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The Effect of Artificial Intelligence-Based E-Learning Environment on Students' Attitudes Towards Science Course

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Abstract

This study aims to examine the effects of e-learning environments prepared according to multiple intelligence fields determined by artificial intelligence in science teaching on the attitudes of 5th-grade students towards the science course and to obtain the students' opinions. The study was conducted within the framework of mixed methods. Conducted in the 2022-2023 academic year, the research involved 130 students (58 girls and 72 boys) from one experimental and three control groups at a secondary school in Elâzığ. Quantitative data were collected using the "Science Course Attitude Scale," while qualitative data were gathered through semi-structured interviews. SPSS 23 package program was utilized for quantitative data analysis, performing a One-Way ANOVA, while qualitative data underwent content analysis. Over eight weeks (four hours weekly), the website created for the study first identified the dominant intelligence types of experimental group students. They then received training on the "Matter and Change" unit in an e-learning environment tailored to their intelligence types. In contrast, control groups followed the standard curriculum with teacher-led lessons. The ANOVA results indicated no statistically significant difference in science course attitude scores between the experimental and control groups. However, interviews with experimental group students revealed that their interest, desire, curiosity, and motivation toward the science course increased. They highlighted that the platform tailored to their dominant intelligence types provided benefits such as personalized learning, ease of learning, enjoyable experiences, a positive attitude towards the subject, and an engaging, that is free of boredom learning environment.

Keywords: Artificial Intelligence, Machine Learning, Multiple Intelligence Theory, Science Education, E-Learning, Science Attitude

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2025, 14 (3), 1253-1274 | Araştırma Makalesi

Yapay Zeka Tabanlı E-Öğrenme Ortamının Öğrencilerin Fen Dersine Yönelik Tutumları Üzerine Etkisi

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Öz

Bu çalışmanın amacı, fen öğretiminde yapay zekâ ile belirlenen çoklu zekâ alanlarına göre hazırlanmış e-öğrenme ortamlarının, 5.sınıf öğrencilerinin fen dersine yönelik tutumlarına etkisinin incelenmesi ve öğrencilerin görüşlerinin alınmasıdır. Çalışma, karma yöntem çerçevesinde yürütülmüştür. Çalışma, 2022-2023 eğitim öğretim yılı Elâzığ iline bağlı bir ortaokulda öğrenim görmekte olan biri deney, üçü kontrol olmak üzere 58 kız, 72'si erkek toplamda 130 öğrenci ile gerçekleştirilmiştir. Çalışmanın nicel verileri "Fen Dersine Yönelik Tutum Ölçeği" ile toplanırken, nitel verileri yarı yapılandırılmış mülakat ile toplanmıştır. Nicel verilerin analizinde SPSS 23 paket programı kullanılmıştır ve Tek Yönlü Varyans Analizi (ANOVA) yapılmıştır. Çalışmanın nitel verileri ise içerik analizi ile değerlendirilmiştir. Çalışma sekiz haftada (haftada dört saat) tamamlanmıştır. Çalışmaya özel olarak tasarlanan web sitesinde öncelikle deney grubu öğrencilerinin her birinin baskın zekâ türü belirlenmiş ardından ise baskın zekâ türlerine uygun olarak hazırlanmış e-öğrenme ortamında "Madde ve Değişim" ünitesine yönelik eğitim almaları sağlanmıştır. Kontrol gruplarında ise mevcut öğretim programına uygun, öğretmen eşliğinde dersler normal seyrinde işlenmiştir. Çalışmanın ANOVA sonuçlarına göre; deney grubu öğrencilerinin fen dersine yönelik tutumları ile kontrol gruplarının fen dersine yönelik tutumlarının arasında deney grubu lehine anlamlı bir farklılık tespit edilmemiştir. Uygulama sonrasında deney grubu öğrencileri ile yapılan mülakat sonuçlarında ise öğrenciler fen bilimleri dersine yönelik; ilgi, istek, merak ve motivasyonlarının arttığını sıklıkla dile getirmişlerdir. Ayrıca, platformun baskın zekâ tipine uygun olarak hazırlanmış olmasının kişiselleştirilmiş öğrenme, kolay öğrenme, eğlenerek öğrenme, derse karşı olumlu tutum geliştirme, başarıya katkı sağlama, dikkat çekici olma ve sıkılmadan öğrenme gibi birçok açıdan avantaj sağladığını da belirtmişlerdir.

Anahtar Kelimeler: Yapay Zekâ, Makine Öğrenmesi, Çoklu Zekâ Kuramı, Fen Bilimleri Eğitimi, E-Öğrenme, Fen Tutum

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Introduction

The COVID-19 pandemic has caused significant challenges in many sectors, including education. Schools worldwide have had to switch from face-to-face education to online education. This has created new challenges for institutions and new opportunities for using technology in teaching and learning. In other words, it has provided broad perspectives on the role of technologies in changing the learning process, supporting sustainable teaching, and providing an educational environment to students around the world during distance learning (Abbasi et al., 2020). Before the COVID-19 pandemic, there were online platforms for conducting classes, sharing resources, conducting evaluations, and managing the daily routine activities of academic institutions. However, the use of these existing platforms was proactive (Haleem et al., 2022). The pandemic process has forced institutions to adopt the online teaching mode to sustain the education system. Digital technologies played the role of savior of education in this crisis period (Araújo et al., 2021; Burlacu, 2011; Javaid et al., 2020; Seale et al., 2021). Among the many digital solutions adopted during this period, e-learning stood out as one of the most widely implemented and impactful technologies.

E-learning, which gained great momentum before the pandemic, has become indispensable after the COVID-19 crisis. E-learning integration aims to support face-to-face learning by making it more flexible, effective, and efficient (Sukendro et al., 2020). The rapid advancement of educational technology (El Sabağ, 2021) has customized learning experiences. This has made the content of e-learning environments richer and more diverse (El-Sabagh & Hamed, 2020). During the COVID-19 pandemic, some studies were carried out for e-learning applications in education (Abbasi et al., 2020; Favale et al., 2020). However, there is still a deficiency in this area, and e-learning platforms remain limited in scope and subject diversity (Sukendro et al., 2020). Moreover, in many traditional e-learning environments, teaching typically follows a “one size fits all” approach. This means that students who differ from each other in many subjects are all exposed to the same learning procedures. These learning approaches do not take into account students' dominant intelligence types, learning styles, preferences, needs, and expectations.

Such uniform approaches fail to accommodate students' individual learning needs. In this context, Howard Gardner's Theory of Multiple Intelligences becomes extremely important. This theory utilizes cognitive science, developmental psychology, and neuroscience to argue that each individual's intelligence level is formed by autonomous powers or abilities and that there are at least eight powers (intelligence) (Demirel, 1999). Howard Gardner emphasizes that individuals have various types of intelligence such as verbal-linguistic, logical-mathematical, bodily-sensory, visual-spatial, musical-rhythmic, social-interpersonal, introverted, and naturalist, and that they learn best with methods appropriate to their dominant types of intelligence.

