High School, Undergraduate, Graduate). As presented in Table 6, the ANOVA revealed no statistically significant difference in spatial intelligence across parents' educational levels, $F(3, 68) = 0.20$, $p = .89$, $\eta^2 = .01$. Similarly, no statistically significant differences were found across educational levels for AR Use Satisfaction, $F(3, 68) = 0.64$, $p = .59$, $\eta^2 = .03$, AR Use Intention, $F(3, 68) = 0.31$, $p = .82$, $\eta^2 = .01$, or AR Use Anxiety, $F(3, 68) = 0.47$, $p = .70$, $\eta^2 = .02$. The effect sizes were small, indicating that educational level explained only a minimal proportion of variance in these AR-related variables.

Table 6.
One-way ANOVA results

		Sum of Squares	*df*	Mean Square	*F*	*p*	η^2
Spatial Intelligence	Between Groups	2.70	3	.90	.20	.89	.01
	Within Groups	308.95	68	4.54			
	Total	311.65	71				
AR Use Satisfaction	Between Groups	.47	3	.16	.64	.59	.03
	Within Groups	16.47	68	.24			
	Total	16.94	71				
AR Use Intention	Between Groups	.32	3	.11	.31	.82	.01
	Within Groups	22.9	68	.34			
	Total	23.22	71				
AR Use Anxiety	Between Groups	.22	3	.07	.47	.70	.02
	Within Groups	10.42	68	.15			
	Total	10.64	71				

Note. Elaborated by the authors.

DISCUSSION AND FINAL CONSIDERATIONS

Educators acknowledge that, in order to create effective and lasting learning environments, students' positive attitudes toward the prepared educational settings and high levels of spatial intelligence are essential. The findings of this study indicate that gifted students exhibit both positive attitudes toward AR-technologies and high spatial intelligence skills. Accordingly, integrating AR-technologies into lessons is expected to enhance teaching and learning environments and support effective and durable learning. Research on AR also aligns with these findings, both in terms of attitudes (Cai et al., 2013; Küçük et al., 2014; Onbaşılı, 2018) and in terms of the role of AR-technologies in improving spatial intelligence (Guntur & Setyaningrum, 2021; Iordache et al., 2012; Shelton & Hedley, 2002).

Correlational analysis revealed a moderate and statistically significant positive association between spatial intelligence and AR Use Satisfaction among middle school gifted students. The observed positive association between spatial intelligence and AR Use Satisfaction suggests that students with higher spatial skills are more likely to experience enjoyment and satisfaction when interacting with AR-technologies. This finding can be explained by the nature of AR environments, which often require users to manipulate, rotate, or visualize objects in three dimensions (Walczak et al., 2006). Gifted students with well-developed spatial intelligence may find these interactions more intuitive and less cognitively demanding, leading to a more positive user experience. On the other hand, this positive relationship suggests that using AR-technologies with gifted students may enhance their attitudes toward technology, which could, in turn, further support the development of their spatial intelligence.

Moreover, Independent samples t-tests revealed significant differences primarily in attitude toward AR-technologies, particularly in AR Use Intention, Satisfaction, and Anxiety across class level and technology usage groups, with effect sizes ranging from medium to large in some cases. In contrast, spatial intelligence did not differ significantly across gender, class level, or daily technology usage. The finding that gifted students differed by gender, particularly in the AR Use Intention variable, with females scoring higher than males, may be explained from several perspectives. AR-technologies often present structured and visually rich learning experiences that facilitate understanding and interaction with instructional content (Nischelwitzer et al., 2007). Such environments may encourage female students to participate more actively and develop stronger intentions to use these technologies in learning processes (Blasco, 2016). Furthermore, this finding may indicate that AR-technologies have the potential to reduce traditional gender differences in technology use by creating more inclusive and engaging learning environments. Therefore, integrating AR-technologies into educational settings may contribute to increasing students' willingness to use technology, particularly among female students. The findings also indicate that students' attitudes toward AR-technologies increase as grade level progresses. As students grow older, their cognitive abilities, particularly abstract and spatial thinking skills, develop further (Vasilyeva & Lourenco, 2012). The improvement of these cognitive skills may enable students to better understand and interact with AR environments, which often require the interpretation of three-dimensional and abstract representations. In addition, older students are generally exposed to digital technologies more frequently and may have greater experience using technological tools. This increased familiarity with technology may positively influence their attitudes toward AR-technologies. Additionally, the findings show that a significant difference was observed only in the AR Use Intention variable with respect to students' daily technology use (less than five hours vs. five hours or more). Students who spend more time using technology may develop greater familiarity and confidence with digital tools (Domínguez-Figaredo & Gil-Jaurena, 2025). This familiarity may increase their willingness to adopt new technologies such as AR.

