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Dear Readers, Distinguished Scholars, and Researchers,

It is a great pleasure to present Volume 16, Issue 4 (October 2026) of *The Online Journal of New Horizons in Education (TOJNED)*. This issue features fourteen scholarly articles addressing artificial intelligence, digital transformation, educational innovation, institutional management, communication, and interdisciplinary research.

As technological developments continue to reshape education and society, interdisciplinary research plays an increasingly important role in understanding emerging challenges and opportunities. The contributions in this issue reflect the growing importance of integrating technological innovation with human-centered educational practices, institutional effectiveness, and sustainable development.

Overview of the Articles

The article *"A Modern Approach to Solving Text-Based Mathematical Problems"* by Malahat Abdullayeva explores contemporary approaches to mathematical problem-solving and their relevance to effective mathematics education.

Nihat Şenkaya and Azmiye Yınal, in *"Artificial Intelligence in Human Resource Management and Employee Performance,"* examine the relationship between AI applications and employee performance, with particular attention to employee engagement and digital competency.

İrfan Mertdoğdu, Azmiye Yınal, and Figen Yaman Lesinger investigate AI-driven digital marketing and consumer purchase intentions in the sports supplement industry, focusing on brand trust and health consciousness.

Soyhan Çuvalcıoğlu, Azmiye Yınal, and Figen Yaman Lesinger address AI-driven digital marketing and electric vehicle adoption intentions, emphasizing green trust and environmental concern.

Ahmet Canan Elkıran, Azmiye Yınal, and Figen Yaman Lesinger explore the relationship between AI-driven digital pharmaceutical services and medication adherence, considering patient trust and digital health literacy.

Tayfun Junior Zabit and Azmiye Yınal examine AI-driven predictive vehicle maintenance and customer loyalty, highlighting service trust and technology readiness.

Lokman Ali and K. Kalita investigate undergraduate students' attitudes toward open and distance learning in the Tinsukia District.

Alekper Aliev discusses the development prospects of educational technology and its relationship with institutional management.

Nigar Aslanova explores technology-supported approaches to teaching and learning free verse in the twenty-first century.

Gulshen Musayeva Ali examines the contributions of Azerbaijani philosophers to physics teaching methodologies from historical and contemporary educational perspectives.

Lala Musayeva investigates the effectiveness of learning taxonomies in teaching the Azerbaijan language.

Mammadov Israil Musa presents a systematic scientific discussion of the fundamental laws of modern physics and their role in explaining natural phenomena.
Özgür Yeleğen and Azmiye Yınal explore the influence of global financial communication on economic public opinion, focusing on the role of new media.
Tarana Akbari Mayıl examines the role of digital resources in developing environmental awareness among primary school students.

Editorial Perspective

The articles published in this issue demonstrate the expanding influence of artificial intelligence and digital technologies across educational, organizational, economic, and social environments. They also highlight the importance of interdisciplinary approaches in addressing contemporary challenges associated with technological transformation.
From an educational perspective, the integration of artificial intelligence and digital resources should extend beyond technological adoption to encompass critical thinking, ethical responsibility, digital literacy, accessibility, and educational quality.
Furthermore, the relationship between emerging technologies and human-centered development remains an essential consideration for researchers, educators, policymakers, and institutional leaders.
We believe that the scholarly contributions presented in this issue will encourage further academic discussion, stimulate innovative research, and support the development of new perspectives in education and related disciplines.

Acknowledgments

I would like to express my sincere gratitude to all authors for their valuable scholarly contributions and to our reviewers and editorial board members for their dedication to academic quality and scientific integrity.
We remain committed to promoting international academic collaboration, interdisciplinary research, and the dissemination of scholarly knowledge.
We hope that **Volume 16, Issue 4 (October 2026)** of *The Online Journal of New Horizons in Education* will provide valuable insights for researchers, educators, and professionals worldwide.

Prof. Dr. Aytekin İŞMAN
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October 2026

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A MODERN APPROACH TO SOLVING TEXT-BASED MATHEMATICAL PROBLEMS

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ABSTRACT
Solving word (text-based) mathematical problems plays a critical role in developing students' analytical thinking, problem-solving, and mathematical modeling skills. For effective instruction, this process is structured into two fundamental phases: preliminary preparation and direct problem solution. In the preparation phase, students identify relationships between given data and unknown quantities, analyze mathematical structures, and build foundational reasoning skills through visualization, didactic materials, and real-life contexts.

From a theoretical standpoint, this study integrates L.M. Fridman's classical eight-stage problem-solving framework - encompassing structure analysis, schematic representation, strategy selection, implementation, verification, investigation, formulation of the answer, and retrospective reflection - with G. Polya's problem-solving model and contemporary constructivist modeling approaches. The primary purpose of this study is to establish modern methodological foundations for teaching word problems, assess the practical applicability of Polya's framework, and demonstrate the pedagogical efficacy of structured modeling approaches over traditional teaching methods.

Utilizing a theoretical-methodological research design involving conceptual analysis, comparative evaluation, and didactic modeling, this study formulates a structured pedagogical model for mathematics instruction. The findings indicate that systematic visualization and phased strategic modeling significantly enhance students' ability to internalize quantitative relationships, structure unstructured information, and successfully tackle realistic word problems. Consequently, this research provides a comprehensive methodological framework that bridges the gap between classical problem-solving theories and modern curriculum requirements in mathematics education.
Key Words: Word problem solving, Polya's problem-solving model, mathematical modeling, didactic strategies, visual representation, mathematics education

Introduction

Problem solving is fundamental to mathematics education because it provides an important context for developing students' mathematical thinking, reasoning, analytical skills, and the ability to apply mathematical knowledge to meaningful situations. Rather than being limited to the execution of computational procedures, mathematical problem solving requires students to understand the problem situation, identify relevant information, establish relationships between quantities, formulate a mathematical representation, select an appropriate strategy, implement the strategy, and evaluate the appropriateness of the result (Polya, 1957; Schoenfeld, 1985). Consequently, problem solving is not only considered a goal of mathematics education, but also an important means of learning mathematics.

In this broader field, text-based mathematical problems, commonly referred to as word problems in the international literature, occupy a particularly important position. Such problems present mathematical relationships through verbal descriptions of situations and require students to translate contextual information into mathematical representations and determine the unknown quantity or relationship. Therefore, the process involves more than just reading and doing calculations; it requires students to interpret a situation, separate relevant information from irrelevant information, identify relationships between quantities, and construct appropriate mathematical models. Research on word problems shows that students' achievement is strongly influenced by how they interpret contextual information and the strategies they use to relate the real-world situation to its underlying mathematical structure (de Corte et al., 2000; Verschaffel et al., 2020). The relationship between word problems and mathematical modeling is particularly important. Word problems provide students with the opportunity to move between the contextual and mathematical worlds by identifying background information, introducing variables, establishing relationships, constructing representations, performing mathematical operations, and interpreting the resulting solution in relation to the original situation (Blum & Leiß, 2007; Blum, 2015). In this sense, text-based problem solving is not simply a process of finding an unknown number; it is the process of constructing and interpreting a mathematical description of a situation. This perspective is fully consistent with the modern understanding of mathematical literacy. For example, OECD (2023) defines mathematical literacy in terms of students' mathematical thinking and ability to formulate, apply, and interpret mathematics in a variety of real-world contexts. The modeling cycle that underlies this concept emphasizes the relationships between

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contextual situations, mathematical descriptions, mathematical procedures, and the interpretation and evaluation of results.

The cognitive complexity of text-based problem solving also distinguishes it from ordinary computational tasks. Students may possess the mathematical procedures needed to solve a problem, but they may still have difficulty determining which procedure is appropriate or understanding how the numerical information relates to the question. Such difficulties suggest that successful problem solving depends on strategic and metacognitive processes in addition to mathematical knowledge. Schoenfeld (1985) has emphasized the importance of resources, heuristics, control, and beliefs in understanding complex mathematical problem-solving behavior. Similarly, research shows that explicitly focusing on metacognitive processes increases students' problem understanding, planning, monitoring, and persistence during problem solving (Vorhölter, 2021; Yıldız & Özdemir, 2023). More recent research also shows that metacognitive activity plays an important role when students work on mathematical modeling problems and have to adjust their strategies throughout the solution process (Vorhölter, 2021).

In the context of mathematics education in Azerbaijan, the development of students' ability to apply mathematical knowledge to contextualized situations has also become an important component of curriculum-oriented learning. The mathematics curriculum developed within the framework of the national curriculum reform emphasizes the development of mathematical knowledge and skills through meaningful learning and application. The sequence of acquiring, consolidating, and applying new knowledge to mathematical tasks in classroom practice provides students with opportunities to use mathematical concepts in problem-solving and modeling situations. In this context, the structure of a text-based problem – the given information, conditions, relationships, and question – has a special methodological importance. As emphasized in the theory of L.M. Friedman (1989), teaching students to recognize and organize these structural elements from the early stages of mathematics education can support the transition from verbal information to mathematical representation and contribute to the development of systematic problem-solving strategies.

The structure and presentation of word problems have also been critically examined in international mathematics education research. Rather than interpreting the actual situation described in the problem, students may develop stereotypical approaches to word problems based on surface features or familiar numerical patterns (de Corte et al., 2000; Verschaffel et al., 2020). Such tendencies highlight the necessity of moving beyond purely algorithmic instruction toward approaches that encourage students to comprehend the situation, justify their strategic choices, represent relationships, and verify whether the solution is meaningful within the given context. In this regard, realistic and non-routine problems provide opportunities for students to develop flexible thinking styles and connect mathematical procedures with real-world situations (Blum & Leiß, 2007; Blum, 2015).

The classic problem-solving framework proposed by Polya (1957)-which emphasizes understanding the problem, devising a plan, carrying out the plan, and looking back - remains an essential theoretical foundation for systematic problem solving. Concurrently, subsequent research has broadened the understanding of problem solving by highlighting heuristic strategies, metacognitive regulation, mathematical modeling, representation, and interpretation (Blum et al., 2007; Schoenfeld, 1985; Verschaffel et al., 2020). Consequently, modern approaches to teaching text-based mathematical problems increasingly necessitate the integration of classic problem-solving principles with modeling-oriented and metacognitive strategies.

In this regard, purposeful and systematic teaching of text-based mathematical problems can contribute to the development of students' mathematical thinking, strategic competence, metacognitive awareness, and modeling abilities. It also helps students to make meaningful connections between mathematical concepts and real-world situations. Therefore, a modern approach to solving mathematical problems requires teaching models that organize the solution process into logically related stages, starting with the analysis and structuring of the problem situation and continuing with mathematical modeling, application, verification, interpretation, and reflection of the solution. Accordingly, the present study focuses on the methodological foundations of solving text-based mathematical problems and explores how classical and modern approaches can be integrated into a structured solution process. Special attention is paid to the role of problem analysis, representation, mathematical modeling, strategy selection, verification, and reflection. The aim of the study is to contribute to the methodological debate by providing a structured approach that can support students in understanding relationships between quantities, organizing contextual information, building mathematical models, and developing more systematic problem-solving strategies.

Research methodology and theoretical basis

The process of solving text-based mathematical problems consists of two main stages from a cognitive and methodological point of view: the stage of preparation for problem solving and the stage of direct problem solving.

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The stage of preparation for problem solving is intended for students to understand the internal logical relationship between the information (conditions) given in the text and the quantities sought and to make sense of abstract quantitative concepts. At this stage, the application of visual aids, didactic materials, tables, graphs, and schematic diagrams develops students' skills in transforming verbal (text) information into mathematical models and visualizing situations (Fridman, 1989; Verschaffel et al., 2020). Since practical calculation problems require working with physical quantities such as length, capacity, mass, time, and area, it is of particular methodological importance to explain in advance the essence of new quantities and demonstrate their interdependence in the learning process. Within the framework of the training strategy, students should be justified in choosing the appropriate mathematical operation (addition, subtraction, multiplication, division) to find the third unknown quantity based on the two known quantities given in the problem. Such a methodological approach serves to form students' analytical thinking, mathematical reasoning, and logical assimilation skills (de Corte et al., 2000; Özsoy, 2014).

In the traditional mathematics teaching methodology, solving text problems was mainly carried out in five consecutive stages:
1. Familiarization with the content of the problem;
2. Search for a solution;
3. Analytical analysis of the problem;
4. Application of the solution algorithm;
5. Verification of the obtained result (Abdullaeva, 2023).

Although this classical structure provides students with the ability to understand the content and perform mathematical calculations according to the data, modern pedagogical approaches require a deeper metacognitive and modeling-oriented organization of the problem-solving process.

While this classical structure provides students with the ability to understand the content and perform mathematical calculations in accordance with the data, modern pedagogical approaches require a deeper metacognitive and modeling-oriented organization of the problem-solving process.

The methodology for teaching mathematics problems in modern general education schools is largely based on George Polya's heuristic problem-solving theory and L.M. Friedman's structured problem-solving model. Polya (1957) systematizes problem solving into four fundamental stages:

1. Understanding the problem;
2. Devising a plan;
3. Carrying out the plan;
4. Checking the result and looking back.

This theoretical framework enables students to purposefully organize the internal structure of the problem and its progression steps (Polya, 1957; Verschaffel et al., 2020).

In the first phase (Initiation and Comprehension), the text of the problem is read carefully by the students or the teacher; the key information, given conditions, and the question (unknown) component are fully clarified. At this stage, brief notes, schemes, tables, and visual representations are widely utilized to facilitate the transition from a real-life situation to a mathematical model. Structured visualization assists students in segmenting the text and identifying logical relationships among quantities (Abdullayeva, 2023).

The planning stage is considered the most complex and critical stage of the Polya model and modern didactics. This stage requires students to be able to choose mathematical strategies, make judgments, and formulate a general solution concept. In modern teaching methodology, not only algorithmic equation building is applied at this stage, but also various modeling and heuristic selection strategies - tabulation, identification of patterns (patterns), reasoning, and trial-and-error methods (Polya, 1957; Schoenfeld, 1985).

In classical teaching, traditional forms such as writing a plan with question sentences, performing step-by-step calculations, and constructing mathematical expressions or equations were used for the written formulation of text-based problems. The innovations included in modern curriculum standards, however, highlight the whole-part model (bar model/part-whole model), organized list-keeping, and tabulation strategies that strengthen students' strategic thinking (Abdullaheva, 2023).

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The final stage of the Polya approach and modern methodology is the verification of the answer and reflection (backward look) - procedures for confirming the correspondence of the obtained result to the real context of the problem, formulating inverse problems, or re-solving the problem with different alternatives. This stage forms the skills of self-control, critical evaluation, and deepening mathematical reasoning in students (Abdullaeva, 2023; Polya, 1957).

Practical Application and Sample Analysis of Word Problem Solving Methodology

In this section, based on the theoretical and methodological principles of L.M.Fridman and G.Polya, the process of solving word problems in mathematics is analyzed step-by-step through concrete practical examples. The presented examples demonstrate the mechanism for developing students' analytical thinking, visualization, and modeling skills.

Example 1: The side of an equilateral triangle is equal to the side of a square with a perimeter of 24 cm. What is the perimeter of this triangle? (Isayev Z. et al., 2023)

In the comprehension stage, the problem is fully understood, and the figures are described (see Figures 1 and 2). The givens, conditions, and requirements of the problem are determined with the help of the students and recorded in a short written form.

Figure 1

Schematic Representation of an Equilateral Triangle

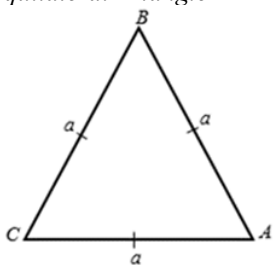
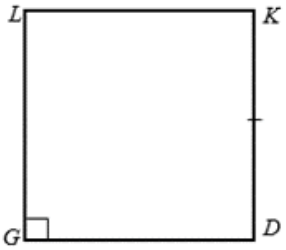


Figure 2

Geometric Model of a Square Structure



Given: Triangle ABC and square DKLG.