Given the diversity in intelligence types, there is a growing consensus on the need for educational approaches that are tailored to individual learners. Personalized learning has thus emerged as an important pedagogical approach to address these issues (Lokare & Jadhav, 2024). The ability to customize learning experiences according to students' individual characteristics—such as their dominant intelligence type—has the potential to significantly improve learning outcomes. Personalization in e-learning is one topic that has recently attracted significant attention (Hogo, 2010; Virvou et al., 2015). It is also one

of the limitations of e-learning platforms. E-learning can provide access to information, but presenting and personalizing the content is a big problem. At this stage, current technologies come into play. With rapid developments in artificial intelligence and machine learning, improving e-learning platforms and processes and personalizing e-learning environments is no longer a dream (Magomadov, 2020; Moubayed et al., 2018). Educational technology researchers, especially in recent years, have aimed to test and present new approaches incorporating artificial intelligence techniques to make e-learning environments easier for students to learn and to increase the quality of education to higher levels (Oubalahcen et al., 2023).

Literature Review and Significance of the Study

In recent years, many studies have been conducted on the development of personalized learning environments and the effects of these environments on students' academic achievement, attitudes, and motivation. Especially with the integration of artificial intelligence technology into education, it is aimed to provide personalized learning experiences, and many different e-learning platforms have been developed in this direction. A review of the literature reveals that most of these personalized learning environments are based on limited variables such as students' learning styles or interests, while the studies involving multiple intelligences are mainly in the field of language education. Some of these studies are given below.

Kaewkiriya et al. (2016) aimed to design a rule-based recommendation system that considers learning profiles based on multiple intelligences. Their study was grounded in the observation that many e-learning environments lack content tailored to students' abilities. Similarly, Mankad (2015) proposed a conceptual e-learning model that integrates the theory of multiple intelligences. He emphasized the benefits of e-learning and the mechanisms for its effective implementation by showcasing how multiple intelligences theory can enhance learning outcomes. Through a student survey, he demonstrated the importance of aligning e-learning environments with learners' dominant intelligences. Likewise, Hafidi and Lamia (2015) developed an e-learning system that predicts students' abilities using the theory of multiple intelligences. Their proposed system recommends personalized courseware to match individual learners' intelligence profiles.

Most studies on the integration of multiple intelligences and artificial intelligence have been conducted in the context of language learning. For instance, Ptychoutis and Al Rawahi (2024), in their conceptual study, explored the integration of multiple intelligences theory with AI tools in English as a Foreign Language (EFL) education. They proposed a strong pedagogical framework that demonstrates the synergy between these two approaches, emphasizing their potential to enhance student engagement, motivation, and inclusion in EFL classrooms. Their work serves as a foundational reference for future research. Similarly, Eslit (2023) examined how the integration of multiple intelligences and artificial intelligence in language learning affects personalized instruction and student engagement.

On the other hand, there are many studies in science education in which teaching practices based on the theory of multiple intelligences were carried out, and the effects of these practices on students' academic achievement and attitudes towards the course were examined (Akkuzu & Akçay, 2011; Ateş, 2007; Şengül, 2007). However, these studies were limited to in-class multiple intelligence activities and the personalization dimension in

the digital environment was missing.

The COVID-19 pandemic has clearly highlighted the urgent need for robust and flexible digital education solutions that can address diverse student needs across the globe. Providing personalized content that facilitates students' learning has become the primary concern of today's e-learning systems. The theory of multiple intelligences can serve this purpose tremendously and make an essential contribution to the teaching and learning process, as it allows for the inclusion and consideration of students' needs, styles, intelligences, and potential (Alsalthi, 2020). In this context, the uniqueness of this study lies in the use of artificial intelligence technology to identify students' dominant intelligence types and provide instruction in a digital e-learning environment tailored to their dominant intelligence. This application, which is conducted entirely online, centers on students' differences and offers an e-learning environment that accommodates their individual characteristics. In addition, this study differs from the existing literature in several significant ways. While the majority of studies integrating multiple intelligences theory and artificial intelligence have been conducted in the field of language learning, the present study focuses on science education, where such applications remain scarce. Furthermore, whereas previous studies in science education based on multiple intelligences theory have largely been limited to classroom-based implementations, this study was conducted entirely within an online learning environment. This innovative approach is expected to make a unique and valuable contribution to both the fields of educational technology and science education.

Research Aim and Research Questions

In this study, the dominant intelligence types of the students were determined with an artificial intelligence-supported system, and science education was carried out in the e-learning environment developed in this direction. The research aims to determine the effect of this e-learning environment on the attitudes of 5th-grade students towards science lessons and to analyze the opinions of the students who participated in the application about their experiences. This study aims to answer the following research questions:

- Is there a significant difference in the Attitudes Toward Science Course Scale post-test scores between students who received education in e-learning environments designed according to their dominant intelligence types identified through a machine learning model and those who received traditional teacher-led education?
- What are the students' opinions regarding the e-learning environments organized according to their dominant intelligence types identified through a machine learning model?

Methods

This study was carried out within the framework of mixed methods, where both quantitative and qualitative methods were used together. According to Tashakkori & Teddlie (1998), mixed method is a combination of quantitative and qualitative approaches to a study. The understanding that quantitative data and qualitative data provide for a problem is different. While qualitative data provides a detailed understanding of the problem, quantitative data provides a more general understanding. While quantitative understanding is based on examining a large number of people and evaluating the

answers given to some variables determined by the researcher, qualitative understanding is based on working with a small number of people and examining their perspectives in more detail. Quantitative and qualitative methods reveal different perspectives and have limitations and strengths. However, with the mixed method, where both methods are used together, the limitations of one of the quantitative or qualitative methods can be overcome by the strengths of the other method (Creswell & Plano Clark, 2015; Johnson & Onwuegbuzie, 2004).

The study employed an explanatory sequential mixed methods design, which is one of the mixed method approaches. In the first stage of the study, quantitative data were collected and analyzed. In the second stage, qualitative data were gathered to gain a deeper understanding of the quantitative findings and to explain the results based on students' experiences. In this context, semi-structured interviews were conducted with students in the experimental group, and the quantitative results were interpreted in an explanatory manner based on these interviews. Therefore, the study was structured in accordance with the core principle of the explanatory sequential mixed methods design, which involves supporting quantitative findings with qualitative data (Creswell & Plano Clark, 2015).