On the other hand, one-way ANOVA results demonstrated that educational level of parents did not produce statistically significant differences in spatial intelligence or AR-related attitudes. Taken together, these results suggest that while certain experiential factors (e.g., class level and technology usage) may influence AR-related perceptions, broader educational background does not appear to play a substantial role. Overall, the findings indicate that gifted students have positive attitudes toward AR-technologies and that these attitudes are positively associated with spatial intelligence. Therefore, integrating AR technologies into educational environments may support the development of spatial skills and provide enriched learning experiences for gifted learner.

REFERENCES

Azı, F. B. (2020). *Artırılmış gerçeklik uygulamalarının sosyal bilgiler dersinde akademik başarı ve ders tutumlarına etkisi* [Unpublished doctoral thesis, Necmettin Erbakan University].

Blasco, D. (2016). Promoting female students' interests in studying with educational technology. *International Journal on Integrating Technology in Education, 5*(2), 19–31. https://doi.org/10.5121/IJITE.2016.5202

Cai, S., Chiang, F. K., & Wang, X. (2013). Using the augmented reality 3D technique for a convex imaging experiment in a physics course. *International Journal of Engineering Education, 29*(4), 856–865.

Cai, S., Chiang, F. K., Sun, Y., Lin, C., & Lee, J. J. (2017). Applications of augmented reality-based natural interactive learning in magnetic field instruction. *Interactive Learning Environments, 25*(6), 778–791.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.

Domínguez-Figaredo, D., & Gil-Jaurena, I. (2025). Effects of familiarity with digital assessment in online education. *Distance Education, 46*(2), 1–16. https://doi.org/10.1080/01587919.2024.2372260

Dunleavy, M., & Dede, C. (2014). Augmented reality teaching and learning. In J. M. Spector, M. D. Merrill, J. Elen, & M. J. Bishop (Eds.), *Handbook of research on educational communications and technology* (pp. 735–745). Springer.

Dunleavy, M., Dede, C., & Mitchell, R. (2009). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. *Journal of Science Education and Technology, 18*(1), 7–22.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2011). *How to design and evaluate research in education* (8th ed.). McGraw-Hill.

Garzón, J., Pavón, J., & Baldiris, S. (2019). Systematic review and meta-analysis of augmented reality in educational settings. *Virtual Reality, 23*, 447–459. https://doi.org/10.1007/s10055-019-00379-9

Guntur, M. I. S., & Setyaningrum, W. (2021). The effectiveness of augmented reality in learning vector to improve students' spatial and problem-solving skills. *International Journal of Interactive Mobile Technologies, 15*(5), 159–173. https://doi.org/10.3991/ijim.v15i05.19037

Herawati, H., & Hariyani, M. (2024). Spatial thinking ability in elementary school. *Pionir: Jurnal Pendidikan, 13*(1), 157–168. https://doi.org/10.22373/pjp.v13i1.23002

Iordache, D. D., Pribeanu, C., & Balog, A. (2012). Influence of specific AR capabilities on the learning effectiveness and efficiency. *Studies in Informatics and Control, 21*(3), 233–240.

Küçük, S., Yılmaz, R., Baydaş, Ö., & Göktaş, Y. (2014). Ortaokullarda artırılmış gerçeklik uygulamaları tutum ölçeği: Geçerlik ve güvenirlik çalışması. *Eğitim ve Bilim, 39*(Suppl. 2), 383–392. https://doi.org/10.15390/EB.2014.3590

Mann, R. L. (2004). Gifted students with spatial strengths and sequential weaknesses: An overlooked and underidentified population. *Roeper Review, 27*(2), 91–96. https://doi.org/10.1080/02783190509554296

Nischelwitzer, A., Lenz, F. L., Searle, G., & Holzinger, A. (2007). Some aspects of the development of low-cost augmented reality learning environments as examples for future interfaces in technology enhanced learning. In C. Stephanidis (Ed.), *Universal access in human-computer interaction: Applications and services* (pp. 728–737). Springer.