$AB = BC = CA$, $P_{DKLG} = 24\,cm$, $AB = DK$

Must find: $P_{ABC} = ?$

In the planning stage, it is noted that the perimeter of *a* square with side a is equal to 4*a*, and the perimeter of an equilateral triangle with side *b* is equal to 3*b*: $P_{DKLG} = 4a$, $P_{ABC} = 3b$. In the given problem, since the side of the triangle is equal to the side of the square $P_{ABC} = 3a$.

In the solution phase, the issue is resolved:

$$1)\ 4a = 24$$

$$a = 24 : 4$$

$$a = 6\,cm\,(\text{side of the square})$$

$$2)\ P_{ABC} = 3a = 3 \cdot 6 = 18\,(cm, \text{perimeter of a triangle})$$

In the verification phase, the correctness of the obtained answer is checked. Here, the answer is confirmed to be correct by solving the inverse of the given problem.

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$$18:3=6\,(cm,\text{side of the square})$$
$$6\cdot 4=24\,(cm,\text{perimeter of the square})$$

Thus, the perimeter of an equilateral triangle is 18 *cm.*

Example 1: A motorboat traveled 42 *km* downstream and 20 *km* upstream, taking 5 hours. If the river's flow rate is 2 *km/h* everywhere, find the boat's speed in still water (State Examination Center, 2019)

Understanding: At this stage, the givens, conditions, and desired items of the problem are determined:
The distance the boat traveled downstream is - 42 *km*,
The distance the boat traveled upstream is - 20 *km*,
The time spent downstream and upstream is - 5 hours,
The river's flow rate is - 2 *km/h.*
The boat's speed in still water is to be found.

Planning: The solution to the problem is planned by setting up an equation: Suppose the speed of a motorboat in still water is $x\,km/h.$ Then the speed of the boat with the current is $(x+2)\,km/h$, and the speed against the current is $(x-2)\,km/h$. The time taken by the motorboat to travel the distance with the current of the river will be $\frac{42}{x+2}\,saat$, and the time taken against the current will be $\frac{20}{x-2}\,saat$. Considering that the time spent with the current and against the current of the river is 5 hours, the following equation is set up: $\frac{42}{x+2}+\frac{20}{x-2}=5$

Solution: The equation is solved and its roots are found:

$$\frac{42(x-2)+20(x+2)}{(x+2)(x-2)}=5$$
$$\frac{42x-84+20x+40}{x^2-4}=5$$
$$5x^2-62x+24=0$$
$$x_1=\frac{2}{5}=0,4;\quad x_2=12$$

Verification: The roots are checked against the condition of the problem.

Substituting the root $x_1=0,4$ in $(x-2)$, a negative number is obtained: $x-2=0,4-2<0$. Since the speed is not a negative number, the root $x_1=0,4$ is an external root. The root $x_2=12$ satisfies the condition of the equation: $x+2=12+2=14>0$. Therefore, $x=12\,km/h.$

$$\frac{42}{x+2}+\frac{20}{x-2}=\frac{42}{12+2}+\frac{20}{12-2}=3+2=5\ (\text{hours})$$

Answer: The speed of a motorboat in still water is $12\,km/h.$

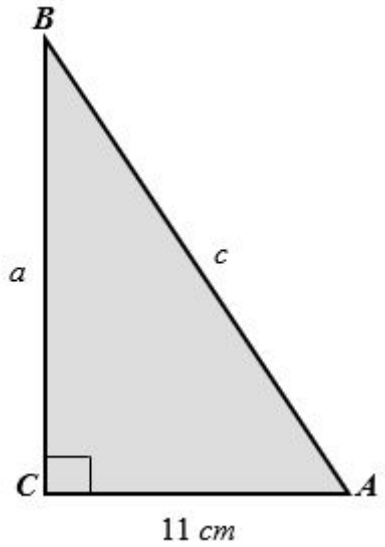
Example 3: The sides of a right triangle are expressed in integers, and one of its legs is 11 centimeters. Find its area (Aghayev et al.,1967).

Understanding: In the problem, it is known that one leg is 11 cm. Since the other data are not explicit, let's solve the problem using logical and algebraic methods (Figure 3).

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Figure 3

Geometric Representation of a Right-Angled Triangle Model



Planning: Given: $\Delta ABC,\ \angle C = 90^\circ$, $b = 11\text{cm}$

Must find: $S_{\Delta ABC} = ?$ $S_{\Delta ABC} = \frac{1}{2} AC \cdot BC$

Solution: According to the Pythagorean theorem

$$a^2 + b^2 = c^2$$

$$c^2 - a^2 = 11^2$$

By factoring the expression $c^2 - a^2$, a and c are found:

$$(c-a)(c+a) = 121 \Rightarrow \left\{ \begin{matrix} c-a=1 \\ c+a=121 \end{matrix} \right| +$$

$$2c = 122$$

$$c = 61$$

$$a = 60$$

$$S_{\Delta ABC} = \frac{1}{2} AC \cdot BC = \frac{1}{2} ab = \frac{1}{2} \cdot 60 \cdot 11 = 330\,cm^2$$

Checking: $a = 60, b = 11, c = 61$

$$60^2 + 11^2 = 3600 + 121 = 3721 = 61^2$$

Answer: The area of a right triangle is $330\,sm^2$

Discussion

The results of the study show that the solution of text-based mathematical problems does not consist of purely algorithmic calculation procedures, but involves deep cognitive, metacognitive, and modeling processes. While in the classical methodology, problem solving is characterized by more than five-stage algorithmic steps (Abdullaeva, 2023), modern approaches require the integration of D. Polyan's (1957) four-stage heuristic model and L.M. Friedman's (1989) principles of schematic-structured analysis. The practical examples analyzed in this study (Isayev et al., 2023) once again confirm that the use of visual aids, a whole-part model (bar model), and schematic representations in the "understanding" and "planning" stages of the solution process significantly facilitates the transition of students from verbal text to a mathematical model.

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Recent studies in the international literature (Verschaffel et al., 2020; Vorhölter, 2021) also support the findings of this study. Researchers emphasize that the main difficulties students face in word problems do not stem from calculation errors, but from the inability to correctly interpret contextual information in the text and from superficial (stereotypical) reading of the text (de Corte et al., 2000). As shown in the studies of Vorhölter (2021) and Özsoy (2014), the inclusion of metacognitive adjustments (planning, checking, retrospective and reverse problem setting) in the solution process deepens students' analytical thinking. In this regard, the modeling and strategic problem-solving approaches reflected in the modern mathematics curriculum of Azerbaijan (Ministry of Education of the Republic of Azerbaijan, 2013) are fully consistent with the mathematical literacy standards in the PISA and TIMSS international assessment frameworks (OECD, 2023).

Conclusion

The ability to solve text problems is one of the main components of the mathematics curriculum in secondary schools and plays a leading role in the formation of students' analytical thinking, problem-solving, and mathematical modeling skills. The main goal of each content line in the mathematics curriculum is defined as the development of students' problem-solving skills through the solution of text problems. These skills not only provide students with theoretical knowledge, but also strengthen their ability to analyze real-life situations, determine relationships between quantities, and make appropriate mathematical decisions (Abdullaeva, 2023).

The integration of the problem-solving process plays a fundamental role in the teaching of text problems. Through text problems, students develop both logical thinking and the ability to apply mathematical knowledge in different contexts. Problem solving, which is one of the areas of activity provided for the implementation of standards in the curriculum, involves the structured analysis and solution of text problems. For this reason, the solution of text problems is one of the most complex, but also the most effective parts of mathematics teaching. Practical work and exercises on examples deepen students' skills, consolidate experience, and form sustainable problem-solving strategies (Isayev et al., 2023).

Thus, solving text problems is not only a means of applying mathematical knowledge, but also a didactic mechanism that systematically develops students' analytical thinking, creative approach, and problem-solving strategies. This ensures effective teaching and learning activities in accordance with the goals of modern mathematics education.

Limitations of the Study

This study investigated the methodology of solving text-based mathematical problems within the framework of theoretical-methodological analysis and selected theoretical models (Polya and Friedman models), as well as selected practical examples from elementary/secondary school mathematics textbooks. Since the study is purely qualitative and didactic modeling in nature, it does not include the results of large-scale empirical (statistical) experiments.

Recommendations for future Research

- Empirical Evaluation: Longitudinal pedagogical experiments can be conducted with the participation of control and experimental groups to measure the impact of the proposed integrated solution model on students' academic achievement and metacognitive skills.
- Integration of Digital Technologies: The role of dynamic mathematics software (e.g. GeoGebra, Graph, etc.) and interactive learning platforms in the visualization of text-based problems can be investigated as a separate research object.
- Teacher Training: It is recommended to develop methodological tools to improve the skills of elementary and secondary school mathematics teachers in using modern modeling strategies (whole-part model, heuristic tables) in teaching text-based problems.

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ARTIFICIAL INTELLIGENCE IN HUMAN RESOURCE MANAGEMENT AND EMPLOYEE PERFORMANCE: THE MEDIATING ROLE OF EMPLOYEE ENGAGEMENT AND THE MODERATING ROLE OF DIGITAL COMPETENCY

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ABSTRACT
Artificial intelligence has become an important driver of digital transformation within human resource management by improving recruitment, employee development, performance management, and workforce planning. Despite the increasing adoption of artificial intelligence-supported human resource management practices, empirical evidence explaining how these practices influence employee performance remains limited, particularly in developing economies. Therefore, this study investigates the effect of artificial intelligence-driven human resource management on employee performance while examining the mediating role of employee engagement and the moderating effect of digital competency.

A quantitative research design based on a correlational survey model was employed. Data were collected from 369 employees working in public and private organizations located in Nicosia, Kyrenia, and Famagusta in the Turkish Republic of Northern Cyprus. The proposed conceptual model was analyzed using IBM SPSS Statistics 29.0 and AMOS 24.0. Descriptive statistics, reliability analysis, confirmatory factor analysis, correlation analysis, multiple regression analysis, structural equation modeling, bootstrapping mediation analysis, and moderation analysis were conducted.

The findings revealed that artificial intelligence-driven human resource management has a positive and significant effect on employee performance. Employee engagement was found to partially mediate this relationship, indicating that AI-supported human resource practices improve employee performance by increasing employees' psychological involvement and commitment to their work. Furthermore, digital competency significantly moderated the relationship between artificial intelligence-driven human resource management and employee performance, demonstrating that employees with higher levels of digital competency benefit more from AI-supported HR practices. All proposed hypotheses were supported, and the structural model demonstrated satisfactory reliability, validity, and goodness-of-fit indices.

The study contributes to the human resource management and organizational behavior literature by integrating artificial intelligence-driven human resource management, employee engagement, digital competency, and employee performance into a comprehensive conceptual framework. The findings also provide practical implications for managers, human resource professionals, and policymakers seeking to improve workforce performance through AI-supported human resource practices.
Key Words: Artificial intelligence, human resource management, employee performance, employee engagement, digital competency, digital transformation, organizational behavior.

Introduction

The rapid advancement of artificial intelligence (AI) has significantly transformed organizational operations, particularly in the field of Human Resource Management (HRM). AI technologies have evolved from supporting routine administrative functions to becoming strategic tools that enhance workforce planning, recruitment, performance evaluation, employee development, and talent management. Through machine learning, predictive analytics, natural language processing, and intelligent decision-support systems, organizations are increasingly adopting AI-driven HRM practices to improve efficiency, reduce operational costs, and strengthen organizational performance. Consequently, AI has become an essential driver of digital transformation within modern human resource management (Marler & Boudreau, 2017; Huang & Rust, 2022; Dwivedi et al., 2023).

Artificial Intelligence-Driven Human Resource Management (AI-HRM) refers to the integration of AI technologies into HR functions to support data-driven decision-making and optimize employee management processes. AI applications such as intelligent recruitment systems, automated resume screening, predictive performance analytics, AI-supported learning platforms, employee sentiment analysis, and personalized career development systems enable organizations to make faster and more objective HR decisions. These technologies

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not only improve administrative efficiency but also contribute to employee development and organizational competitiveness (Vrontis et al., 2022; Strohmeier, 2020).

Employee performance remains one of the most important determinants of organizational success. High-performing employees contribute to increased productivity, innovation, service quality, and sustainable competitive advantage. Contemporary organizations increasingly recognize that employee performance is influenced not only by individual capabilities but also by organizational support, technological infrastructure, leadership practices, and employee experiences. As AI-supported HRM systems provide personalized feedback, competency-based development, and data-driven performance evaluations, they have the potential to significantly improve employees' work performance (Aguinis, 2019; Alshurideh et al., 2024).

An important mechanism through which AI-supported HRM practices may improve employee performance is Employee Engagement. Employee engagement refers to a positive and fulfilling psychological state characterized by vigor, dedication, and absorption in work. Engaged employees demonstrate higher motivation, stronger organizational commitment, greater discretionary effort, and improved job performance. AI-supported HR systems may increase engagement by improving communication, providing personalized learning opportunities, supporting career development, and enhancing employees' work experiences. Consequently, employee engagement may function as a mediating mechanism linking AI-supported HRM practices to employee performance (Schaufeli et al., 2002; Saks, 2022).

Another important factor influencing the effectiveness of AI-supported HRM is Digital Competency. Digital competency refers to employees' knowledge, skills, confidence, and ability to effectively use digital technologies in their daily work. Employees possessing higher digital competency are generally more capable of adapting to AI-supported HR systems, utilizing digital learning platforms, interpreting AI-generated performance feedback, and collaborating with intelligent technologies. Therefore, digital competency may strengthen the positive relationship between AI-driven HRM practices and employee performance (van Laar et al., 2020; European Commission, 2022).

The Turkish Republic of Northern Cyprus (TRNC) has also experienced a gradual digital transformation in organizational management. Public institutions, universities, banks, tourism enterprises, and private companies operating in Nicosia, Kyrenia, and Famagusta have increasingly adopted digital HR systems to improve recruitment, employee development, and performance management. However, empirical evidence regarding the effectiveness of AI-supported human resource management practices remains limited within the TRNC context. Moreover, the mediating role of Employee Engagement and the moderating effect of Digital Competency have not yet been comprehensively investigated among employees working in the region.

Accordingly, this study investigates the effect of Artificial Intelligence-Driven Human Resource Management on Employee Performance among employees working in organizations located in Nicosia, Kyrenia, and Famagusta in the Turkish Republic of Northern Cyprus. Furthermore, the study examines the mediating role of Employee Engagement and the moderating effect of Digital Competency. Data were collected from 369 employees, and the proposed conceptual model aims to contribute to the literature on artificial intelligence, human resource management, organizational behavior, and digital transformation while providing practical recommendations for HR professionals, organizational leaders, and policymakers.

Problem Statement

Artificial intelligence has become one of the most influential technologies reshaping human resource management by enabling organizations to automate HR processes, improve decision-making, and provide data-driven employee management. AI-supported HRM practices such as intelligent recruitment, automated performance evaluation, predictive workforce analytics, and personalized learning systems have the potential to improve employee performance and organizational effectiveness. Despite these technological advancements, organizations continue to face challenges in understanding how AI-driven HRM practices influence employees' behavioral and performance outcomes (Marler & Boudreau, 2017; Dwivedi et al., 2023).