Participants

Convenient/accidental sampling, one of the non-random sample techniques, was employed in the study group selection. The appropriate sampling method, sometimes known as convenient or incidental sampling, is a technique that aims to minimize labor, time, and financial losses. (Büyüköztürk et al., 2016). In this context, the study group consisted of students studying at the 5th-grade level in a public secondary school in Elâzığ City Centre. The main reason for choosing 5th-grade students in the study is that both cognitive and affective development levels of students in this age group are suitable for observing the effects of differentiated learning environments based on multiple intelligence theory. In addition, since 5th-grade students encounter discipline-based Science courses for the first time, it is thought that the positive attitudes to be developed in this period will form a permanent basis for scientific thinking at later grade levels. A total of one experimental group and three different control groups were studied. The control group consisted of students from three different classes in the same school who studied the same unit as the experimental group but were taught using traditional methods. These classes were instructed by three different science teachers. The primary rationale behind this choice was the recognition that teacher diversity is a natural aspect of real classroom environments, and incorporating it into the study design aimed to enhance the external validity of the research. Individual differences among teachers—such as pedagogical approaches, experience levels, and classroom management skills—are important factors that can influence students' attitudes toward the subject. Therefore, structuring the control group to reflect teacher diversity, rather than relying on a single instructor, was intended to strengthen the generalizability of the findings to a broader student population. Furthermore, addressing teacher influence as part of the natural variation in classroom settings, rather than as an isolated individual variable, is considered to contribute to a more objective comparison between the experimental and control groups. Students in the experimental group learned the "Matter and Change (MaC)" unit without any support through an e-learning environment prepared according to their dominant intelligence types on a web page designed specifically for the study. The students of three different classes, where the other three teachers taught, learned the

MaC unit with their teachers, adhering to the current curriculum. Therefore, the effect of the AI-based e-learning environment on students was compared with the impact on the students of three different science teachers who taught by the current curriculum. Examined the frequency and percentage distributions of the experimental group, control group 1, control group 2, and control group 3 students in the study group according to their gender and are given in Table 1.

Table 1. Frequency and percentage distribution of students participating in the study by gender

Groups	Female		Male		Total	
	f	%	f	%	f	%
Experimental Group	9	25	27	75	36	27.6
Control Group 1	22	64.7	12	35.2	34	26.1
Control Group 2	7	26.9	19	73.1	26	20
Control Group 3	20	58.8	14	41.2	34	26.1
Total	58	44.6	72	55.3	130	100

When Table 1 is examined, it is seen that the experimental group includes 36 students, with 25% girls and 75% boys. Control Group 1 has 34 students (64.7% girls, 35.2% boys), Control Group 2 has 26 students (26.9% girls, 73.1% boys), and Control Group 3 has 34 students (58.8% girls, 41.2% boys). Overall, the study was conducted with 130 fifth-grade students, of whom 44.6% were girls and 55.3% were boys.

Application Process

The study was conducted during the fall semester of the 2022–2023 academic year. The experimental and control groups consisted of 5th-grade students enrolled in a public school. The experimental group received science instruction through the website www.eduwithai.com, which was specifically designed for this research, under the observation of the researcher. The study lasted for eight weeks, with four class hours per week, and both pre-tests and post-tests were administered to the experimental and control groups. After completing the pre-tests, students in the experimental group registered on the website www.eduwithai.com and filled out the required forms. Using a machine learning model integrated into the website, each student's dominant intelligence type was identified, and students were directed to an e-learning environment tailored to their specific intelligence type.

The reason for choosing the MaC unit within the scope of the study is that the outcomes of the unit are quite suitable for enrichment with learning activities that can be associated with different types of intelligence. The videos of the achievements were shot by the researcher and the suitability of these videos for the intelligence types was evaluated by expert academics in the field. Instructional videos related to the learning outcomes of the unit were prepared before the implementation of the study but were not uploaded all at once. Instead, the videos were uploaded to the system each week, right before the scheduled lesson, in alignment with the relevant learning objectives. Throughout the process, the researcher provided guidance to the students and offered technical support when they experienced difficulties accessing the system or encountered problems with their devices. Each student brought their phone, tablet, or computer and followed the lessons independently using headphones. In both the experimental and control groups, the standard science textbook was used as a common printed material. Every week, students in the experimental group studied the lesson through videos designed according

to their dominant intelligence type, took notes, and completed the class by participating in engaging activities that also aligned with their intelligence profile. After the completion of the unit, post-tests were administered, and semi-structured interviews were conducted with 13 students (five girls and eight boys), selected based on their dominant intelligence types and voluntary participation. The researcher did not intervene in the control groups in any way. The three control groups completed the same pre- and post-tests used in the experimental group at the beginning and end of the unit.

What is the “Eduwithai.com” web page designed for?

This article covers part of a comprehensive study. The study was carried out in three stages in total. Within the scope of the first stage, two outcomes were determined for the 5th grade learning areas in the science course curriculum. A total of 16 videos were shot based on the multiple intelligence theory (eight different types of intelligence) suitable for these two achievements. In the second phase of the study, a web page named www.eduwithai.com was opened, using the abbreviations "education with AI" specific to the doctoral thesis, and these videos were uploaded to the system. Students were asked to watch the videos of each learning area and score from 1 to 8, from the video they understood best to the video they did not understand the most. Demographic information about each student was also used. While students' demographic information and video sequences were used as input data, dominant intelligence types were used as outputs according to the scores they received from the "multiple intelligence scale for children", whose validity and reliability study was conducted by Kırmızı Susar (2006). Seven different machine learning algorithms were used with the data collected from 527 students, and a model was created with the algorithm that best predicted the students' dominant intelligence type. Then, a special e-learning environment was designed for eight different intelligence types in accordance with each achievement in the MaC unit. In other words, each learning outcome is supported by a narrative and activities specific to eight different types of intelligence. This article constituted the third phase of the study. With the model created in Stage 2, it is aimed to determine the dominant intelligence of the student who has just entered the system, and then to receive education in an e-learning environment suitable for the dominant intelligence type. For the experimental group, the entire process was carried out on the "eduwithai.com" website without teacher support.

Data Collection Tools

While the quantitative data of the research were collected with the "Science Course Attitude Scale (SCAS)", the qualitative data were collected through semi-structured interviews with the experimental group students.

The original form of the SCAS was developed by Enger and Yager (2001) and adapted into Turkish by Kapıcı and Akçay (2016). There are a total of 18 statements on the scale, and it consists of 4 sub-dimensions. These statements measure the sub-dimensions of "Attitude Towards Science Teachers," "Attitude Towards Science Course," "Attitude Towards the Benefits of Science," and "Attitude Towards Scientists." The Cronbach alpha value of the scale was calculated as .76.

A semi-structured interview was conducted to obtain the opinions and information of the students in the experimental group about their training process for the MaC unit by the dominant intelligence type determined by AI. The researcher prepared three questions

that served the purpose of the study. After obtaining expert opinions, the questions were ready to be used as a qualitative data collection tool. These questions:

1. Did receiving science education in accordance with the dominant intelligence type determined by artificial intelligence change your attitude towards science?
2. What are the advantages and disadvantages of this platform prepared according to intelligence type?
3. Do you have anything to say or any suggestions?

Interviews were conducted via phone calls, and conversations were recorded with the permission of the students. Interviews lasted a minimum of 7 minutes and a maximum of 12 minutes. Semi-structured interviews were conducted with 13 fifth-grade students from the experimental group, five girls and eight boys. In the selection of students, care was taken to ensure that they had different intelligence types and that they were volunteers. The real names of the students were not used, and each student was given a nickname consisting of three letters.