Onbaşılı, İ. Ü. (2018). The effect of augmented reality practices on the attitudes of primary school students towards augmented reality practices and science motivation. *Ege Eğitim Dergisi, 19*(1), 320–337.

Özçakır, B. (2017). *Fostering spatial abilities of seventh graders through augmented reality environment in mathematics education: A design study* [Unpublished doctoral thesis, Middle East Technical University].

Özer, M. (2021). Science and art centers in support of talent development for gifted and talented students: Current situation and areas for improvement. *OPUS International Journal of Society Researches, 17*(33), 727–749. https://doi.org/10.26466/opus.810856

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education, 147*, Article 103778. https://doi.org/10.1016/j.compedu.2019.103778

Serio, A. D., Ibáñez, M. B., & Kloos, C. (2013). Impact of an augmented reality system on students' motivation for a visual art course. *Computers & Education, 68*, 586–596. https://doi.org/10.1016/j.compedu.2012.03.002

Shelton, B. E., & Hedley, N. H. (2002, September 29). Using augmented reality for teaching Earth-sun relationships to undergraduate geography students. *The First IEEE International Workshop Augmented Reality Toolkit*, Darmstadt, Germany. https://doi.org/10.1109/ART.2002.1106948

Singhal, S., Bagga, S., Goyal, P., & Saxena, V. (2012). Augmented chemistry: Interactive education system. *International Journal of Computer Applications, 49*(15), 1–5. https://doi.org/10.5120/7700-1041

Vasilyeva, M., & Lourenco, S. F. (2012). Development of spatial cognition. *WIREs Cognitive Science, 3*(3), 349–362. https://doi.org/10.1002/WCS.1171

Walczak, K., Wojciechowski, R., & Cellary, W. (2006). Dynamic interactive VR network services for education. In M. Slater, Y. Kitamura, A. Tal, A. Amditis, & Y. Chrysanthou (Eds.), *Proceedings of the ACM Symposium on Virtual Reality Software and Technology* (pp. 277–286). ACM.

Wu, H.-K., Lee, S. W.-Y., Chang, H.-Y., & Liang, J.-C. (2013). Current status, opportunities and challenges of augmented reality in education. *Computers & Education, 62*, 41–49. https://doi.org/10.1016/j.compedu.2012.10.024

Yılmaz, Z. A., & Batdı, V. (2016). Artırılmış gerçeklik uygulamalarının eğitimle bütünleştirilmesinin meta-analitik ve tematik karşılaştırmalı analizi. *Eğitim ve Bilim, 41*(Suppl. 2), 273–289. https://doi.org/10.15390/EB.2016.6707

CRediT Author Statement

- **Acknowledgements**: No.
- **Funding**: No.
- **Conflicts of interest**: No.
- **Ethical approval**: This study was approved by the Ethics Committee of Mersin University, Educational Sciences. The ethics approval was granted on June 15, 2022 under the protocol number 2022/280. All procedures involving human participants were conducted in accordance with institutional and national ethical standards, and applicable regulations. Informed consent was obtained from all participants and their parents.
- **Data and material availability**: The data are available upon request to the editors but cannot be shared publicly due to ethical and legal restrictions.
- **Authors' contributions**: First Author: Writing – first essay and Research. Contributed to the development of the research methodology and was responsible for writing several sections of the manuscript, as well as participating in the overall organization of the study. Second Author: Writing – first essay and Research. Contributed to the development of the research methodology and assisted in writing various parts of the manuscript, including the refinement of methodological explanations. Third Author: Data curation and Research. Primarily responsible for the data collection process and conducted the statistical data analysis. Fourth Author: Concept, Supervision and Writing – proofreading and editing. Played a key role in formulating the research questions, designing the methodological framework of the study, and provided academic guidance and supervision throughout the research process, including critical revisions of the manuscript. Fifth Author: Formal Analysis and Visualization. Contributed to the data analysis, prepared the results section, and interpreted the findings by attributing meaning to the results based on predetermined theoretical frameworks.

Processing and editing: Editora Ibero-Americana de Educação
Proofreading, formatting, normalization and translation

EDITORA IBERO-AMERICANA