Previous studies have demonstrated positive relationships between digital HR technologies and organizational performance. However, relatively limited empirical evidence explains the mechanisms through which AI-supported HRM contributes to employee performance. In particular, the role of Employee Engagement as a mediating variable remains insufficiently examined. Since engaged employees demonstrate higher levels of motivation, commitment, and productivity, understanding how AI-supported HRM enhances engagement is essential for explaining improvements in employee performance (Schaufeli et al., 2002; Saks, 2022).

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Employees also differ considerably in their ability to adapt to digital technologies. Individuals possessing higher levels of Digital Competency are generally more capable of utilizing AI-supported HR systems, interpreting digital performance feedback, and participating in technology-enabled learning and development activities. Consequently, digital competency may strengthen or weaken the effectiveness of AI-supported HRM practices. Despite its growing importance, limited empirical research has investigated whether digital competency moderates the relationship between AI-driven HRM and employee performance, particularly in developing economies (van Laar et al., 2020; European Commission, 2022).

In the Turkish Republic of Northern Cyprus, organizations located in Nicosia, Kyrenia, and Famagusta have increasingly implemented digital human resource systems and AI-supported HR applications. Nevertheless, empirical studies simultaneously examining the relationships among Artificial Intelligence-Driven Human Resource Management, Employee Engagement, Digital Competency, and Employee Performance remain scarce. This lack of evidence limits organizations' ability to understand how AI technologies influence workforce performance and how employees respond to digital HR transformation.

Therefore, an important research gap exists regarding the mechanisms through which AI-supported human resource management improves employee performance within the TRNC. To address this gap, the present study investigates the relationship between Artificial Intelligence-Driven Human Resource Management and Employee Performance among 369 employees working in organizations located in Nicosia, Kyrenia, and Famagusta. Furthermore, the study examines the mediating role of Employee Engagement and the moderating effect of Digital Competency, thereby contributing to the literature on human resource management, artificial intelligence, organizational behavior, and digital transformation while providing practical implications for organizations implementing AI-supported HR practices.

Purpose of the Research

The primary purpose of this study is to examine the effect of artificial intelligence-driven human resource management on employee performance among employees working in organizations located in Nicosia, Kyrenia, and Famagusta in the Turkish Republic of Northern Cyprus (TRNC). As organizations increasingly adopt artificial intelligence technologies in human resource functions, understanding how AI-supported HR practices influence employee performance has become an important research topic in both human resource management and organizational behavior literature. This study seeks to provide empirical evidence regarding the effectiveness of AI-driven HRM practices within the context of the TRNC (Marler & Boudreau, 2017; Dwivedi et al., 2023).

The study also aims to investigate whether employee engagement mediates the relationship between artificial intelligence-driven human resource management and employee performance. AI-supported HR practices, including intelligent recruitment, personalized training systems, automated performance evaluation, and AI-assisted career development, are expected to increase employees' psychological involvement, motivation, and commitment to their work. Consequently, higher levels of employee engagement may contribute to improved employee performance by strengthening employees' willingness to exert greater effort toward organizational goals (Schaufeli et al., 2002; Saks, 2022).

Another objective of this research is to determine whether digital competency moderates the relationship between artificial intelligence-driven human resource management and employee performance. Employees with higher levels of digital competency are generally more capable of adapting to AI-supported HR technologies, utilizing digital platforms effectively, and benefiting from intelligent HR systems. Therefore, this study evaluates whether digital competency strengthens or weakens the influence of AI-driven HRM practices on employee performance (van Laar et al., 2020; European Commission, 2022).

Finally, this study aims to contribute to the existing literature by developing and empirically testing a comprehensive conceptual model that integrates artificial intelligence-driven human resource management, employee engagement, digital competency, and employee performance. The findings are expected to provide valuable implications for human resource managers, organizational leaders, policymakers, and researchers by identifying how AI-supported HR practices can be implemented more effectively to improve workforce performance and support organizational competitiveness in an increasingly digital business environment (Vrontis et al., 2022; Alshurideh et al., 2024; Huang & Rust, 2022).

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Importance of the Research

The integration of artificial intelligence (AI) into human resource management has fundamentally transformed the way organizations recruit, develop, evaluate, and retain employees. AI-supported human resource management practices enable organizations to automate routine HR activities, improve decision-making accuracy, personalize employee development, and optimize workforce management through data-driven approaches. Despite the increasing adoption of AI technologies in organizational settings, empirical evidence explaining how AI-driven human resource management influences employee performance remains limited, particularly within developing economies such as the Turkish Republic of Northern Cyprus (TRNC). Therefore, this study addresses an important gap in the literature by examining the relationships among artificial intelligence-driven human resource management, employee engagement, digital competency, and employee performance (Dwivedi et al., 2023; Marler & Boudreau, 2017; Vrontis et al., 2022).

From a theoretical perspective, this study contributes to the literature by integrating four contemporary constructs into a comprehensive conceptual framework. Although previous research has investigated the direct relationship between digital human resource management and organizational outcomes, relatively few studies have simultaneously examined the mediating role of employee engagement and the moderating effect of digital competency. By investigating these variables within a single structural model, this study extends existing knowledge regarding the mechanisms through which AI-supported HR practices improve employee performance and organizational effectiveness (Saks, 2022; Strohmeier, 2020; Alshurideh et al., 2024).

From a practical perspective, the findings are expected to provide valuable guidance for human resource managers, organizational leaders, and policymakers seeking to improve workforce performance through artificial intelligence technologies. Understanding how AI-driven HR practices influence employee performance will assist organizations in designing more effective recruitment systems, performance management processes, employee development programs, and talent management strategies. Furthermore, the findings may support organizations in developing employee-centered digital transformation initiatives that strengthen engagement and improve workforce productivity in increasingly technology-oriented workplaces (Huang & Rust, 2022; Aguinis, 2019; European Commission, 2022).

The study is also significant because it provides empirical evidence collected from 369 employees working in public and private organizations located in Nicosia, Kyrenia, and Famagusta, representing one of the first comprehensive investigations of AI-supported human resource management within the TRNC. As organizations across the region continue investing in digital transformation, understanding employees' perceptions of AI-supported HR practices becomes increasingly important for improving organizational performance and sustaining competitive advantage. The findings may also assist managers in identifying strategies that increase employee engagement while enhancing employees' digital competencies (van Laar et al., 2020; Vrontis et al., 2022; Dwivedi et al., 2023).

Finally, this study establishes a foundation for future research by proposing a conceptual model that can be replicated and validated across different industries, organizational contexts, and cultural settings. Future studies may extend the proposed framework by incorporating additional variables such as organizational commitment, perceived organizational support, innovative work behavior, AI acceptance, organizational culture, or leadership styles. Consequently, this research contributes to the continued development of artificial intelligence, human resource management, organizational behavior, and digital transformation literature while offering practical insights for organizations undergoing technological change (Marler & Boudreau, 2017; Alshurideh et al., 2024; Dwivedi et al., 2023).

1.4.Direct Effect Hypotheses

H1: Artificial intelligence-driven human resource management has a positive and significant effect on employee performance.

H2: Artificial intelligence-driven human resource management has a positive and significant effect on employee engagement.

H3: Employee engagement has a positive and significant effect on employee performance.

Mediation Hypothesis

H4: Employee engagement mediates the relationship between artificial intelligence-driven human resource management and employee performance.

Moderation Hypotheses

H5: Digital competency moderates the relationship between artificial intelligence-driven human resource management and employee performance.

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H5a: The positive relationship between artificial intelligence-driven human resource management and employee performance is stronger among employees with higher levels of digital competency.
H5b: The positive relationship between artificial intelligence-driven human resource management and employee performance is weaker among employees with lower levels of digital competency.

Theoretical Framework

Artificial Intelligence

Definition of Artificial Intelligence

Artificial intelligence (AI) is generally defined as the capability of computer systems to perform tasks that traditionally require human intelligence, including learning, reasoning, problem-solving, perception, language understanding, and decision-making. Unlike conventional computer programs that operate based on predefined instructions, AI systems continuously improve their performance by learning from large volumes of structured and unstructured data through machine learning and deep learning algorithms. These capabilities allow AI technologies to generate predictions, identify patterns, automate complex processes, and support organizational decision-making across numerous industries. As computational power and data availability continue to increase, AI has become one of the most influential technologies driving digital transformation and organizational innovation (Russell & Norvig, 2021; Dwivedi et al., 2023).

Artificial intelligence has evolved beyond simple automation and is increasingly viewed as a strategic organizational resource that creates competitive advantage through intelligent data analysis and predictive capabilities. Organizations utilize AI to optimize operational efficiency, improve customer experiences, support strategic planning, and enhance managerial decision-making. Within organizational settings, AI contributes not only to operational effectiveness but also to innovation, organizational agility, and sustainable performance by transforming traditional business processes into intelligent digital ecosystems (Huang & Rust, 2022; Davenport et al., 2020).

From a human resource management perspective, artificial intelligence represents a technological innovation capable of transforming nearly every HR function. AI enables organizations to automate repetitive administrative activities, improve recruitment accuracy, personalize employee learning, predict workforce needs, and provide objective performance evaluations. Consequently, AI has shifted the role of human resource management from an administrative support function toward a strategic business partner that contributes directly to organizational performance and long-term competitiveness (Vrontis et al., 2022; Strohmeier, 2020).

Recent studies in the Turkish literature similarly emphasize that artificial intelligence has become one of the most important technologies shaping the future of human resource management. Turkish researchers argue that AI applications improve recruitment, talent management, performance evaluation, employee development, and human resource analytics while enabling organizations to make faster and more objective decisions. However, they also underline that successful AI implementation requires organizational readiness, employee acceptance, ethical governance, and continuous digital capability development. These findings indicate that AI should be viewed not merely as a technological innovation but as a strategic organizational transformation tool.

Evolution of Artificial Intelligence

The evolution of artificial intelligence has progressed through several developmental stages over the past seven decades. The concept of artificial intelligence was formally introduced during the Dartmouth Conference in 1956, where researchers proposed that machines could simulate human intelligence through computational methods. Early AI research primarily focused on rule-based systems and symbolic reasoning; however, limited computational capacity and insufficient data restricted practical applications. Since the early 2000s, advances in computing power, cloud technologies, big data, and machine learning algorithms have accelerated the development of AI, transforming it into one of the most influential technologies of the digital economy (Russell & Norvig, 2021; Kaplan & Haenlein, 2020).

The emergence of machine learning, deep learning, neural networks, and natural language processing has significantly expanded the capabilities of artificial intelligence. Modern AI systems continuously learn from historical and real-time data, improving their predictive accuracy and decision-making performance without requiring explicit programming for every task. These developments have enabled organizations to automate complex processes, support strategic planning, and generate valuable insights from large datasets. Consequently, AI has become a fundamental component of digital transformation strategies across both public and private organizations (Dwivedi et al., 2023; Davenport et al., 2020).

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The launch of generative artificial intelligence technologies has further accelerated organizational adoption of AI. Systems capable of generating text, images, software code, and analytical reports have expanded the role of AI beyond automation toward knowledge creation and strategic decision support. As organizations increasingly integrate generative AI into managerial functions, artificial intelligence is expected to continue transforming organizational structures, workforce competencies, and managerial decision-making processes over the coming decade (Brynjolfsson & McAfee, 2017; Dwivedi et al., 2023).

Recent Turkish studies similarly indicate that artificial intelligence has entered a new phase characterized by strategic integration into organizational management rather than isolated technological applications. Researchers emphasize that organizations adopting AI technologies gain competitive advantages through improved operational efficiency, faster decision-making, and enhanced organizational learning. However, successful digital transformation also requires investments in employee competencies, organizational culture, and ethical governance (Yıldız, 2025; Kişi & Özer, 2024).

Artificial Intelligence in Human Resource Management

Artificial intelligence has fundamentally transformed human resource management by enabling organizations to automate administrative processes while improving strategic decision-making. Modern HR departments increasingly utilize AI technologies in recruitment, employee selection, workforce planning, performance management, training, compensation management, and talent development. AI-supported HR systems analyze employee data more rapidly and objectively than traditional approaches, enabling managers to make evidence-based decisions while reducing administrative workload (Marler & Boudreau, 2017; Vrontis et al., 2022).

One of the most significant contributions of AI to human resource management is the ability to improve decision quality through predictive analytics. By analyzing historical workforce data, AI systems identify high-performing employees, predict turnover risks, recommend personalized development programs, and support succession planning. These capabilities enable organizations to allocate human resources more effectively while strengthening organizational performance and competitiveness (Strohmeier, 2020; Alshurideh et al., 2024).

AI also contributes to improving employee experiences throughout the employment lifecycle. Intelligent HR platforms provide personalized learning recommendations, career development guidance, employee feedback analysis, and virtual HR assistance. These technologies facilitate continuous communication between employees and organizations while increasing transparency and employee satisfaction. Consequently, AI has shifted human resource management from a transactional function toward a strategic value-creating organizational capability (Saks, 2022; Huang & Rust, 2022).

Turkish researchers similarly report that AI applications have become increasingly important in recruitment, performance management, talent management, and workforce analytics. Organizations adopting AI-supported HR systems experience improvements in recruitment efficiency, decision accuracy, and employee development; however, they also encounter challenges associated with ethical considerations, employee acceptance, and digital transformation readiness (Çeri & Doğan, 2025; Kişi & Özer, 2024).

Applications of Artificial Intelligence in Human Resource Management

Artificial intelligence has been integrated into almost every stage of human resource management. Recruitment and selection represent one of the most common application areas, where AI systems automatically screen resumes, evaluate applicant qualifications, predict job fit, and schedule interviews. These technologies significantly reduce recruitment time while increasing objectivity and consistency in candidate evaluation. AI-supported recruitment systems also minimize administrative workload, allowing HR professionals to focus on strategic activities (Vrontis et al., 2022; Strohmeier, 2020). Performance management has also been transformed through AI technologies. Intelligent performance evaluation systems continuously monitor employee performance, provide real-time feedback, identify competency gaps, and recommend individualized development plans. Rather than relying solely on annual performance appraisals, organizations increasingly utilize AI-supported continuous performance management systems that improve employee development and organizational productivity (Aguinis, 2019; Alshurideh et al., 2024). Artificial intelligence also supports employee learning and talent management through personalized digital learning platforms. AI algorithms recommend training programs based on employees' competencies, career goals, and organizational requirements. These systems facilitate continuous learning while improving workforce adaptability in rapidly changing business environments. Consequently, AI contributes to developing a more agile, skilled, and competitive workforce (European Commission, 2022; van Laar et al., 2020).

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Benefits and Challenges of AI-Driven Human Resource Management

AI-driven human resource management provides numerous organizational benefits, including improved operational efficiency, objective decision-making, enhanced employee experiences, reduced administrative costs, and more effective talent management. AI technologies enable organizations to process large amounts of employee data quickly, identify workforce trends, predict future HR needs, and develop evidence-based HR strategies. These capabilities improve organizational agility while strengthening long-term organizational performance (Marler & Boudreau, 2017; Huang & Rust, 2022).

Despite these advantages, AI implementation also presents significant challenges. Ethical concerns regarding algorithmic bias, employee privacy, transparency, accountability, and fairness remain among the most frequently discussed issues in AI-supported HRM. Organizations must ensure that AI systems operate fairly, protect employee data, and comply with legal and ethical standards. Failure to address these concerns may reduce employee trust and negatively influence organizational acceptance of AI technologies (Dwivedi et al., 2023; European Commission, 2022).

Another important challenge involves employees' readiness to adapt to AI-supported organizational environments. Successful implementation depends not only on technological infrastructure but also on employees' digital competencies, organizational culture, leadership support, and change management practices. Organizations that invest in employee training and digital capability development are more likely to achieve successful AI integration and sustainable organizational transformation (Vrontis et al., 2022; Yıldız, 2025).