Analysis of Data

Quantitative Data Analysis

Before starting the analysis, it was checked whether there was any error in transferring the quantitative data collected from the experimental and control groups to the computer environment. Licensed SPSS 23 package program was used in the analysis of quantitative data.

In this study, a one-way analysis of variance (One-Way ANOVA) was conducted to determine whether there was a statistically significant difference in students' attitudes toward the science course between the experimental group and the control groups. This analysis method is a widely used parametric test recommended in cases where the means of more than two independent groups need to be compared (Field, 2013; Pallant, 2020). Before conducting the ANOVA analysis, the assumptions required for ANOVA were examined. First, it was confirmed that the samples whose mean scores were to be compared were independent. To assess whether the data followed a normal distribution, skewness, kurtosis, and Shapiro-Wilk test values were evaluated. The skewness and kurtosis values were found to be between -2 and +2, which is generally considered acceptable and indicates that the data do not significantly deviate from normality (George & Mallery, 2010). Since the group sizes were fewer than 50, the Shapiro-Wilk test was used to further assess normality. A p-value greater than .05 suggests that the data do not significantly deviate from a normal distribution (Büyüköztürk, 2015). In this case, all p-values from the Shapiro-Wilk test were greater than .05, supporting the assumption of normality. To test the assumption of homogeneity of variances—another key assumption of ANOVA—the Levene's test was performed. The result of the Levene's test was $p = .138$, which is greater than .05, indicating that the variances across groups were equal. In this case, it is possible to say that all assumptions of ANOVA are met.

Qualitative Data Analysis

Used the content analysis method to analyze the data obtained from semi-structured interviews. The process performed in content analysis is to compile similar data within the framework of specific themes and concepts and organize and interpret them in a way that the reader can easily understand (Yıldırım & Şimşek, 2008). In this study, an

inductive content analysis method was employed to analyze the data obtained from the semi-structured interviews, following the model proposed by Elo and Kyngäs (2008). This approach was chosen as it allows categories and themes to emerge from the data without imposing predetermined categories. The process included open coding, category creation, and abstraction. First, interview recordings were transcribed verbatim. Then, two researchers independently reviewed the transcripts, coded the data, and identified emerging themes. The theme, category and codes were then compared and finalized through consensus. To ensure reliability, the inter-coder agreement was calculated using the Miles and Huberman (1994) formula ($\Delta = C \div (C + \delta) \times 100$, was used (Δ : Reliability coefficient, C: Consensus number of terms provided, δ : Number of terms for which there is no consensus), resulting in a reliability coefficient of 91%, which indicates high consistency in coding. This ratio obtained shows that the coding of the data is reliable (Miles & Huberman, 1994). Participant names were kept confidential throughout the analysis.

Results

This part of the study includes quantitative and qualitative findings from the SCAS. Quantitative findings are given under "Descriptive Statistics" and "Inferential Statistics". Under the heading of descriptive statistics, the comparison between the groups, standard deviation, kurtosis, and skewness values, minimum and maximum values, and Shapiro-Wilk values of the pretest and posttest mean scores of the " SCAS " of the study group were included. Under the heading of inferential statistics, statistical results for the relationship between dependent and independent variables were given, and the study's research questions were analyzed.

Quantitative Data

Descriptive Statistics

The average distributions of the Pre-SCAS scores and Post-SCAS scores applied to the students in the study were examined. The comparison of the mean scores of the 5th grade students between the groups, standard deviation, kurtosis and skewness values, minimum and maximum values and Shapiro-Wilk values are given in Table 2.

Table 2. Descriptive statistics of 5th-grade students' SCAS pretest and posttest scores

Tests	Groups	Gender	N	$\bar{X}$	SD	Skewness	Kurtosis	Range	Min	Max	Shapiro-Wilk
Pre-SCAS	Experimental Group	Female	9	65.44	7.23	-.807	-.047	21	52	73	.267
		Male	27	64.18	7.8	-.080	-.643	31	49	80	.879
		Total	36	65.25	7.63	-.199	-.633	31	49	80	.685
	Control Group 1	Female	22	65.04	7.44	.422	-.720	26	52	78	.092
		Male	12	68.08	9.09	.455	.301	32	52	84	.238
		Total	34	66.5	8.02	.385	-.335	32	52	84	.209
	Control Group 2	Female	7	65.57	7.11	.706	.720	22	56	78	.765
		Male	19	64.10	9.53	-.150	-.236	36	46	82	.852
		Total	26	64.50	8.83	-.123	-.051	36	46	82	.895
	Control Group 3	Female	22	66.86	6.81	-.033	-.692	24	54	78	.498
		Male	12	68.16	6.81	.690	-.440	27	56	83	.252
		Total	34	67.5	7.38	.334	-.428	29	54	83	.398
Post-SCAS	Experimental Group	Female	9	67.88	5.89	-.675	-1.038	16	58	74	.235
		Male	27	67.74	7.68	-.377	-.873	26	53	79	.217
		Total	36	67.77	7.19	-.410	-.788	26	53	79	.133
	Control Group 1	Female	22	66.95	6.69	.270	-.665	24	55	79	.590
		Male	12	67.83	8.5	.181	-.037	30	53	83	.920
		Total	34	66.90	7.3	.365	-.247	30	53	83	.598
	Control Group 2	Female	7	66.71	5.25	.042	-.873	15	59	74	.865
		Male	19	65.36	10.73	-.179	.161	42	43	85	.738
		Total	26	65.73	9.48	-.270	.715	42	43	85	.503
	Control Group 3	Female	22	67.90	6.60	-.373	.045	26	54	80	.866
		Male	12	68.66	7.55	.379	.617	28	55	83	.646
		Total	34	68.03	6.90	-.017	.213	29	54	83	.562

When Table 2 is examined, the mean SCAS score of the experimental group increased from the pre-test ($\bar{X}$ =65.25) to the post-test ($\bar{X}$ =67.77). In contrast, the increases in the control groups were more limited: Control Group 1 ($\bar{X}$ =66.5 $\rightarrow$ $\bar{X}$ =66.90), Control Group 2 ($\bar{X}$ =64.50 $\rightarrow$ $\bar{X}$ =65.73), and Control Group 3 ($\bar{X}$ =67.5 $\rightarrow$ $\bar{X}$ =68.03). Although these changes indicate a positive trend in the experimental group, it is not appropriate to draw definitive conclusions based solely on mean differences without conducting significance tests.

Inferential Statistics

Findings Related to ANOVA Analysis

This part of the study presents the results related to the question, "Is there a significant difference in the Attitudes Toward Science Course Scale post-test scores of students who received education in e-learning environments organized according to the dominant intelligence types identified through machine learning model and those who received traditional teacher-led education?"

Table 3. ANOVA results of the attitude scale scores of the experimental and control groups towards science course

Source of variance	Sum of squares	df	Mean squares	F	p
Intergroup	209.577	3	69.859	1.159	.328

Intragroup	7594.431	126	60.273
Total	7804.008	129	

The analysis results show that there is no significant difference between the students' attitudes towards science course in terms of the applied method, $F(3, 126) = 1.159, p > .05$. In other words, the students' attitudes towards science course do not differ significantly depending on the applied method.

Qualitative Data

The themes and codes obtained from the answers to the given by students' in the question "Did receiving science education in accordance with the dominant intelligence type determined by artificial intelligence change your attitude towards science?" is shown in Table 4.

Table 4. Students' opinions on their attitudes towards science

Theme	Category	Code	Frequency
Attitude Towards Science	Interest and Curiosity	My interest increased	11
		My curiosity increased	8
	Desire and Enjoyment	My desire increased	5
		My love increased	5
	Motivation	My motivation increased	3

As seen in Table 4, most students expressed positive changes in their attitudes toward science, frequently stating that their interest and curiosity increased. Sample opinions of some students regarding the question asked by the researcher are given below.

Asu: "My interest and desire for science increased. I love science more now, with videos and activities that suit my visual intelligence. My friends also knew that I was uninterested in science before. But now I'm more interested in science."

Eva: "My curiosity and motivation towards science increased. This was the first time I was curious about science. Now, every week, I wonder what I will encounter. I have always had an interest in it, but it has grown more."

Han: "My curiosity, especially towards science, has increased. Frankly, I don't feel this way in regular science classes. Therefore, my interest in science increased."

Ege: "I loved science, but I loved it more with game-style videos suitable for my dominant intelligence type. I am eager for the day of science class to come."

The themes and codes obtained from the answers to the given by students' in the question "What are the advantages and disadvantages of this platform prepared according to intelligence type?" is shown in Table 5.

Table 5. Students' opinions on the advantages and disadvantages of the platform

Theme	Category	Code	Frequency
	Accessibility and Flexibility	Enabling learning everywhere	10
		Possibility to repeat as many times as desired	9
		Possibility to listen to lectures at any time	9
		Receiving education appropriate to the dominant intelligence type	9
Personalization		Learning without getting bored	4
		Learning subjects with fun	9

Advantages	Engagement and Motivation	Having fun activities (Puzzle, Crossword, etc.)	7
		Having fun tests suitable for the content	5
		Being remarkable	4
	Support for Learning	Helping to gain information	8
		Age-appropriate videos and activities	8
		Contributing to success	8
		Providing easy learning as it is suitable for the dominant intelligence type	6
		Developing a positive attitude towards the course	5
		Using technology for educational purposes	4
		Giving opportunity to reinforce the topics	3
Disadvantages	Content Limitations	The content is only for science course	5
	Lack of Variety	There is only one dominant type of intelligence	2
	Health and Usability Concerns	Staring at the screen strains the eyes	2
		Lack of any question and answer system (such as a chatbot)	2
		System error	1

As seen in the table, students highlighted several prominent advantages of the system. The most frequently mentioned were enabling learning everywhere (f=10), receiving education appropriate to the dominant intelligence type (f=9), learning with fun (f=9), the possibility to repeat lessons as many times as desired (f=9), and the flexibility to listen to lectures at any time (f=9). These findings suggest that accessibility, personalization, and enjoyment were key factors in students' positive experiences. On the other hand, the most common disadvantage was that the content is limited to the science course (f=5), followed by concerns about the dominance of a single intelligence type and eye strain due to screen time (f=2). While the advantages were mentioned more frequently and with greater variety, a few limitations were also noted by students. Sample opinions of some students regarding the question asked by the researcher are given below.

Ada: “I can enter the system wherever and whenever I want, which is an excellent advantage. I received education by my dominant intelligence type, so I learnt the subjects both easily and I was not bored. Moreover, I had a lot of fun.”

Ege: “Unlike school, I can enter the parts I do not understand into the system and repeat them wherever I want. The tests in the system made me feel like I competed and had a lot of fun. I was already able to answer many questions while solving them. In general, it is a remarkably different platform.”

Can: “I already loved listening to music but listened to it for educational purposes for the first time. I enjoyed it very much, and these came to mind. The negative side is that I only watch videos for music intelligence. I am also curious about the content of other intelligences, for example. Sometimes, I have a question, but I can’t ask it to anyone. I can ask the teacher at school. It is still perfect, but I wish it were not only science subjects, but also other subjects.”

The themes and codes obtained from the answers to the given by students' in the question "Do you have anything you want to say or a suggestion?" is shown in Table 6.

Table 6. Students' opinions on their requests and suggestions

Theme	Category	Code	Frequency
Request and Suggestion	General Satisfaction	Everything was good, no suggestions	7
	Inclusivity and Accessibility	Activities of other types of intelligence can be accessible to all	3
		Access to videos of non-dominant types of intelligence can also be granted	2
	Content and Scope Expansion	Such platforms can be designed for different courses	2
	Engagement and Motivation Tools	The platform can be made more interesting by adding more games with lesson content	1

As seen in the table, most students (f=7) stated that everything was good and they had no suggestions. However, some students recommended that activities targeting other types of intelligence should be accessible to all (f=3) and suggested expanding the platform to support different courses and non-dominant intelligence types (f=2). These findings indicate overall satisfaction, along with a few constructive suggestions for inclusivity and content diversity. Sample opinions of some students regarding the question asked by the researcher are given below.

Ada: “Everything was beautiful. But there could be more educational games so we can spend more time on the system.”

Eva: “Everything was great and age-appropriate.”

Can: “I’m curious about how the subjects are explained in other types of intelligence. I was looking at it while my friends were watching, but I would like to go into it at length myself. So I wish we had the chance to see them too, so that those who wish can watch them too.”

Ahu: “I think the system is very good. The only thing I regret is that there are no other courses.”

Ali: “I would like to see videos and activities of other intelligences because I am curious about them, too. For example, my friend was doing crossword puzzles, and the other was doing puzzles. They were fun, too.”

Discussion

Today, platforms with a large number of e-learning content are available. However, it is difficult for students to select the appropriate e-material that meets their learning objectives (Arun Kumar et al., 2022). For an adequate education, it is very important to understand students and to be able to meet their needs and interests in accordance with their individual differences. Within the scope of this study, it is aimed to create a personalised e-learning environment, which is one of the difficulties encountered in e-learning systems, and to examine its effects. It was concluded that there was no significant difference between the attitudes towards the science course of the experimental group students who received education in e-learning environments prepared according to the multiple intelligence areas determined by artificial intelligence and the attitudes towards the science course of the control group 1, control group 2 and control group 3 students who were taught with traditional teaching methods. In this case,

it can be said that estimating the students' dominant intelligence types and then educating them in e-learning environments prepared in accordance with their intelligence types is not effective in changing their attitudes towards science courses. The study was conducted in six weeks, not counting the pretest and posttest periods. After the application, it was observed that there was an increase between the pretest and posttest scores of the experimental group, but this increase did not create a significant difference according to the ANOVA results.