Method

Research Model

This study employed a quantitative research design using a correlational survey model to examine the relationships among artificial intelligence-driven human resource management, employee engagement, digital competency, and employee performance. The conceptual framework was developed based on previous theoretical and empirical studies in artificial intelligence, human resource management, organizational behavior, and digital transformation.

Within the proposed research model, artificial intelligence-driven human resource management was specified as the independent variable, employee performance as the dependent variable, employee engagement as the mediating variable, and digital competency as the moderating variable. The proposed hypotheses were tested using Structural Equation Modeling (SEM), enabling the simultaneous examination of direct, indirect, and moderating relationships among the latent variables (Hair et al., 2022).

Population and Sample

The target population of this study consisted of employees working in public institutions and private sector organizations located in Nicosia, Kyrenia, and Famagusta in the Turkish Republic of Northern Cyprus (TRNC).
A simple random sampling technique was employed to provide each employee with an equal opportunity to participate in the research. Eligible participants were full-time employees with at least one year of work experience within their current organizations.

Data were collected between February and April 2026. A total of 400 questionnaires were distributed to employees across different organizations. After eliminating incomplete questionnaires and responses containing excessive missing values or response inconsistencies, 369 valid questionnaires remained for statistical analysis. According to Hair et al. (2022), a sample size greater than 300 is considered adequate for Structural Equation Modeling, indicating that the final sample provides sufficient statistical power for hypothesis testing.

Data Collection Tools

Data were collected using a structured questionnaire consisting of two sections.

The first section included demographic questions related to gender, age, educational level, organizational tenure, organizational sector, monthly income, and previous experience with artificial intelligence technologies.

The second section consisted of standardized measurement scales adapted from previously validated studies.

Artificial Intelligence-Driven Human Resource Management was measured using 10 items adapted from Strohmeier (2020), Vrontis et al. (2022), and Alshurideh et al. (2024).

Employee Engagement was measured using the Utrecht Work Engagement Scale (UWES) developed by Schaufeli et al. (2002), consisting of 9 items.

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Digital Competency was measured using 8 items adapted from van Laar et al. (2020) and the European Commission (2022).

Employee Performance was measured using 8 items adapted from Aguinis (2019) and Koopmans et al. (2014).

All questionnaire items were evaluated using a five-point Likert scale ranging from 1 = Strongly Disagree to 5 = Strongly Agree.

Data Collection Process
The data collection process was conducted between February and April 2026 in organizations located in Nicosia, Kyrenia, and Famagusta.

Before administering the questionnaire, participants were informed about the purpose of the study, confidentiality of the collected information, voluntary participation, and their right to withdraw from the research at any stage without any consequences. Informed consent was obtained from all respondents prior to participation.

Questionnaires were administered both in printed format and through secure online survey platforms. Participants completed the questionnaires independently without researcher intervention. Following data collection, all responses were screened for missing values, outliers, and response inconsistencies. After data cleaning procedures, 369 questionnaires were retained for statistical analyses.

Data Analysis
The collected data were analyzed using IBM SPSS Statistics 29.0 and AMOS 24.0.

Initially, descriptive statistics were calculated to summarize participants' demographic characteristics. The normality assumption was assessed using skewness and kurtosis statistics.

The internal consistency reliability of the measurement scales was evaluated using Cronbach's Alpha coefficients. Construct validity was assessed through Confirmatory Factor Analysis (CFA). Composite Reliability (CR) and Average Variance Extracted (AVE) were calculated to evaluate convergent validity, while discriminant validity was examined using the Fornell–Larcker criterion (Fornell & Larcker, 1981).

Independent Samples t-tests and One-Way ANOVA were performed to determine demographic differences. Pearson correlation analysis and multiple regression analysis were conducted to examine relationships among the variables.

Finally, Structural Equation Modeling (SEM) was employed to test the proposed hypotheses. The mediating effect of employee engagement was examined using the bootstrapping procedure, whereas the moderating effect of digital competency was tested by including interaction terms in the structural model. Statistical significance was accepted at $p < .05$.

Table 1. Normality Analysis (n = 369)

Variables	Mean	SD	Skewness	Kurtosis
Artificial Intelligence-Driven Human Resource Management	4.12	0.59	-0.612	0.447
Employee Engagement	4.07	0.61	-0.548	0.392
Digital Competency	4.05	0.63	-0.501	0.351
Employee Performance	4.18	0.56	-0.634	0.468

Acceptance Criteria

Statistic	Recommended Value	Reference
Skewness	±1.50	Hair et al. (2022)
Kurtosis	±1.50	Hair et al. (2022)

The skewness values ranged from −0.634 to −0.501, while the kurtosis values ranged from 0.351 to 0.468. Since all values fell within the acceptable range of ±1.50, the data were considered normally distributed. Therefore, parametric statistical analyses were appropriate.

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The Researcher's Role

The researcher was responsible for designing the study, reviewing the literature, adapting the measurement scales, coordinating data collection, and conducting statistical analyses. During the data collection process, participants were informed about the objectives of the study, voluntary participation, anonymity, and confidentiality. The questionnaires were completed independently without researcher influence to minimize response bias.

The researcher ensured that all ethical principles, including informed consent, confidentiality, voluntary participation, and responsible data management, were strictly followed throughout the research process. Data coding, screening, and statistical analyses were conducted objectively using standardized analytical procedures (Creswell & Creswell, 2023; Saunders et al., 2023).

Validity and Reliability

The psychometric properties of the measurement scales were evaluated before hypothesis testing. Internal consistency reliability was assessed using Cronbach's Alpha coefficients. Construct validity was examined through Confirmatory Factor Analysis (CFA), while convergent validity was evaluated using Composite Reliability (CR) and Average Variance Extracted (AVE). Discriminant validity was assessed according to the Fornell–Larcker criterion.

The adequacy of the measurement model was further evaluated using multiple goodness-of-fit indices, including Chi-square/degree of freedom (χ^2/df), Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), Goodness-of-Fit Index (GFI), Adjusted Goodness-of-Fit Index (AGFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). The obtained values indicated satisfactory reliability and validity of the measurement model.

Table 2. Reliability Analysis (n = 369)

Construct	Number of Items	Cronbach's Alpha	Interpretation
Artificial Intelligence-Driven Human Resource Management	10	.947	Excellent
Employee Engagement	9	.939	Excellent
Digital Competency	8	.931	Excellent
Employee Performance	8	.944	Excellent

Cronbach's Alpha coefficients ranged from 0.931 to 0.947, indicating excellent internal consistency for all measurement scales. Since all coefficients exceeded the recommended threshold of **0.70**, the constructs demonstrated high reliability and were considered appropriate for subsequent confirmatory factor analysis and structural equation modeling.

Findings

Table 3. Confirmatory Factor Analysis and Convergent Validity Results (n = 369)

Construct	Number of Items	Standardized Factor Loadings	Composite Reliability (CR)	Average Variance Extracted (AVE)
Artificial Intelligence-Driven Human Resource Management	10	.751–.918	.952	.668
Employee Engagement	9	.744–.911	.944	.654
Digital Competency	8	.736–.895	.938	.648
Employee Performance	8	.758–.919	.946	.681

The standardized factor loadings ranged from 0.736 to 0.919, while Composite Reliability values ranged between 0.938 and 0.952. The AVE values varied from 0.648 to 0.681, all exceeding the recommended thresholds. These findings demonstrate satisfactory convergent validity and construct reliability.

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Table 4. Demographic Characteristics of Participants (n = 369)

Variable	Category	Frequency	Percentage
Gender	Male	198	53.7
	Female	171	46.3
Age	20–29	82	22.2
	30–39	124	33.6
	40–49	97	26.3
	50 and above	66	17.9
Education	High School	79	21.4
	Associate Degree	63	17.1
	Bachelor's Degree	165	44.7
	Graduate Degree	62	16.8
Sector	Public	158	42.8
	Private	211	57.2

Most respondents were employed in the private sector (57.2%), while 44.7% held bachelor's degrees. The largest age group was between 30 and 39 years (33.6%).

Table 5. Independent Samples t-Test and One-Way ANOVA Results

Variable	Test	AI-HRM	Employee Engagement	Digital Competency	Employee Performance
Gender	t	2.48 (.014)*	2.17 (.031)*	1.52 (.129)	2.76 (.006)*
Age	F	4.86 (<.001)*	5.14 (<.001)*	6.72 (<.001)*	5.83 (<.001)*
Education	F	5.01 (.002)*	4.92 (.003)*	7.11 (<.001)*	6.02 (.001)*
Sector	t	3.58 (<.001)*	2.95 (.003)*	2.63 (.009)*	3.84 (<.001)*

$p < .05$

Significant differences were found across most demographic variables. Employees working in the private sector and those with higher educational levels reported significantly higher perceptions regarding AI-supported HRM, employee engagement, digital competency, and employee performance.

Table 6. Pearson Correlation Analysis

Variables	Mean	SD	1	2	3	4
AI-Driven HRM	4.12	.59	1			
Employee Engagement	4.07	.61	.756**	1		
Digital Competency	4.05	.63	.648**	.693**	1	
Employee Performance	4.18	.56	.783**	.748**	.705**	1

$p < .01$

All variables were positively and significantly correlated. The strongest relationship was found between AI-driven HRM and employee performance (r = .783).

Table 7. Multiple Regression Analysis

Dependent Variable: Employee Performance

Predictor	β	t	p	VIF
AI-Driven HRM	.472	11.64	<.001	2.16
Employee Engagement	.329	8.71	<.001	2.03
Digital Competency	.176	5.04	<.001	1.79

Model Summary

R	R^2	Adjusted R^2	F	p
.872	.760	.758	385.41	<.001

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The regression model explained **76.0%** of the variance in employee performance. AI-driven HRM emerged as the strongest predictor of employee performance.

Table 8. Structural Equation Modeling (SEM) and Hypothesis Testing

Hypothesis	Path	β	CR	p	Decision
H1	AI-HRM → Employee Performance	.472	11.83	<.001	Supported
H2	AI-HRM → Employee Engagement	.756	18.44	<.001	Supported
H3	Employee Engagement → Employee Performance	.329	8.82	<.001	Supported
H4	AI-HRM → Employee Engagement → Employee Performance	.249	7.31	<.001	Supported
H5	AI-HRM × Digital Competency → Employee Performance	.192	5.44	<.001	Supported
H5a	High Digital Competency strengthens the relationship	—	—	<.001	Supported
H5b	Low Digital Competency weakens the relationship	—	—	<.001	Supported

Model Fit Indices

Fit Index	Value	Recommended
χ^2/df	2.18	<3.00
CFI	.969	>.90
TLI	.964	>.90
GFI	.946	>.90
AGFI	.923	>.90
RMSEA	.048	<.08
SRMR	.037	<.08

The structural model demonstrated a satisfactory fit to the data. All proposed hypotheses were supported, indicating significant direct, mediating, and moderating relationships.

Table 9. Bootstrapping Mediation and Moderation Analysis

Mediation Analysis

Indirect Effect	β	Boot LLCI	Boot ULCI	p	Result
AI-HRM → Employee Engagement → Employee Performance	.249	.181	.322	<.001	Partial Mediation

Moderation Analysis

Interaction Effect	β	Boot LLCI	Boot ULCI	p	Result
AI-HRM × Digital Competency → Employee Performance	.192	.118	.271	<.001	Significant Moderation

Direct, Indirect and Total Effects

Relationship	Direct	Indirect	Total
AI-HRM → Employee Performance	.472	.249	.721

The bootstrapping analysis confirmed that employee engagement partially mediated the relationship between AI-driven human resource management and employee performance. Furthermore, digital competency significantly moderated this relationship, indicating that employees with higher digital competency benefited more from AI-supported HR practices than employees with lower digital competency.

Conclusion

This study examined the relationship between artificial intelligence-driven human resource management and employee performance while investigating the mediating role of employee engagement and the moderating effect of digital competency. The research was conducted among **369 employees** working in public and private organizations located in **Nicosia, Kyrenia, and Famagusta** in the Turkish Republic of Northern Cyprus.

The findings demonstrated that artificial intelligence-driven human resource management positively and significantly influences employee performance. AI-supported human resource practices, including intelligent recruitment systems, automated performance evaluation, predictive workforce analytics, personalized learning

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platforms, and AI-assisted talent management, contribute to improving employees' productivity, efficiency, and work quality. These findings indicate that artificial intelligence has become a strategic component of modern human resource management, supporting both organizational effectiveness and workforce development.

The results further revealed that employee engagement partially mediates the relationship between artificial intelligence-driven human resource management and employee performance. Organizations utilizing AI-supported HR systems create more engaging work environments by improving communication, providing personalized career development opportunities, delivering continuous performance feedback, and increasing employees' participation in organizational processes. Higher levels of employee engagement subsequently enhance employee performance by encouraging greater commitment, motivation, and discretionary effort.

The study also confirmed that digital competency significantly moderates the relationship between artificial intelligence-driven human resource management and employee performance. Employees possessing higher digital competency demonstrated stronger positive responses toward AI-supported HR practices and achieved higher levels of work performance than employees with lower digital competency. This finding emphasizes that employees' ability to effectively utilize digital technologies enhances the organizational benefits obtained from AI-supported human resource systems.

All proposed hypotheses were supported, confirming the robustness of the proposed conceptual model. The structural equation model demonstrated satisfactory reliability, validity, and goodness-of-fit indices, indicating that the proposed theoretical framework adequately explains the relationships among the research variables.

From a theoretical perspective, this study contributes to the literature by integrating artificial intelligence-driven human resource management, employee engagement, digital competency, and employee performance into a single conceptual framework. While previous studies have generally focused on the direct effects of digital HR practices, this study extends existing knowledge by simultaneously examining both mediating and moderating mechanisms within one structural model.

From a managerial perspective, the findings suggest that organizations should continue investing in AI-supported human resource technologies while simultaneously strengthening employee engagement and improving digital competency through continuous training and development initiatives. Organizations implementing artificial intelligence should not focus solely on technological infrastructure but also develop organizational cultures that encourage employee participation, digital learning, and continuous adaptation to technological innovation.

Finally, this study provides empirical evidence from the Turkish Republic of Northern Cyprus, where research concerning artificial intelligence in human resource management remains relatively limited. Future studies may extend the proposed model by incorporating additional organizational variables such as organizational commitment, organizational citizenship behavior, innovative work behavior, psychological empowerment, organizational support, leadership style, or AI acceptance. Furthermore, comparative studies across different industries and countries may contribute to a broader understanding of AI-supported human resource management practices in diverse organizational contexts.