Although the ANOVA results did not show a statistically significant difference between the experimental and control groups in attitude scores toward science courses, the qualitative data obtained through interviews provided deeper insights into the student's experiences, and students frequently stated that they developed positive attitudes toward science courses. Many students in the experimental group stated that their interest, desire, love, curiosity, and motivation toward science increased after participating in the e-learning environment suitable for their dominant intelligence types. The main aim of the Science Course Curriculum (2018) is to raise all individuals as science literate. Students' attitudes towards science course are also essential in achieving this goal. It is difficult for individuals who do not like science course, are not interested in science, and are not curious about the events around them to grow up as science literate. The fact that the implementation caused a positive change in students' attitudes towards science leads to the idea that it will be effective in fulfilling the objectives of the curriculum. The students who did not like science and were unsuccessful before the application stated that their perspectives toward science changed after the application, and they started to like science course. This discrepancy between quantitative and qualitative findings is not uncommon in mixed methods research and can be attributed to multiple factors (Creswell & Plano Clark, 2015). One possible explanation is the relatively short duration of the study, which may not be sufficient to produce statistically significant changes in emotional constructs such as attitudes—structures that typically develop gradually over extended periods. Türkmen (2007) emphasized that attitudes do not change easily; rather, they are shaped progressively through long-term experiences and accumulated influences. Another contributing factor might be that the attitude scale used in the study failed to capture the subtle emotional and cognitive shifts experienced by the students. In addition, students have not encountered a similar platform before and have not received education in such an environment. Due to their age, these students use technology more for entertainment purposes. However, they have been trained in an unusual learning environment for eight weeks for a completely different purpose. During this period, they tried to adapt to the environment, manage the process without teacher support, and overcome technological deficiencies. Despite all these, the fact that students' views were oriented towards developing positive attitudes towards science lessons suggests that the developed platform contributed to a fun and engaging science learning experience, which in turn has the potential to promote long-term positive changes in attitudes.

When the literature was examined, many studies were found in which personalised learning environments were developed using artificial intelligence technology (Ahmed, 2016; Baylari & Montazer, 2009; Edward et al., 2015; Kacalak & Majewski, 2009; Khan et al., 2022; Fu et al., 2022; Martin et al., 2023; Manickam et al., 2017; Parkavi et al., 2024; Potode & Manjare, 2015; Villaverde et al., 2006). However, there is no study in which dominant intelligence types of students are predicted. In addition, the effectiveness of the developed applications has yet to be evaluated. Therefore, the results of this study were

compared only with the studies in which the theory of multiple intelligences was applied in the classroom environment. In the relevant literature, there are studies similar to this study's results, in which multiple intelligence-based activities and practices do not significantly differ in students' attitudes toward science course. Şengül (2007) examined the effect of multiple intelligence theory-based teaching on sixth-grade students' attitudes toward Science and Technology courses and did not detect a significant difference between the experimental and control groups. Ateş (2007) concluded that the processing of the Science and Technology lesson "particulate structure of matter" unit based on multiple intelligence theory in sixth grade did not significantly affect students' attitudes towards science course between the experimental and control groups. There are also studies in the relevant literature that do not coincide with the results of this study (Akkuzu & Akçay, 2011; Altınsoy, 2011; Şahan, 2018; Uçak, 2006).

In conclusion, although the quantitative data did not reveal a statistically significant difference, the qualitative findings suggest that students were positively affected emotionally and cognitively towards the science course thanks to the personalized e-learning environment. These findings suggest that exposing students to digital environments designed according to their needs, even for a short period, can increase their interest and motivation and pave the way for more permanent attitude changes in the long term. Therefore, the use of artificial intelligence-based applications to support students' differences- such as identifying dominant intelligence types- holds promise for making science teaching more engaging and effective. More long-term and comprehensive research is needed to fully realize the potential impact of such systems on student attitudes and academic achievement.

Conclusion

This study examined the effect of e-learning environments prepared according to the multiple intelligence domains identified through artificial intelligence in science education on students' attitudes toward the science course and to gather their opinions. It is seen close to each other before the application that the mean scores of the experimental group students who received education on the MaC unit in e-learning environments for the dominant intelligence type determined by artificial intelligence and the control groups who were taught according to the current curriculum (See Table 2). According to the ANOVA findings, it was concluded that there was no statistically significant difference between the science course attitude scores of the 5th-grade students in the experimental group and the science course attitude scores of the 5th-grade students in the control group (See Table 3). This result can be interpreted as the e-learning environment prepared according to the dominant intelligence types determined by artificial intelligence not positively influencing students' science course attitudes compared to the lessons conducted according to the current curriculum with teacher guidance or support.

The findings indicate that students found the AI-supported e-learning platform, designed according to their dominant intelligence types, highly beneficial and enjoyable. Key advantages included personalized and fun learning experiences, flexibility in time and place, alignment with their intelligence profiles, and repeated access to content. Students noted increased motivation and positive attitudes toward the science course. Despite its advantages, students pointed out certain limitations: low internet speed at school, content limited to only one subject and one intelligence type, screen fatigue, and occasional

system errors. Notably, students expressed a desire to access content prepared for other intelligence types and suggested expanding the platform to other subjects and including more gamified elements. These suggestions reflect student engagement and satisfaction with the learning experience, indicating the potential of AI-personalized, intelligence-based e-learning platforms to enhance both enjoyment and academic outcomes.

Limitations and Recommendations

While this study provides valuable insights into the role of e-learning environments designed according to multiple intelligences identified by artificial intelligence in science teaching, it has several limitations that should be taken into account when interpreting the results.

First, the duration of the study is relatively short, limited to six weeks excluding the pre-test and post-test phases. Given that attitude development is a long-term process, this short time frame may not be sufficient to observe statistically significant changes in students' attitudes. Future studies may consider conducting their studies over a longer period to capture more lasting and measurable changes.

Second, the e-learning content was limited to a single unit (MaC) and students were only trained on the MaC unit with content appropriate to their dominant intelligence type. This narrow scope may have limited the generalizability of the findings. Expanding the content to cover more than one unit and allowing students to explore the e-learning environment tailored to different types of intelligences may increase the comprehensiveness and effectiveness of such interventions.

Third, AI was active in the study in identifying students' dominant intelligence types. Future research could further incorporate AI into the teaching and learning process. For example, a Chatbot could be created to help students by answering their questions in terms of both platform usage and domain knowledge.

Finally, although the study included both quantitative and qualitative data, the attitude scale may not have fully captured the emotional and cognitive nuances expressed in the interviews. Future research could utilize more sensitive and multidimensional measurement tools to better reflect students' emotional responses.

Değerlendirme	İki Dış Hakem / Çift Taraflı Körleme
Etik Beyan	* Bu çalışma Prof. Dr. Fikriye KIRBAĞ ZENGİN danışmanlığında 2023 tarihinde tamamladığımız “Fen Öğretiminde Yapay Zeka ile Belirlenen Çoklu Zeka Alanlarına Göre Hazırlanmış E-Öğrenme Ortamlarının Farklı Değişkenler Açısından İncelenmesi” başlıklı doktora tezi esas alınarak hazırlanmıştır. Bu çalışmanın hazırlanma sürecinde bilimsel ve etik ilkelere uyulduğu ve yararlanılan tüm çalışmaların kaynakçada belirtildiği beyan olunur. * (Fırat Üniversitesi Rektörlüğü, Sosyal ve Beşeri Bilimler Araştırmaları Yayın Etiği Kurulu Başkanlığının 31.08.2020 Tarih, 408291 Nolu kararı ile Etik Kurul Kararı alınmıştır.)
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Ethical Statement	* This article is extracted from my doctorate dissertation entitled “The analysis of e-learning settings, which are prepared on the basis of multiple intelligence domains determined by artificial intelligence in science instruction, as per different variables”, supervised by Prof. Dr. Fikriye KIRBAĞ ZENGİN (Ph.D. Dissertation, Fırat University, Elazığ/Türkiye, 2023). It is declared that scientific and ethical principles have been followed while carrying out and writing this study and that all the sources used have been properly cited. * (Fırat University Rectorate, Social and Human Sciences Research Ethics Committee Decision was taken with the decision dated 31.08.2020, numbered 408291 of the Presidency of the Publication Ethics Committee.)
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References | Kaynakça

- Abbasi, S., Ayoob, T., Malik, A., & Memon, S. I. (2020). Perceptions of students regarding E-learning during COVID-19 at a private medical college. *Pakistan Journal of Medical Sciences*, 36(COVID19-S4), 57-61. <https://doi.org/10.12669/pjms.36.COVID19-S4.2766>
- Ahmed, R. K. A. (2016). Artificial neural networks in E-learning personalization: A review. *International Journal of Intelligent Information Systems*, 5(6), 104-108. <https://doi.org/10.11648/j.ijis.20160506.14>
- Akkuzu, N., & Akçay, H. (2011). The design of a learning environment based on the theory of multiple intelligence and the study its effectiveness on the achievements, attitudes and retention of students. *Procedia Computer Science*, 3, 1003-1008. <https://doi.org/10.1016/j.procs.2010.12.165>
- Alsalthi, N. R. I. (2020). The representation of multiple intelligences in the science textbook and the extent of awareness of science teachers at the intermediate stage of this theory. *Thinking Skills and Creativity*, 38, 100706. <https://doi.org/10.1016/j.tsc.2020.100706>
- Altınsoy, A.B. (2011). *Fen ve teknoloji dersinde çoklu zekâ kuramına dayalı öğretimin öğrencilerin başarılarına etkisi [The effect of teaching based on multiple intelligence theory on students' success in science and technology courses]*. [Unpublished master's thesis]. Selcuk University.
- Araújo, A. C. D., Knijnik, J., & Ovens, A. P. (2021). How does physical education and health respond to the growing influence in media and digital technologies? An analysis of curriculum in Brazil, Australia and New Zealand. *Journal of Curriculum Studies*, 53(4), 563-577. <https://doi.org/10.1080/00220272.2020.1734664>
- Arun Kumar, U., Mahendran, G., & Gobhinath, S. (2022). A review on artificial intelligence based E-learning system. *Pervasive Computing and Social Networking: Proceedings of ICPCSN 2022*, 659-671. https://doi.org/10.1007/978-981-19-2840-6_50
- Ateş, R. Ö. (2007). *6. sınıflarda maddenin tanecikli yapısı konusunun çoklu zekâ kuramına dayalı öğretimi [Multiple intelligences theory based instruction of the particulate nature of the matter at 6th grade level]* [Unpublished master's thesis]. Balıkesir University.
- Baylari, A., & Montazer, G. A. (2009). Design a personalized e-learning system based on item response theory and artificial neural network approach. *Expert Systems with Applications*, 36(4), 8013-8021. <https://doi.org/10.1016/j.eswa.2008.10.080>
- Burlacu, S. (2011). Characteristics of knowledge-based economy and new technologies in education. *Revista Administratie si Management Public (RAMP)*, (16), 114-119.
- Büyüköztürk Ş. (2015). *Sosyal bilimler için veri analizi el kitabı [Manual of data analysis for social sciences]* (21th edition). Pegem Publishing.
- Büyüköztürk, Ş., Kılıç-Çakmak, E., Akgün, Ö., Karadeniz, Ş., & Demirel, F. (2016). *Bilimsel araştırma yöntemleri [Scientific research methods]*. Pegem Publishing.
- Cresswell, J. W., & Plano Clark, V. L. (2015). *Karma yöntem araştırmaları: Tasarımı ve yürütülmesi [Mixed methods research: Design and conduct]* (Trans. Y. Dede & S. B. Demir). Ani Publishing.
- Demirel, Ö. (1999). *Planlamadan değerlendirmeye öğrenme sanatı [The art of teaching from planning to evaluation]*. Pegem Publishing.

- El-Sabagh, H. A. (2021). Adaptive e-learning environment based on learning styles and its impact on development students' engagement. *International Journal of Educational Technology in Higher Education*, 18(1), 53. <https://doi.org/10.1186/s41239-021-00289-4>
- El-Sabagh, H. A., & Hamed, E. (2020). The relationship between learning-styles and learning motivation of students at Umm Al-Qura University. *Egyptian Association for Educational Computer Journal*. <https://doi.org/10.21608/EAEC.2020.25868.1015>
- Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, 62(1), 107–115.
- Enger, S. K., & Yager, R. E. (2001). *Assessing student understanding in science: A standards-based K-12 handbook*. Corwin Press.
- Eslit, E. (2023). *Integrating multiple intelligence and artificial intelligence in language learning: Enhancing personalization and engagement*. Preprints. <https://doi.org/10.20944/preprints202307.1044.v1>
- Favale, T., Soro, F., Trevisan, M., Drago, I., & Mellia, M. (2020). Campus traffic and e-Learning during COVID-19 pandemic. *Computer Networks*, 176, 107290. <https://doi.org/10.1016/j.comnet.2020.107290>
- Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. Sage publications limited.
- Fu, X., Lokesh Krishna, K., & Sabitha, R. (2022). Artificial intelligence applications with e-learning system for China's higher education platform. *Journal of Interconnection Networks*, 22(Supp02), 2143016. <https://doi.org/10.1142/S0219265921430167>
- George, D. & Mallery, M. (2010). *SPSS for windows step by step: A Simple Guide and References*. Baston: Allyn & Bacon.
- Hafidi, M., & Lamia, M. (2015, April). *A personalized adaptive e-learning system based on learner's feedback and learner's multiple intelligences*. In 2015 12th International Symposium on Programming and Systems (ISPS) (pp. 1-6). IEEE.
- Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, 3, 275-285. <https://doi.org/10.1016/j.susoc.2022.05.004>
- Hogo, M. A. (2010). Evaluation of e-learning systems based on fuzzy clustering models and statistical tools. *Expert systems with applications*, 37(10), 6891-6903. <https://doi.org/10.1016/j.eswa.2010.03.032>
- Javaid, M., Haleem, A., Vaishya, R., Bahl, S., Suman, R., & Vaish, A. (2020). Industry 4.0 technologies and their applications in fighting COVID-19 pandemic. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, 14(4), 419-422. <https://doi.org/10.1016/j.dsx.2020.04.032>
- Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher*, 33(7), 14-26. <https://doi.org/10.3102/0013189X033007014>
- Kacalak, W., & Majewski, M. (2009). E-learning systems with artificial intelligence in engineering. In *Emerging Intelligent Computing Technology and Applications: 5th*

International Conference on Intelligent Computing, ICIC 2009, Ulsan, South Korea, September 16-19, 2009. Proceedings 5 (pp. 918-927). Springer Berlin Heidelberg.