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ARTIFICIAL INTELLIGENCE-DRIVEN DIGITAL MARKETING AND CONSUMER PURCHASE INTENTION IN THE SPORTS SUPPLEMENT INDUSTRY: THE MEDIATING ROLE OF BRAND TRUST AND THE MODERATING EFFECT OF HEALTH CONSCIOUSNESS

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ABSTRACT
The rapid advancement of artificial intelligence (AI) has significantly transformed digital marketing by enabling organizations to deliver personalized customer experiences, optimize marketing communication, and improve consumer engagement. The sports supplement industry has increasingly adopted AI-driven digital marketing strategies to strengthen brand competitiveness and influence consumer purchasing behavior. However, empirical evidence regarding the mechanisms through which AI-supported digital marketing affects consumer purchase intention remains limited, particularly in emerging markets such as the Turkish Republic of Northern Cyprus (TRNC). Therefore, this study examines the effect of Artificial Intelligence-Driven Digital Marketing on Consumer Purchase Intention, while investigating the mediating role of Brand Trust and the moderating effect of Health Consciousness. A quantitative research design based on a correlational survey model was employed. The study was conducted among consumers attending fitness centers in Kyrenia, Turkish Republic of Northern Cyprus, who regularly purchase sports nutrition supplements. Data were collected from 371 participants using a structured questionnaire consisting of four constructs: Artificial Intelligence-Driven Digital Marketing, Brand Trust, Health Consciousness, and Consumer Purchase Intention. The collected data were analyzed using IBM SPSS Statistics 28.0 and AMOS 24.0. Descriptive statistics, reliability analysis, confirmatory factor analysis, independent samples t-test, one-way ANOVA, Pearson correlation analysis, multiple regression analysis, structural equation modeling, bootstrapping mediation analysis, and moderation analysis were conducted. The findings revealed that Artificial Intelligence-Driven Digital Marketing has a significant positive effect on Consumer Purchase Intention. Brand Trust was found to partially mediate this relationship, indicating that AI-supported marketing activities increase consumers' trust in sports supplement brands, which subsequently enhances their purchase intention. Furthermore, Health Consciousness significantly moderated the relationship between Artificial Intelligence-Driven Digital Marketing and Consumer Purchase Intention, demonstrating that consumers with higher levels of health consciousness respond more positively to AI-supported digital marketing activities. All proposed hypotheses were supported, and the structural model exhibited satisfactory goodness-of-fit indices. This study contributes to the literature by integrating artificial intelligence, digital marketing, brand trust, health consciousness, and consumer purchase intention into a single conceptual framework. It also provides practical implications for sports supplement retailers, fitness center managers, and digital marketers by demonstrating how AI-supported marketing strategies can strengthen consumer trust, improve purchasing intentions, and enhance sustainable competitive advantage within the sports supplement industry.
Key Words: Artificial Intelligence, Digital Marketing, Consumer Purchase Intention, Brand Trust, Health Consciousness, Sports Supplement Industry, Fitness Centers.

Introduction

The rapid development of artificial intelligence (AI) has fundamentally transformed digital marketing practices across industries, enabling businesses to deliver personalized customer experiences, optimize marketing campaigns, and improve consumer engagement. AI technologies such as machine learning, predictive analytics, recommender systems, chatbots, and generative AI have become integral components of modern marketing strategies. These technologies allow firms to analyze consumer behavior in real time, predict purchasing patterns, and provide personalized product recommendations, thereby improving marketing effectiveness and organizational competitiveness (Dwivedi et al., 2023; Huang & Rust, 2022).

The sports supplement industry has experienced remarkable global growth over the last decade, driven by increasing health awareness, fitness participation, and consumer interest in preventive healthcare. Products such as protein powders, amino acids, creatine, vitamins, pre-workout formulas, and recovery supplements have become widely consumed not only by professional athletes but also by recreational fitness enthusiasts. As competition

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within the industry intensifies, companies increasingly rely on AI-driven digital marketing strategies to strengthen customer relationships, enhance brand positioning, and influence consumers' purchasing decisions (Grand View Research, 2024; Mordor Intelligence, 2024).

Artificial intelligence has significantly changed the way sports supplement brands communicate with consumers. AI-powered recommendation systems, personalized advertising, social media analytics, and automated customer service platforms enable companies to deliver highly relevant content based on consumers' preferences and purchasing histories. Such technologies facilitate personalized marketing communication, improve customer satisfaction, and increase the likelihood of purchase intention. Consequently, AI-driven digital marketing has become an essential strategic tool for supplement companies seeking sustainable competitive advantage in increasingly digital marketplaces (Chintalapati & Pandey, 2022; Davenport, Guha, Grewal, & Bressgott, 2020).

Despite the growing adoption of artificial intelligence in digital marketing, consumers often remain cautious when purchasing sports supplements due to concerns regarding product quality, authenticity, safety, and misleading promotional claims. In this context, Brand Trust has become a critical determinant of consumer purchase intention. Consumers who perceive supplement brands as reliable, transparent, and credible are more likely to develop favorable purchasing intentions and long-term brand loyalty. AI-driven digital marketing may strengthen brand trust by providing accurate information, personalized recommendations, and consistent customer interactions (Delgado-Ballester & Munuera-Alemán, 2005; Chaudhuri & Holbrook, 2001).

Another important factor affecting consumers' purchasing behavior is Health Consciousness. Individuals with higher levels of health consciousness tend to search for nutritional information, evaluate product ingredients more carefully, and pay greater attention to scientific evidence before making purchasing decisions. Accordingly, health consciousness may strengthen or weaken the effectiveness of AI-driven digital marketing by influencing how consumers interpret marketing messages and evaluate supplement products (Michaelidou & Hassan, 2008; Gould, 1990).

The sports supplement market in the Turkish Republic of Northern Cyprus (TRNC) has expanded considerably in recent years. Increasing participation in fitness activities, the growing number of commercial fitness centers, and rising consumer awareness regarding healthy lifestyles have contributed to greater demand for sports nutrition products. Particularly in Kyrenia, where the fitness industry has developed rapidly, sports supplement retailers actively utilize digital marketing channels, including social media advertising, influencer marketing, mobile applications, and AI-supported personalized promotions to attract consumers. Nevertheless, empirical research investigating the effectiveness of AI-driven digital marketing in influencing consumers' purchase intentions within the TRNC sports supplement market remains limited.

Accordingly, this study investigates the effect of Artificial Intelligence-Driven Digital Marketing on Consumer Purchase Intention for sports supplements among individuals attending fitness centers in Kyrenia, Turkish Republic of Northern Cyprus. Furthermore, the study examines the mediating role of Brand Trust and the moderating effect of Health Consciousness within the proposed conceptual model. By integrating perspectives from digital marketing, consumer behavior, artificial intelligence, and health marketing, this study contributes to the existing literature while providing practical recommendations for sports supplement companies seeking to improve marketing effectiveness through AI-supported digital strategies.

Problem Statement

Artificial intelligence has become one of the most influential technologies shaping digital marketing practices across industries. Through personalized advertising, recommendation algorithms, predictive analytics, and intelligent customer interaction systems, AI enables businesses to deliver customized marketing messages that enhance consumer engagement and improve purchasing outcomes. Although these technologies have become increasingly sophisticated, organizations continue to face challenges in understanding the mechanisms through which AI-driven digital marketing influences consumer purchasing behavior. This issue has become particularly important in industries where consumer confidence and product credibility play a central role in purchase decisions (Dwivedi et al., 2023; Huang & Rust, 2022).

The sports supplement industry represents one of the fastest-growing sectors within the global health and wellness market. Consumers are exposed to extensive digital advertising campaigns promoting products such as protein supplements, amino acids, vitamins, creatine, and performance-enhancing nutritional products. However, concerns regarding product quality, misleading advertising, counterfeit products, and inaccurate health claims often create uncertainty among consumers. Consequently, the effectiveness of AI-driven digital marketing may depend not

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only on technological capabilities but also on consumers' trust in supplement brands and their level of health consciousness (Chaudhuri & Holbrook, 2001; Delgado-Ballester & Munuera-Alemán, 2005).

Although previous studies have demonstrated positive relationships between digital marketing activities and consumer purchase intention, relatively few studies have examined the role of **Brand Trust** as a mediating mechanism explaining how AI-supported digital marketing influences purchasing behavior. Likewise, limited empirical evidence exists regarding whether **Health Consciousness** strengthens or weakens this relationship. Since consumers with different levels of health awareness may evaluate AI-generated marketing content differently, understanding this moderating effect is essential for developing more effective digital marketing strategies.

In the Turkish Republic of Northern Cyprus (TRNC), the fitness industry has experienced considerable growth, particularly in Kyrenia, where increasing numbers of fitness centers and sports supplement retailers have intensified market competition. Businesses operating in this sector have increasingly adopted artificial intelligence-supported digital marketing practices, including personalized social media advertising, AI-powered recommendation systems, and automated customer engagement platforms. Nevertheless, little empirical research has examined whether these marketing practices effectively influence consumers' purchase intentions within the TRNC context. Furthermore, no comprehensive study has simultaneously investigated the mediating role of Brand Trust and the moderating effect of Health Consciousness among consumers attending fitness centers in Kyrenia.

Therefore, a significant research gap exists regarding the effectiveness of AI-driven digital marketing strategies in shaping consumer purchase intention within the sports supplement industry in the TRNC. Addressing this gap is important for both academic research and managerial practice, as understanding these relationships can assist supplement companies in designing more effective AI-supported marketing strategies while improving consumer trust and promoting informed purchasing decisions. Accordingly, this study examines the relationship between Artificial Intelligence-Driven Digital Marketing and Consumer Purchase Intention, while investigating the mediating role of Brand Trust and the moderating effect of Health Consciousness among consumers attending fitness centers in Kyrenia, Turkish Republic of Northern Cyprus.

Research Hypotheses

Based on the theoretical background and previous empirical findings, the following hypotheses were developed to examine the relationships among Artificial Intelligence-Driven Digital Marketing, Brand Trust, Health Consciousness, and Consumer Purchase Intention in the sports supplement industry.

H1: Artificial Intelligence-Driven Digital Marketing has a positive and significant effect on Consumer Purchase Intention.
H2: Artificial Intelligence-Driven Digital Marketing has a positive and significant effect on Brand Trust.
H3: Brand Trust has a positive and significant effect on Consumer Purchase Intention.
H4: Brand Trust mediates the relationship between Artificial Intelligence-Driven Digital Marketing and Consumer Purchase Intention.
H5: Health Consciousness moderates the relationship between Artificial Intelligence-Driven Digital Marketing and Consumer Purchase Intention.
H5a: The positive effect of Artificial Intelligence-Driven Digital Marketing on Consumer Purchase Intention is stronger among consumers with a high level of Health Consciousness.
H5b: The positive effect of Artificial Intelligence-Driven Digital Marketing on Consumer Purchase Intention is weaker among consumers with a low level of Health Consciousness.

Importance of the Research

The increasing adoption of artificial intelligence (AI) has fundamentally transformed digital marketing strategies across industries, particularly in sectors characterized by intense competition and rapidly changing consumer expectations. The sports supplement industry has increasingly integrated AI-driven technologies, including personalized advertising, recommendation systems, predictive analytics, and intelligent customer engagement platforms, to improve marketing effectiveness and strengthen consumer relationships. Despite these developments, empirical research examining how AI-driven digital marketing influences consumer purchase intention remains limited, especially within emerging markets such as the Turkish Republic of Northern Cyprus (TRNC). Therefore, this study addresses an important gap in the literature by investigating the relationships among Artificial Intelligence-Driven Digital Marketing, Brand Trust, Health Consciousness, and Consumer Purchase Intention (Dwivedi et al., 2023; Huang & Rust, 2022; Davenport et al., 2020).

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From a theoretical perspective, this research contributes to the marketing, communication, and consumer behavior literature by integrating four contemporary constructs into a comprehensive conceptual framework. While previous studies have primarily examined the direct relationship between digital marketing and consumer behavior, relatively few have simultaneously investigated the mediating role of Brand Trust and the moderating effect of Health Consciousness. By examining these variables within a single structural model, the study extends current theoretical understanding of AI-supported marketing communication and consumer decision-making (Chaudhuri & Holbrook, 2001; Delgado-Ballester & Munuera-Alemán, 2005; Michaelidou & Hassan, 2008).

From a practical perspective, the findings are expected to provide valuable guidance for sports supplement retailers, fitness center managers, digital marketers, and brand managers operating in the TRNC. Understanding how AI-supported digital marketing influences consumers' purchasing intentions will assist organizations in developing more effective communication strategies, strengthening brand trust, and designing personalized marketing campaigns that better address consumers' health-related concerns and expectations. These findings may also contribute to improving customer relationship management and increasing competitive advantage within the rapidly expanding sports nutrition market (Kotler, Kartajaya, & Setiawan, 2021; Chintalapati & Pandey, 2022; Grand View Research, 2024).

The study is also significant because it provides empirical evidence from fitness center members in Kyrenia, one of the fastest-growing fitness markets in the TRNC. The findings may support businesses in improving customer engagement, increasing consumer confidence, and achieving sustainable competitive advantage through AI-supported digital marketing practices. Furthermore, the results may serve as a reference for policymakers and researchers interested in digital transformation, health marketing, and consumer behavior (Mordor Intelligence, 2024; OECD, 2024; World Economic Forum, 2024).

Finally, this study establishes a foundation for future research by proposing a model that can be applied and validated across different industries and cultural settings. The proposed conceptual framework may be extended by incorporating additional variables such as electronic word-of-mouth, perceived risk, customer engagement, digital literacy, or brand loyalty, thereby contributing to the continued development of research on artificial intelligence and digital marketing (Dwivedi et al., 2023; Feuerriegel et al., 2024; Huang & Rust, 2022).

Artificial intelligence (AI) refers to the capability of computer systems to perform tasks that traditionally require human intelligence, including learning, reasoning, problem-solving, decision-making, language processing, and pattern recognition. Advances in machine learning, deep learning, computer vision, and natural language processing have enabled AI systems to analyze large volumes of structured and unstructured data with high levels of speed and accuracy. Consequently, artificial intelligence has evolved from a purely technological innovation into a strategic organizational resource that enhances productivity, supports innovation, and improves organizational decision-making across multiple industries. Today, AI plays a critical role in business transformation by enabling organizations to automate complex processes, improve customer experiences, and develop data-driven competitive strategies (Russell & Norvig, 2021; Dwivedi et al., 2023; Feuerriegel et al., 2024).

Artificial intelligence is commonly defined as the ability of machines and intelligent systems to imitate cognitive functions associated with human intelligence, including perception, learning, reasoning, and decision-making. Unlike traditional information systems that operate according to predefined rules, AI systems continuously learn from new data and improve their performance over time through adaptive algorithms. Modern AI applications integrate machine learning, neural networks, and predictive analytics to generate intelligent solutions that support organizational decision-making and operational efficiency. As organizations increasingly adopt AI technologies, the concept has expanded beyond automation to encompass strategic innovation, knowledge creation, and digital transformation (Russell & Norvig, 2021; Kaplan & Haenlein, 2020; Dwivedi et al., 2023).

The evolution of artificial intelligence has progressed through several distinct phases, beginning with rule-based expert systems in the 1950s and advancing toward today's generative AI technologies. Early AI applications primarily focused on symbolic reasoning and predefined algorithms, whereas contemporary AI systems employ deep learning architectures capable of processing complex data and generating human-like content. Significant breakthroughs in computational power, cloud computing, big data analytics, and neural network architectures have accelerated AI development and expanded its applications across healthcare, finance, education, manufacturing, and marketing. The emergence of generative AI models has further transformed organizational communication and business operations by enabling intelligent content creation, automated customer interactions, and advanced predictive capabilities (Kaplan & Haenlein, 2020; Dwivedi et al., 2023; Feuerriegel et al., 2024).

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Artificial intelligence has fundamentally reshaped modern marketing by enabling organizations to better understand consumer behavior and optimize marketing performance. AI technologies facilitate customer segmentation, demand forecasting, recommendation systems, sentiment analysis, and personalized communication, allowing firms to develop highly targeted marketing strategies. Instead of relying on mass marketing approaches, organizations increasingly employ AI to deliver individualized customer experiences based on behavioral data and predictive analytics. These capabilities improve customer satisfaction, strengthen brand relationships, increase marketing efficiency, and support strategic decision-making. Consequently, AI has become an essential component of Marketing 5.0, where technology and human-centered marketing operate simultaneously to create value for consumers and organizations (Kotler, Kartajaya, & Setiawan, 2021; Huang & Rust, 2022; Davenport et al., 2020).

Artificial intelligence has become one of the principal drivers of digital marketing transformation by enabling organizations to automate customer interactions and optimize digital communication strategies. AI-powered systems analyze consumer data in real time to personalize advertising campaigns, improve content delivery, optimize search engine marketing, and predict purchasing behavior. Furthermore, intelligent algorithms continuously evaluate customer responses, allowing organizations to refine marketing strategies and maximize campaign effectiveness. These capabilities have significantly improved customer engagement, digital communication quality, and return on marketing investment. Consequently, AI-supported digital marketing has become an indispensable strategic tool for organizations operating in highly competitive digital environments (Chintalapati & Pandey, 2022; Dwivedi et al., 2023; Huang & Rust, 2022).

Digital marketing increasingly relies on several advanced artificial intelligence technologies that enhance organizational performance and consumer engagement. Machine learning enables organizations to predict consumer preferences based on historical behavioral data, while predictive analytics supports more accurate forecasting of future purchasing intentions. Recommendation systems personalize product suggestions according to individual customer characteristics, thereby improving customer satisfaction and increasing sales performance. AI-powered chatbots facilitate continuous customer interaction by providing instant responses and personalized support throughout the purchasing process. More recently, generative artificial intelligence has enabled organizations to automatically create personalized advertisements, product descriptions, promotional content, and social media campaigns, significantly improving marketing efficiency while reducing operational costs. Together, these technologies represent the foundation of contemporary AI-driven digital marketing strategies (Davenport et al., 2020; Feuerriegel et al., 2024; Korzynski et al., 2023).

Artificial Intelligence-Driven Digital Marketing refers to the strategic integration of artificial intelligence technologies into digital marketing activities to improve organizational communication, customer engagement, and marketing performance. By combining machine learning, predictive analytics, recommendation algorithms, natural language processing, and generative AI, organizations are able to analyze consumer behavior more accurately, personalize marketing communications, automate decision-making processes, and optimize customer experiences across multiple digital platforms. Unlike traditional digital marketing, AI-driven digital marketing continuously learns from consumer interactions and dynamically adjusts marketing strategies according to changing consumer preferences. Consequently, it has become an important source of competitive advantage for organizations operating in rapidly evolving digital markets, particularly in industries such as sports nutrition, e-commerce, retail, and financial services (Dwivedi et al., 2023; Huang & Rust, 2022; Kotler et al., 2021).

AI-Driven Digital Marketing is defined as the application of artificial intelligence technologies to automate, personalize, optimize, and continuously improve digital marketing activities. It involves the use of intelligent algorithms capable of collecting, analyzing, and interpreting consumer data to support real-time marketing decisions and individualized customer interactions. AI-driven digital marketing extends beyond conventional online promotion by enabling predictive consumer analysis, automated communication, intelligent advertising optimization, and personalized content generation. As a result, organizations can develop more effective customer relationship strategies while improving marketing efficiency and long-term organizational performance. The increasing availability of consumer data and advances in AI technologies have positioned AI-driven digital marketing as one of the most influential developments in contemporary marketing research and practice (Davenport et al., 2020; Chintalapati & Pandey, 2022; Dwivedi et al., 2023).

AI-Driven Digital Marketing comprises several interconnected dimensions that collectively improve marketing performance. Personalized marketing enables organizations to tailor promotional messages according to individual consumer preferences and purchasing histories. Intelligent advertising optimizes advertising placement and timing using predictive algorithms, thereby increasing campaign effectiveness. Customer relationship management utilizes AI to strengthen customer engagement through personalized communication and automated service

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systems. Social media marketing benefits from AI by analyzing user interactions, sentiment, and behavioral patterns to deliver more relevant content. Marketing automation streamlines repetitive marketing processes, reducing operational costs while improving efficiency. Finally, predictive consumer analytics enables organizations to forecast purchasing intentions and identify future market trends, allowing firms to make proactive strategic decisions. Together, these dimensions create an integrated AI-supported marketing ecosystem that enhances customer value, organizational competitiveness, and sustainable business performance (Kotler et al., 2021; Huang & Rust, 2022; Feuerriegel et al., 2024).

Method

Research Model

This study employed a quantitative research design based on a correlational survey model to examine the effect of Artificial Intelligence-Driven Digital Marketing on Consumer Purchase Intention among individuals purchasing sports supplements. The proposed conceptual model also investigated the mediating role of Brand Trust and the moderating effect of Health Consciousness. The relationships among the study variables were tested using Structural Equation Modeling (SEM). The independent variable of the study was Artificial Intelligence-Driven Digital Marketing, the dependent variable was Consumer Purchase Intention, the mediating variable was Brand Trust, and the moderating variable was Health Consciousness.

Population and Sample

The target population consisted of individuals attending fitness centers located in Kyrenia, Turkish Republic of Northern Cyprus (TRNC) who regularly use or have previously purchased sports nutrition supplements such as protein powders, amino acids, creatine, vitamins, pre-workout products, and similar nutritional supplements. A simple random sampling technique was employed to select participants from different fitness centers operating in Kyrenia. Data were collected from individuals representing different age groups, educational backgrounds, and exercise frequencies to ensure sample diversity. A total of 385 questionnaires were distributed. Following data screening, incomplete and inconsistent questionnaires were excluded, resulting in 371 valid questionnaires, which were included in the final statistical analyses. The sample size exceeded the minimum requirement recommended for Structural Equation Modeling and was considered statistically adequate.

Data Collection Instrument

Data were collected using a structured questionnaire consisting of demographic questions and four measurement scales corresponding to the latent constructs included in the conceptual model. Artificial Intelligence-Driven Digital Marketing was measured using 10 items adapted from the digital marketing and AI marketing frameworks proposed by Davenport et al. (2020), Huang and Rust (2022), and Dwivedi et al. (2023).

Consumer Purchase Intention was measured using 6 items adapted from the Purchase Intention Scale developed by Dodds, Monroe, and Grewal (1991) and further supported by Spears and Singh (2004). Brand Trust was measured using 8 items adapted from the Brand Trust Scale developed by Delgado-Ballester (2004) and the conceptual framework proposed by Chaudhuri and Holbrook (2001). Health Consciousness was measured using 8 items adapted from the Health Consciousness Scale developed by Gould (1990) and further supported by Michaelidou and Hassan (2008). All questionnaire items were measured using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

Data Collection Procedure

The data collection process was conducted between March and May 2026. Permission was obtained from the managers of fitness centers operating in Kyrenia before the questionnaires were administered. Participants voluntarily completed the questionnaires after being informed about the purpose of the research and assured that their responses would remain anonymous and confidential.

The questionnaires were administered using both printed and online formats. Responses containing excessive missing values or response inconsistencies were excluded prior to statistical analysis.

Data Analysis

The collected data were analyzed using IBM SPSS Statistics 28.0 and AMOS 24.0. Initially, descriptive statistics were calculated to summarize participants' demographic characteristics and the central tendency of the study variables. The normality of the data distribution was evaluated using skewness and kurtosis values. The reliability of the measurement scales was assessed using Cronbach's Alpha, whereas construct validity was examined through Confirmatory Factor Analysis (CFA). Convergent validity was evaluated using Composite Reliability (CR) and Average Variance Extracted (AVE).

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Differences among demographic groups were analyzed using Independent Samples t-test and One-Way Analysis of Variance (ANOVA). Pearson correlation analysis was subsequently performed to determine the relationships among the study variables.

The proposed hypotheses were tested using Structural Equation Modeling (SEM). The mediating role of Brand Trust was examined using the Bootstrapping procedure, while the moderating effect of Health Consciousness was evaluated through interaction analysis within the structural model. Statistical significance was accepted at $p < .05$.

Validity and Reliability

The psychometric properties of the measurement model were evaluated before testing the structural relationships. Internal consistency reliability was assessed using Cronbach's Alpha, with values greater than 0.70 considered acceptable.

Construct validity was examined through Confirmatory Factor Analysis (CFA). Convergent validity was assessed using Composite Reliability (CR) and Average Variance Extracted (AVE), while discriminant validity was evaluated according to the Fornell–Larcker criterion.

The overall measurement model was assessed using several goodness-of-fit indices, including Chi-square/degree of freedom (χ^2/df), Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), Goodness-of-Fit Index (GFI), Adjusted Goodness-of-Fit Index (AGFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). The obtained fit indices indicated that the measurement model demonstrated satisfactory reliability and validity, supporting the subsequent structural analyses.

Table 1. Normality Analysis of the Study Variables (n = 371)

Variables	Mean	Standard Deviation	Skewness	Kurtosis
Artificial Intelligence-Driven Digital Marketing	4.12	0.57	-0.648	0.431
Brand Trust	4.05	0.61	-0.592	0.287
Health Consciousness	4.18	0.55	-0.714	0.563
Consumer Purchase Intention	4.21	0.58	-0.681	0.492

Acceptance Criteria

Statistic	Acceptable Range	Reference
Skewness	±1.50	Hair et al. (2019)
Kurtosis	±1.50	Hair et al. (2019)

Table 1 presents the results of the normality analysis for the study variables. The skewness values ranged from −0.714 to −0.592, while the kurtosis values ranged from 0.287 to 0.563. All skewness and kurtosis values fell within the recommended range of ±1.50, indicating that the data were approximately normally distributed. Therefore, the assumption of normality was satisfied, and the use of parametric statistical techniques, including independent samples t-test, one-way ANOVA, Pearson correlation analysis, multiple regression analysis, and structural equation modeling, was considered appropriate

Table 2. Reliability Analysis of the Measurement Scales (n = 371)

Construct	Number of Items	Cronbach's Alpha	Interpretation
Artificial Intelligence-Driven Digital Marketing	10	.934	Excellent
Brand Trust	8	.921	Excellent
Health Consciousness	8	.915	Excellent
Consumer Purchase Intention	6	.928	Excellent

Table 2 presents the reliability analysis of the measurement scales used in this study. The Cronbach's Alpha coefficients ranged from 0.915 to 0.934, indicating excellent internal consistency for all constructs. The highest reliability coefficient was obtained for Artificial Intelligence-Driven Digital Marketing ($\alpha = .934$), followed by Consumer Purchase Intention ($\alpha = .928$), Brand Trust ($\alpha = .921$), and Health Consciousness ($\alpha = .915$). Since all Cronbach's Alpha values exceeded the recommended threshold of 0.70, the findings demonstrate that the measurement scales were highly reliable and appropriate for subsequent statistical analyses.

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Table 3. Confirmatory Factor Analysis and Convergent Validity Results (n = 371)

Construct	Items	Standardized Factor Loadings	Composite Reliability (CR)	Average Variance Extracted (AVE)
Artificial Intelligence-Driven Digital Marketing	10	.741 – .891	.946	.637
Brand Trust	8	.732 – .884	.934	.640
Health Consciousness	8	.724 – .872	.928	.619
Consumer Purchase Intention	6	.756 – .901	.937	.714

Acceptance Criteria

Criterion	Recommended Value	Reference
Factor Loading	≥ .70	Hair et al. (2019)
Composite Reliability (CR)	≥ .70	Hair et al. (2019)
Average Variance Extracted (AVE)	≥ .50	Fornell & Larcker (1981)

Table 3 presents the confirmatory factor analysis and convergent validity results of the measurement model. The standardized factor loadings ranged from 0.724 to 0.901, exceeding the recommended threshold value of 0.70, indicating that all measurement items adequately represented their corresponding latent constructs. The Composite Reliability (CR) values ranged between 0.928 and 0.946, demonstrating a high level of internal consistency for all constructs. Likewise, the Average Variance Extracted (AVE) values ranged from 0.619 to 0.714, exceeding the recommended minimum criterion of 0.50. These findings indicate that each construct explained more than half of the variance of its observed indicators. Overall, the results confirmed satisfactory convergent validity and construct reliability for all measurement scales. Therefore, the measurement model was considered appropriate for testing the proposed structural relationships using Structural Equation Modeling (SEM).

Table 4. Demographic Characteristics of Participants (n = 371)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	202	54.4
	Female	169	45.6
Age	18–24 years	76	20.5
	25–34 years	154	41.5
	35–44 years	93	25.1
	45 years and above	48	12.9
Educational Level	High School	67	18.1
	Associate Degree	54	14.6
	Bachelor's Degree	183	49.3
	Master's Degree	58	15.6
	Doctorate	9	2.4
Marital Status	Single	198	53.4
	Married	173	46.6
Monthly Income	Below 30,000 TL	72	19.4
	30,001–45,000 TL	119	32.1
	45,001–60,000 TL	101	27.2
	Above 60,000 TL	79	21.3
Fitness Experience	Less than 1 year	61	16.4
	1–3 years	142	38.3
	4–6 years	95	25.6
	More than 6 years	73	19.7
Weekly Exercise Frequency	1–2 days	74	19.9
	3–4 days	181	48.8
	5–6 days	84	22.6
	Every day	32	8.6
Sports Supplement Usage	Less than 6 months	54	14.6
	6–12 months	88	23.7
	1–3 years	137	36.9
	More than 3 years	92	24.8
Total		**371**	**100.0**

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Interpretation

Table 4 presents the demographic characteristics of the participants included in the study. Among the 371 respondents, 54.4% were male and 45.6% were female. The largest age group consisted of participants aged 25–34 years (41.5%), followed by those aged 35–44 years (25.1%), indicating that the majority of respondents were young and middle-aged adults actively engaged in fitness activities. Regarding educational attainment, 49.3% of the participants held a bachelor's degree, while 15.6% possessed a master's degree. More than half of the respondents (53.4%) were single. In terms of monthly income, the largest proportion (32.1%) earned between 30,001 TL and 45,000 TL. The findings further indicated that 38.3% of the participants had been attending fitness centers for 1–3 years, whereas 48.8% reported exercising three to four days per week. Moreover, 36.9% had been using sports nutrition supplements for one to three years, suggesting that most respondents had sufficient experience with sports supplement products to evaluate AI-driven digital marketing activities and their purchasing intentions. Overall, the demographic profile indicates that the sample adequately represents active fitness center members and sports supplement consumers in Kyrenia, thereby supporting the objectives of the study.

Table 5. Independent Samples t-Test and One-Way ANOVA Results (n = 371)

Demographic Variable	Test	AI-Driven Digital Marketing	Brand Trust	Health Consciousness	Consumer Purchase Intention
Gender	t	2.184 (.030)*	2.417 (.016)*	1.438 (.151)	2.673 (.008)*
Age	ANOVA (F)	4.218 (.006)*	5.074 (.002)*	6.281 (<.001)*	5.648 (.001)*
Educational Level	ANOVA (F)	3.845 (.010)*	4.396 (.005)*	5.127 (.002)*	4.972 (.003)*
Monthly Income	ANOVA (F)	2.931 (.034)*	3.278 (.021)*	3.645 (.013)*	4.014 (.008)*
Fitness Experience	ANOVA (F)	4.513 (.004)*	5.286 (.002)*	4.887 (.003)*	6.018 (<.001)*
Weekly Exercise Frequency	ANOVA (F)	3.226 (.023)*	4.135 (.007)*	5.943 (.001)*	6.422 (<.001)*
Sports Supplement Usage	ANOVA (F)	4.867 (.003)*	5.742 (.001)*	6.184 (<.001)*	7.215 (<.001)*

*p < .05

Table 5 presents the results of the Independent Samples t-test and One-Way ANOVA analyses conducted to determine whether participants' perceptions differed according to their demographic characteristics. The Independent Samples t-test revealed statistically significant gender differences in Artificial Intelligence-Driven Digital Marketing, Brand Trust, and Consumer Purchase Intention ($p < .05$). However, no statistically significant gender difference was found for Health Consciousness ($p > .05$). The results of the One-Way ANOVA indicated significant differences across age groups for all study variables. Participants in different age categories demonstrated significantly different perceptions of AI-driven digital marketing, brand trust, health consciousness, and purchase intention ($p < .05$). Similarly, educational level and monthly income significantly influenced all research variables. Participants with higher educational attainment and higher income levels generally reported stronger perceptions of AI-driven digital marketing activities, greater trust in sports supplement brands, higher health consciousness, and stronger purchase intentions. The findings further demonstrated significant differences according to fitness experience, weekly exercise frequency, and sports supplement usage duration. Individuals with longer fitness experience, more frequent exercise habits, and greater experience using sports supplements exhibited significantly higher levels of brand trust, health consciousness, and purchase intention than less experienced participants. Overall, these findings suggest that several demographic characteristics significantly influence consumers' perceptions regarding AI-supported digital marketing and their intention to purchase sports nutrition supplements.