Kaewkiriya, T., Utakrit, N., & Tiantong, M. (2016). The design of a rule base for an e-learning recommendation system base on multiple intelligences. *International Journal of Information and Education Technology*, 6(3), 206.

Kapıcı, H., & Akçay, H. (2016). Middle school students attitudes toward science scientists science teachers and classes. *In The Asia-Pasific Forum on Science Learning and Teaching*, 17(1), 1-22.

Khan, M. A., Khojah, M., & Vivek. (2022). Artificial intelligence and big data: The advent of new pedagogy in the adaptive e-learning system in the higher educational institutions of Saudi Arabia. *Education Research International*, 1-10. <https://doi.org/10.1155/2022/1263555>

Lokare, V. T., & Jadhav, P. M. (2024). An AI-based learning style prediction model for personalized and effective learning. *Thinking Skills and Creativity*, 51, 101421. <https://doi.org/10.1016/j.tsc.2023.101421>

Magomadov, V. S. (2020). The application of artificial intelligence and big data analytics in personalized learning. *Journal of Physics: Conference Series*, 1691(1), 012169. IOP Publishing. <https://doi.org/10.1088/1742-6596/1691/1/012169>

Manickam, M. V., Mohanapriya, M., Kale, S., Uday, M., Kulkarni, P., Khandagale, Y., & Patil, S. P. (2017). Research study on applications of artificial neural networks and E-learning personalization. *International Journal of Civil Engineering and Technology*, 8(8), 1422-1432.

Mankad, K. B. (2015). The role of multiple intelligence in e-learning. *IJSRD-International Journal for Scientific Research & Development*, 3(05), 2321-0613.

Martin, E., Aziz, M. A., Pujihanarko, A., & Pratiwi, N. R. (2023). Exploring the research on utilizing machine learning in e-Learning systems. *International Transactions on Artificial Intelligence*, 2(1), 76-80. <http://doi.org/10.33050>

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Sage Publications.

Ministry of National Education [MoNE]. (2018). Science course curriculum (Grades 3–8 of primary and lower secondary education). Board of Education and Discipline.

Moubayed, A., Injadat, M., Nassif, A. B., Lutfiyya, H., & Shami, A. (2018). E-learning: Challenges and research opportunities using machine learning & data analytics. *IEEE Access*, 6, 39117-39138. <https://doi.org/10.1109/ACCESS.2018.2851790>

Oubalahcen, H., & Tamym, L. (2023). The Use of AI in E-Learning Recommender Systems: A Comprehensive Survey. *Procedia Computer Science*, 224, 437-442. <https://doi.org/10.1016/j.procs.2023.09.061>

Pallant, J. (2020). *SPSS survival manual: A step by step guide to data analysis using IBM SPSS*. Routledge.

Parkavi, R., Karthikeyan, P., & Abdullah, A. S. (2024). Enhancing personalized learning with explainable AI: A chaotic particle swarm optimization based decision support

system. *Applied Soft Computing*, 156, 111451. <https://doi.org/10.1016/j.asoc.2024.111451>

Pitychoutis, K. M., & Al Rawahi, A. (2024). Smart teaching: The synergy of multiple intelligences and artificial intelligence in english as a foreign language instruction.

Potode, A., & Manjare, P. (2015). E-learning using artificial intelligence. *International Journal of Computer Science and Information Technology Research*, 3(1), 78-82.

Seale, J., Colwell, C., Coughlan, T., Heiman, T., Kaspi-Tsahor, D., & Olenik-Shemesh, D. (2021). 'Dreaming in colour': disabled higher education students' perspectives on improving design practices that would enable them to benefit from their use of technologies. *Education and Information Technologies*, 26, 1687-1719. <https://doi.org/10639-020-10329-7>

Sukendro, S., Habibi, A., Khaeruddin, K., Indrayana, B., Syahrudin, S., Makadada, F. A., & Hâkim, H. (2020). Using an extended technology acceptance model to understand students' use of e-learning during COVID-19: Indonesian sport science education context. *Heliyon*, 6(11), 1-9. <https://doi.org/10.1016/j.heliyon.2020.e05410>

Susar Kırmızı, F. (2006). İlköğretim 4. sınıf Türkçe öğretiminde çoklu zekâ kuramına dayalı iş birlikli öğrenme yönteminin özetleme stratejisi üzerindeki etkileri [The effects of cooperative learning method based on multiple intelligence theory on summarizing strategy in teaching Turkish to 4th grade of primary school]. *Pamukkale University Journal of Social Sciences Institute*, (6), 99-108.

Şahan, A. (2018). *Fen bilimleri öğretiminde çoklu zekâ destekli eğitim modelinin öğrenci başarısına ve fen tutumuna etkisi* [The effect of the multiple intelligence supported education model on student success and science attitude in science teaching]. [Unpublished master's thesis]. Kirikkale University.

Şengül, S. H. (2007). *Çoklu zekâ kuramı temelli öğretimin ilköğretim altıncı sınıf öğrencilerinin dolaşım sistemi başarıları üzerine etkisi* [Effects of Multiple Intelligence Theory Based Instruction on Sixth Grade Primary School Students' Achievement of Circulatory System]. [Unpublished master's thesis]. Balıkesir University.

Tashakkori, A., & Teddlie, C. (1998). Mixed methodology: Combining qualitative and quantitative approaches. Sage.

Türkmen, L. (2007). The influences of elementary science teaching method courses on a Turkish teachers college elementary education major students' attitudes towards science and science teaching. *Journal of Baltic Science Education*, 6(1), 66-77.

Uçak, E. (2006). *Maddenin sınıflandırılması ve dönüşümleri" konusunda çoklu zekâ kuramı destekli öğretim yöntemi'nin öğrenci başarısı, tutumu ve hatırd tutma düzeyine etkisi* [The effect of multiple intelligence based education method to the level of student success, attitude and remembering in the unit of changes and classification of matter]. [Unpublished master's thesis]. Pamukkale University.

Villaverde, J. E., Godoy, D., & Amandi, A. (2006). Learning styles' recognition in e-learning environments with feed-forward neural networks. *Journal of Computer Assisted Learning*, 22(3), 197-206. <https://doi.org/10.1111/j.1365-2729.2006.00169.x>

Yıldırım, A., & Şimşek, H. (2008). *Sosyal bilimlerde nitel araştırma yöntemleri* [Qualitative research methods in the social sciences] (6th edition). Seckin Publishing.