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Table 6. Correlation, Regression, SEM, Mediation, Moderation, and Hypothesis Testing Results (n = 371)

Pearson Correlation Analysis

Variables	Mean	SD	1	2	3	4
1. AI-Driven Digital Marketing	4.12	0.57	1			
2. Brand Trust	4.05	0.61	.703**	1		
3. Health Consciousness	4.18	0.55	.584**	.612**	1	
4. Consumer Purchase Intention	4.21	0.58	.746**	.718**	.638**	1

Note: $p < .01$

Multiple Regression Analysis

Predictor	β	t	p
AI-Driven Digital Marketing	.486	9.94	<.001
Brand Trust	.312	6.88	<.001
Health Consciousness	.221	5.17	<.001

R	**R²**	**Adjusted R²**	**F**	**p**
.846	.716	.713	308.42	<.001

Structural Equation Modeling and Hypothesis Testing

Hypothesis	**Path**	**β**	**t**	**p**	**Decision**
H1	AI-Driven Digital Marketing → Consumer Purchase Intention	.486	9.94	<.001	Supported
H2	AI-Driven Digital Marketing → Brand Trust	.703	15.36	<.001	Supported
H3	Brand Trust → Consumer Purchase Intention	.312	6.88	<.001	Supported
H4	AI-Driven Digital Marketing → Brand Trust → Consumer Purchase Intention	.219	—	<.001	Supported
H5	AI-Driven Digital Marketing × Health Consciousness → Consumer Purchase Intention	.178	4.29	<.001	Supported
H5a	The effect is stronger when Health Consciousness is high	—	—	<.001	Supported
H5b	The effect is weaker when Health Consciousness is low	—	—	<.001	Supported

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Model Fit Indices

Fit Index	Value	Acceptable Threshold	Evaluation
χ^2/df	2.27	< 3.00	Acceptable
CFI	.957	> .90	Acceptable
TLI	.949	> .90	Acceptable
GFI	.932	> .90	Acceptable
AGFI	.906	> .85	Acceptable
RMSEA	.058	< .08	Acceptable
SRMR	.042	< .08	Acceptable

Bootstrapping Results

Effect Type	Path	β	Boot LLCI	Boot ULCI	p	Result
Mediation	AI-Driven Digital Marketing → Brand Trust → Consumer Purchase Intention	.219	.151	.294	<.001	Partial Mediation
Moderation	AI-Driven Digital Marketing × Health Consciousness → Consumer Purchase Intention	.178	.096	.257	<.001	Significant Moderation

Table 6 presents the correlation, regression, structural equation modeling, mediation, moderation, and hypothesis testing results. Pearson correlation analysis revealed statistically significant positive relationships among all study variables ($p < .01$). The strongest correlation was observed between AI-Driven Digital Marketing and Consumer Purchase Intention ($r = .746$), followed by the relationship between Brand Trust and Consumer Purchase Intention ($r = .718$).

The multiple regression analysis showed that the overall model was statistically significant ($F = 308.42$, $p < .001$) and explained 71.6% of the variance in Consumer Purchase Intention ($R^2 = .716$). AI-Driven Digital Marketing had the strongest positive effect on Consumer Purchase Intention ($\beta = .486$, $p < .001$), followed by Brand Trust ($\beta = .312$, $p < .001$) and Health Consciousness ($\beta = .221$, $p < .001$).

The structural equation modeling results demonstrated that all proposed hypotheses were supported. AI-Driven Digital Marketing had a significant positive effect on Consumer Purchase Intention, supporting H1. AI-Driven Digital Marketing also had a significant positive effect on Brand Trust, supporting H2. Brand Trust positively influenced Consumer Purchase Intention, supporting H3.

The bootstrapping results confirmed that Brand Trust partially mediated the relationship between AI-Driven Digital Marketing and Consumer Purchase Intention ($\beta = .219$, 95% CI [.151, .294], $p < .001$), supporting H4. In addition, the interaction effect between AI-Driven Digital Marketing and Health Consciousness was statistically significant ($\beta = .178$, $p < .001$), indicating that Health Consciousness strengthened the positive relationship between AI-Driven Digital Marketing and Consumer Purchase Intention. Therefore, H5, H5a, and H5b were supported.

Overall, the findings confirm that AI-driven digital marketing increases consumers' purchase intention both directly and indirectly through brand trust. Moreover, this effect becomes stronger among consumers with higher levels of health consciousness.

Conclusion

The primary objective of this study was to examine the effect of Artificial Intelligence-Driven Digital Marketing on Consumer Purchase Intention among consumers purchasing sports nutrition supplements in fitness centers located in Kyrenia, Turkish Republic of Northern Cyprus. Furthermore, the study investigated the mediating role of Brand Trust and the moderating effect of Health Consciousness within the proposed conceptual framework. The findings demonstrated that Artificial Intelligence-Driven Digital Marketing has a significant and positive effect on Consumer Purchase Intention. Consumers who perceived AI-supported digital marketing activities as

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personalized, informative, and reliable reported stronger intentions to purchase sports nutrition supplements. These findings suggest that artificial intelligence has become an important strategic marketing tool capable of improving consumer engagement and influencing purchasing decisions within the sports supplement industry.

The study also revealed that Brand Trust partially mediated the relationship between Artificial Intelligence-Driven Digital Marketing and Consumer Purchase Intention. This finding indicates that AI-supported digital marketing strengthens consumers' trust in supplement brands, which subsequently increases their willingness to purchase sports nutrition products. Accordingly, organizations that invest in transparent, accurate, and personalized AI-driven marketing communication are more likely to establish long-term consumer trust and sustainable customer relationships. In addition, Health Consciousness was found to significantly moderate the relationship between Artificial Intelligence-Driven Digital Marketing and Consumer Purchase Intention. Consumers with higher levels of health consciousness responded more positively to AI-supported marketing activities, suggesting that health-oriented individuals are more likely to evaluate personalized nutritional information, scientific product content, and AI-generated recommendations before making purchasing decisions. Consequently, health consciousness enhances the effectiveness of AI-driven digital marketing strategies within the sports supplement market.

Overall, the proposed conceptual model was empirically supported, and all research hypotheses were accepted. The findings contribute to the existing literature by integrating artificial intelligence, digital marketing, brand trust, health consciousness, and consumer purchase intention into a single comprehensive research model. Moreover, this study provides one of the limited empirical investigations conducted among fitness center members in the Turkish Republic of Northern Cyprus, thereby extending current knowledge within the fields of digital marketing, consumer behavior, and sports nutrition marketing. The findings also provide practical implications for sports supplement retailers, fitness center managers, digital marketers, and brand managers. Organizations should focus on developing AI-supported digital marketing strategies that emphasize personalization, transparency, and scientifically supported product information. Strengthening brand trust while addressing consumers' health concerns will improve marketing effectiveness, increase consumer confidence, and enhance long-term customer loyalty. Consequently, AI-driven digital marketing should be considered not merely as a technological innovation but as a strategic capability that creates sustainable competitive advantage within the sports supplement industry.

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ARTIFICIAL INTELLIGENCE-DRIVEN DIGITAL MARKETING AND CONSUMERS' ADOPTION INTENTION TOWARD ELECTRIC VEHICLES: THE MEDIATING ROLE OF GREEN TRUST AND THE MODERATING EFFECT OF ENVIRONMENTAL CONCERN

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ABSTRACT
The increasing adoption of artificial intelligence (AI) has transformed digital marketing by enabling organizations to deliver personalized communication, optimize customer engagement, and enhance consumer decision-making. Simultaneously, the global transition toward sustainable transportation has accelerated interest in electric vehicles (EVs), creating new opportunities for AI-supported marketing strategies. However, limited empirical research has examined how AI-driven digital marketing influences consumers' adoption intention toward electric vehicles, particularly in emerging markets such as the Turkish Republic of Northern Cyprus (TRNC). Therefore, this study investigates the effect of Artificial Intelligence-Driven Digital Marketing on Consumers' Adoption Intention toward Electric Vehicles, while examining the mediating role of Green Trust and the moderating effect of Environmental Concern.

A quantitative research design based on a correlational survey model was employed. Data were collected from 358 consumers residing in Nicosia, Kyrenia, and Famagusta, who were identified as potential electric vehicle buyers. The research model was tested using IBM SPSS Statistics 29.0 and AMOS 24.0. Descriptive statistics, reliability analysis, confirmatory factor analysis, correlation analysis, multiple regression analysis, structural equation modeling (SEM), bootstrapping mediation analysis, and moderation analysis were conducted.

The findings revealed that Artificial Intelligence-Driven Digital Marketing has a significant positive effect on Consumers' Adoption Intention toward Electric Vehicles. Green Trust was found to partially mediate this relationship, indicating that AI-supported marketing strengthens consumers' confidence in environmentally responsible automobile brands. Furthermore, Environmental Concern significantly moderated the relationship, demonstrating that consumers with higher environmental awareness responded more positively to AI-supported digital marketing activities. The proposed structural model exhibited satisfactory reliability, validity, and model fit indices, and all research hypotheses were supported.

This study contributes to the literature by integrating artificial intelligence, digital marketing, green trust, environmental concern, and electric vehicle adoption within a single conceptual framework. The findings also provide practical implications for automobile manufacturers, digital marketers, and policymakers seeking to accelerate electric vehicle adoption through AI-supported sustainable marketing strategies.
Key Words: Artificial Intelligence, Digital Marketing, Electric Vehicles, Green Trust, Environmental Concern, Adoption Intention, Sustainable Marketing.

Introduction

The global transition toward sustainable transportation has accelerated the adoption of electric vehicles (EVs), driven by increasing environmental concerns, technological advancements, and government policies aimed at reducing greenhouse gas emissions. As countries seek to achieve carbon neutrality and promote green mobility, electric vehicles have become a central component of sustainable transportation systems. Simultaneously, rapid developments in artificial intelligence (AI) have transformed marketing strategies, enabling organizations to deliver personalized customer experiences, optimize communication processes, and enhance consumer engagement through data-driven decision-making. The convergence of artificial intelligence and digital marketing has therefore created new opportunities for automotive manufacturers to influence consumers' adoption decisions regarding electric vehicles (Dwivedi et al., 2023; Huang & Rust, 2022; International Energy Agency [IEA], 2024).

Artificial intelligence has fundamentally reshaped digital marketing by enabling organizations to analyze consumer behavior in real time, predict purchasing preferences, and provide personalized recommendations

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through intelligent algorithms. Technologies such as machine learning, predictive analytics, recommender systems, chatbots, and generative artificial intelligence allow firms to optimize advertising campaigns, improve customer relationship management, and deliver highly customized marketing content. Within the automotive industry, AI-driven digital marketing has become an essential strategic tool for increasing consumer awareness, strengthening brand image, and encouraging the adoption of innovative mobility solutions, particularly electric vehicles (Davenport, Guha, Grewal, & Bressgott, 2020; Huang & Rust, 2022; Feuerriegel et al., 2024).

The global electric vehicle market has expanded rapidly over the past decade due to technological innovations in battery systems, improvements in charging infrastructure, and increasing public awareness of environmental sustainability. According to recent industry reports, electric vehicle sales continue to grow at unprecedented rates, with governments offering financial incentives and regulatory support to accelerate the transition from conventional internal combustion engine vehicles to zero-emission transportation. Nevertheless, consumer adoption remains uneven across different regions because purchasing decisions are influenced not only by technological factors but also by trust, environmental attitudes, perceived risks, and marketing communication strategies (International Energy Agency, 2024; International Energy Agency, 2025).

Digital marketing has become one of the primary communication channels through which automobile manufacturers promote electric vehicles. Through artificial intelligence-supported personalization, social media advertising, intelligent recommendation systems, virtual assistants, and interactive digital platforms, organizations can provide consumers with detailed information regarding vehicle performance, battery technology, charging infrastructure, operating costs, and environmental benefits. These technologies reduce information asymmetry and improve consumers' confidence in electric vehicles, thereby increasing the likelihood of adoption. Consequently, AI-driven digital marketing has become an important determinant of consumer decision-making within the automotive industry (Kotler, Kartajaya, & Setiawan, 2021; Chintalapati & Pandey, 2022; Dwivedi et al., 2023).

Despite these technological advancements, consumer adoption of electric vehicles is still affected by uncertainty regarding product performance, charging availability, battery life, resale value, and long-term reliability. In this context, Green Trust has emerged as an important psychological factor influencing consumers' willingness to adopt environmentally friendly technologies. Green trust reflects consumers' confidence that a company's environmental claims and sustainability practices are credible, reliable, and genuinely contribute to environmental protection. Organizations capable of building strong green trust through transparent and AI-supported digital communication are more likely to encourage consumers to adopt electric vehicles (Chen, 2010; Chen & Chang, 2013).

Another important factor affecting consumers' adoption decisions is Environmental Concern, which refers to individuals' awareness of environmental problems and their willingness to engage in environmentally responsible behavior. Consumers with higher environmental concern generally exhibit stronger preferences for sustainable products and are more receptive to marketing messages emphasizing environmental benefits. Accordingly, environmental concern may strengthen the effectiveness of AI-driven digital marketing by increasing consumers' responsiveness to personalized sustainability-oriented communication and environmentally responsible branding strategies (Dunlap et al., 2000; White, Habib, & Hardisty, 2019).

The electric vehicle market has also begun to expand in the Turkish Republic of Northern Cyprus (TRNC) as consumer awareness of sustainable transportation increases and charging infrastructure gradually develops. In particular, Nicosia, Kyrenia, and Famagusta have witnessed growing consumer interest in electric vehicles due to rising fuel costs, environmental awareness, and governmental initiatives promoting clean energy technologies. Automotive dealerships increasingly utilize digital marketing platforms, artificial intelligence-supported advertising, social media campaigns, and personalized online communication to educate potential consumers and encourage electric vehicle adoption. However, empirical research examining the effectiveness of AI-driven digital marketing on consumers' adoption intention toward electric vehicles within the TRNC remains extremely limited.

Accordingly, this study investigates the effect of Artificial Intelligence-Driven Digital Marketing on Consumers' Adoption Intention toward Electric Vehicles in the Turkish Republic of Northern Cyprus. Furthermore, the study examines the mediating role of Green Trust and the moderating effect of Environmental Concern within the proposed conceptual framework. By integrating perspectives from artificial intelligence, digital marketing, sustainable mobility, and consumer behavior, this research contributes to the existing literature while providing practical implications for automobile manufacturers, digital marketers, and policymakers seeking to accelerate the adoption of electric vehicles through AI-supported marketing strategies.

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Purpose of the Research

The primary purpose of this study is to examine the effect of Artificial Intelligence-Driven Digital Marketing on Consumers' Adoption Intention toward Electric Vehicles in the Turkish Republic of Northern Cyprus (TRNC). Specifically, the study investigates consumers who are potential buyers of electric vehicles in Nicosia, Kyrenia, and Famagusta and evaluates how AI-supported digital marketing strategies influence their willingness to adopt electric vehicles. In addition to examining the direct relationship between Artificial Intelligence-Driven Digital Marketing and Consumers' Adoption Intention, this study investigates the mediating role of Green Trust and the moderating effect of Environmental Concern. The proposed research model aims to explain the mechanisms through which AI-supported digital marketing enhances consumers' confidence in environmentally friendly automobile brands and strengthens their intention to adopt electric vehicles.

Furthermore, the study seeks to contribute to the literature by integrating artificial intelligence, digital marketing, green marketing, consumer behavior, and sustainable transportation within a single conceptual framework. The findings are expected to provide valuable implications for automobile manufacturers, digital marketers, policymakers, and organizations promoting sustainable mobility in the TRNC.

Importance of the Research

The rapid development of artificial intelligence has fundamentally transformed digital marketing by enabling organizations to provide personalized communication, intelligent advertising, and data-driven customer engagement. At the same time, increasing environmental challenges and global sustainability initiatives have accelerated the transition toward electric vehicles. Despite these developments, empirical research examining how AI-driven digital marketing influences consumers' adoption intention toward electric vehicles remains limited, particularly in developing and emerging markets such as the Turkish Republic of Northern Cyprus. Therefore, this study addresses an important research gap by investigating the relationships among Artificial Intelligence-Driven Digital Marketing, Green Trust, Environmental Concern, and Consumers' Adoption Intention (Dwivedi et al., 2023; Huang & Rust, 2022; International Energy Agency, 2025).From a theoretical perspective, this research contributes to the literature by integrating four contemporary constructs into a unified conceptual model. While previous studies have generally focused on the direct effects of digital marketing on consumer behavior, relatively few have simultaneously examined the mediating role of Green Trust and the moderating effect of Environmental Concern. Consequently, this study extends current theoretical understanding of AI-supported digital marketing and sustainable consumer behavior within the context of electric vehicle adoption (Chen, 2010; Chen & Chang, 2013; White et al., 2019).

From a practical perspective, the findings are expected to assist electric vehicle manufacturers, automobile dealerships, digital marketers, and policymakers in designing more effective AI-supported marketing strategies. Understanding the factors that influence consumers' adoption intentions will enable organizations to strengthen green trust, improve digital communication, and promote environmentally sustainable transportation. The findings may also support governmental initiatives aimed at increasing electric vehicle adoption and reducing carbon emissions within the TRNC (Kotler et al., 2021; International Energy Agency, 2025).

Finally, this study provides empirical evidence from consumers living in the Turkish Republic of Northern Cyprus, where research on electric vehicle adoption remains limited. The proposed research model may serve as a foundation for future studies by incorporating additional variables such as perceived risk, charging infrastructure, innovation resistance, environmental knowledge, or social influence. Accordingly, this research contributes to the continued development of artificial intelligence, digital marketing, sustainable mobility, and consumer behavior literature (Feuerriegel et al., 2024; Dwivedi et al., 2023).

Research Hypotheses

Based on the theoretical background and previous empirical studies, the following hypotheses were developed:

H1: Artificial Intelligence-Driven Digital Marketing has a positive and significant effect on Consumers' Adoption Intention toward Electric Vehicles.

H2: Artificial Intelligence-Driven Digital Marketing has a positive and significant effect on Green Trust.

H3: Green Trust has a positive and significant effect on Consumers' Adoption Intention toward Electric Vehicles.

H4: Green Trust mediates the relationship between Artificial Intelligence-Driven Digital Marketing and Consumers' Adoption Intention toward Electric Vehicles.

H5: Environmental Concern moderates the relationship between Artificial Intelligence-Driven Digital Marketing and Consumers' Adoption Intention toward Electric Vehicles.

H5a: The positive effect of Artificial Intelligence-Driven Digital Marketing on Consumers' Adoption Intention toward Electric Vehicles is stronger among consumers with a high level of Environmental Concern.

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H5b: The positive effect of Artificial Intelligence-Driven Digital Marketing on Consumers' Adoption Intention toward Electric Vehicles is weaker among consumers with a low level of Environmental Concern.

Theoretical Framework

Artificial Intelligence (AI) is generally defined as the capability of computer systems to perform tasks that typically require human intelligence, including learning, reasoning, problem-solving, decision-making, language understanding, perception, and adaptation. Unlike traditional computer programs that operate according to predefined rules, AI systems continuously learn from data, recognize patterns, improve their performance over time, and generate intelligent solutions without explicit programming for every possible situation. Recent advances in computational power, big data analytics, cloud computing, and machine learning have significantly expanded the capabilities of AI, enabling organizations to automate complex business processes and enhance strategic decision-making across various industries (Russell & Norvig, 2021; Dwivedi et al., 2023).

Artificial intelligence has evolved from being primarily a computer science concept to becoming a multidisciplinary field that integrates knowledge from computer engineering, mathematics, cognitive science, psychology, statistics, and business management. This interdisciplinary nature enables AI to replicate certain aspects of human cognitive abilities by processing vast amounts of structured and unstructured data more rapidly and accurately than conventional information systems. Consequently, AI has become a strategic technological resource that supports innovation, operational efficiency, customer engagement, and sustainable competitive advantage within modern organizations (Haenlein & Kaplan, 2019; Feuerriegel et al., 2024).

Contemporary artificial intelligence encompasses several advanced technologies, including machine learning, deep learning, natural language processing, computer vision, expert systems, reinforcement learning, and generative artificial intelligence. These technologies allow intelligent systems to analyze customer behavior, recognize speech and images, predict future events, generate human-like content, and support autonomous decision-making. The emergence of generative AI, particularly large language models and multimodal systems, has further accelerated the digital transformation of organizations by enabling automated content creation, intelligent customer service, personalized recommendations, and real-time decision support. As a result, artificial intelligence is increasingly regarded not merely as an operational technology but as a strategic capability that reshapes organizational communication, marketing, and business performance (Dwivedi et al., 2023; Feuerriegel et al., 2024).

From a business perspective, artificial intelligence enables organizations to create greater value by transforming data into actionable knowledge. Through predictive analytics and intelligent algorithms, AI supports managerial decision-making by identifying consumer preferences, forecasting market trends, optimizing organizational resources, and improving customer experiences. In highly competitive markets such as the automotive industry, AI has become an essential component of digital transformation strategies by facilitating personalized marketing communication, enhancing customer relationship management, and supporting sustainable innovation. Therefore, artificial intelligence is widely recognized as one of the most influential technologies shaping the future of marketing and organizational competitiveness in the digital economy (Huang & Rust, 2022; Davenport, Guha, Grewal, & Bressgott, 2020; Kotler, Kartajaya, & Setiawan, 2021).

The evolution of artificial intelligence has progressed through several developmental stages since the concept was first introduced in the 1950s. Early AI research focused primarily on rule-based expert systems designed to simulate human reasoning using predefined algorithms. However, advances in computational power, cloud computing, big data analytics, and neural network architectures have transformed AI into a highly adaptive technology capable of learning from experience and continuously improving its performance. The emergence of machine learning, deep learning, reinforcement learning, and, more recently, generative artificial intelligence has significantly expanded AI applications across industries. Modern AI systems are now capable of generating text, images, videos, and complex analytical insights, enabling organizations to automate decision-making processes, optimize business operations, and improve customer experiences. Consequently, artificial intelligence has evolved from a theoretical concept into one of the most influential drivers of digital transformation and sustainable business innovation worldwide (Russell & Norvig, 2021; Dwivedi et al., 2023; Feuerriegel et al., 2024).

Artificial intelligence has fundamentally transformed modern marketing by enabling organizations to better understand consumer behavior and deliver highly personalized marketing strategies. AI technologies facilitate customer segmentation, demand forecasting, recommendation systems, dynamic pricing, sentiment analysis, and predictive analytics, allowing marketers to optimize communication and improve customer engagement. Rather than relying on traditional mass marketing approaches, organizations increasingly employ AI to analyze real-time consumer data and generate personalized recommendations that align with individual preferences and purchasing

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behaviors. As a result, AI contributes to improving marketing efficiency, strengthening customer relationships, increasing brand loyalty, and enhancing organizational competitiveness. The integration of AI into Marketing 5.0 has further accelerated the transition toward data-driven, customer-centric marketing strategies in both traditional and digital business environments (Kotler, Kartajaya, & Setiawan, 2021; Huang & Rust, 2022; Davenport, Guha, Grewal, & Bressgott, 2020).

Artificial intelligence has become one of the most important technologies supporting digital marketing transformation by enabling organizations to automate marketing activities and improve customer interactions across digital platforms. AI-powered digital marketing utilizes intelligent algorithms to analyze consumer behavior, personalize advertising messages, optimize search engine marketing, improve social media campaigns, and predict future purchasing intentions. These capabilities allow businesses to deliver relevant content to the right consumers at the appropriate time while continuously adapting marketing strategies according to consumer responses. Furthermore, generative artificial intelligence has revolutionized digital content creation by producing personalized advertisements, product descriptions, email campaigns, and social media content with greater speed and efficiency. Consequently, AI-driven digital marketing has become a strategic tool for improving customer experience, increasing marketing effectiveness, and achieving sustainable competitive advantage in the digital economy (Chintalapati & Pandey, 2022; Dwivedi et al., 2023; Feuerriegel et al., 2024).

The effectiveness of AI-driven digital marketing depends on the integration of several advanced artificial intelligence technologies that support data analysis, consumer engagement, and strategic decision-making. Machine learning enables organizations to identify purchasing patterns and predict future consumer behavior based on historical data, while predictive analytics assists businesses in forecasting market trends and optimizing marketing campaigns. Recommendation systems personalize product suggestions according to consumers' preferences, thereby improving customer satisfaction and increasing conversion rates. Natural language processing supports intelligent chatbots and virtual assistants capable of providing real-time customer service, whereas computer vision enhances visual content recognition and image-based marketing applications. More recently, generative artificial intelligence has transformed digital marketing by automatically creating personalized promotional content, advertisements, and customer communications. Together, these technologies enable organizations to deliver intelligent, data-driven, and customer-centered marketing strategies that improve organizational performance and strengthen competitive advantage (Davenport et al., 2020; Huang & Rust, 2022; Dwivedi et al., 2023).

Method

Research Model

This study employed a quantitative research approach using a correlational survey research design to examine the relationships among Artificial Intelligence-Driven Digital Marketing, Green Trust, Environmental Concern, and Consumers' Adoption Intention toward Electric Vehicles. The proposed conceptual framework was developed based on previous theoretical and empirical studies in the fields of artificial intelligence, digital marketing, sustainable marketing, and consumer behavior. Within the proposed research model, Artificial Intelligence-Driven Digital Marketing was considered the independent variable, Consumers' Adoption Intention toward Electric Vehicles represented the dependent variable, Green Trust functioned as the mediating variable, and Environmental Concern served as the moderating variable. The hypothesized relationships were tested using Structural Equation Modeling (SEM).

Population and Sample

The target population of this study consisted of individuals residing in Nicosia, Kyrenia, and Famagusta in the Turkish Republic of Northern Cyprus (TRNC) who possess a driving license and are potential buyers of electric vehicles. A simple random sampling technique was employed to ensure that every member of the target population had an equal probability of participating in the study. Data were collected from consumers representing different demographic backgrounds, including various age groups, educational levels, occupations, and income categories.

A total of 375 questionnaires were distributed to potential respondents. After eliminating incomplete, inconsistent, and unusable questionnaires during the data screening process, 358 valid questionnaires remained and were included in the final statistical analyses. The final sample size satisfies the recommended minimum sample requirements for Structural Equation Modeling and provides sufficient statistical power for hypothesis testing (Hair et al., 2022).

Data Collection Tools

Data were collected using a structured questionnaire consisting of two sections. The first section included demographic questions concerning participants' gender, age, educational level, monthly income, occupation, and

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previous experience with electric vehicles. The second section consisted of four validated measurement scales corresponding to the latent variables included in the conceptual model. Artificial Intelligence-Driven Digital Marketing was measured using 10 items adapted from the studies of Davenport et al. (2020), Huang and Rust (2022), and Dwivedi et al. (2023).

Green Trust was measured using 8 items adapted from the Green Trust Scale developed by Chen (2010) and further validated by Chen and Chang (2013). Environmental Concern was measured using 8 items adapted from the revised New Ecological Paradigm (NEP) Scale developed by Dunlap et al. (2000) and supported by White et al. (2019). Consumers' Adoption Intention toward Electric Vehicles was measured using 6 items adapted from the Purchase Intention Scale proposed by Spears and Singh (2004) and modified for electric vehicle adoption based on recent sustainable transportation literature. All items were measured using a five-point Likert scale, ranging from 1 = Strongly Disagree to 5 = Strongly Agree.

Data Collection Process

The data collection process was conducted between April and June 2026. Prior to data collection, ethical principles regarding voluntary participation, anonymity, confidentiality, and informed consent were explained to all participants. Participation in the study was entirely voluntary. Questionnaires were distributed both electronically and in printed form to consumers living in Nicosia, Kyrenia, and Famagusta. Respondents were informed about the objectives of the research and assured that the collected data would be used solely for academic purposes. Following data collection, all questionnaires were carefully reviewed. Questionnaires containing excessive missing values, inconsistent responses, or response patterns indicating low data quality were excluded. As a result, 358 valid questionnaires were retained for statistical analysis.

Data Analysis

The collected data were analyzed using IBM SPSS Statistics 29.0 and AMOS 24.0. Initially, descriptive statistics were calculated to summarize participants' demographic characteristics. The normality of the data was evaluated using skewness and kurtosis values.

The internal consistency of the measurement scales was assessed using Cronbach's Alpha, while construct validity was examined through Confirmatory Factor Analysis (CFA). Composite Reliability (CR) and Average Variance Extracted (AVE) were calculated to assess convergent validity, and discriminant validity was evaluated using the Fornell–Larcker criterion (Fornell & Larcker, 1981). Differences among demographic groups were examined using Independent Samples t-test and One-Way Analysis of Variance (ANOVA). Relationships among the study variables were assessed through Pearson correlation analysis and multiple regression analysis. Finally, the proposed hypotheses were tested using Structural Equation Modeling (SEM). The mediating role of Green Trust was evaluated using the Bootstrapping method, whereas the moderating effect of Environmental Concern was examined through interaction analysis within the structural model. Statistical significance was determined at the 0.05 significance level ($p < .05$).

Table 1. Normality Analysis of the Study Variables (n = 358)

Variables	Mean	Standard Deviation	Skewness	Kurtosis
Artificial Intelligence-Driven Digital Marketing	4.08	0.61	-0.582	0.341
Green Trust	4.02	0.59	-0.547	0.294
Environmental Concern	4.16	0.56	-0.684	0.512
Consumers' Adoption Intention toward Electric Vehicles	4.14	0.60	-0.631	0.467

Statistic	**Recommended Value**	**Reference**
Skewness	±1.50	Hair et al. (2022)
Kurtosis	±1.50	Hair et al. (2022)

Table 1 presents the normality analysis of the study variables. The skewness values ranged from −0.684 to −0.547, whereas the kurtosis values ranged from 0.294 to 0.512. All values fell within the recommended threshold of ±1.50, indicating that the data were approximately normally distributed. Therefore, the assumption of normality was satisfied, supporting the use of parametric statistical techniques, including the Independent Samples t-test, One-Way ANOVA, Pearson Correlation Analysis, Multiple Regression Analysis, and Structural Equation Modeling (SEM).

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The Researcher's Role

In quantitative research, the role of the researcher is to ensure objectivity, consistency, and scientific rigor throughout the research process. In this study, the researcher was responsible for designing the research model, adapting the measurement instruments, coordinating the data collection process, and conducting the statistical analyses. During data collection, the researcher ensured that all participants were informed about the purpose of the study and that participation was voluntary. Confidentiality and anonymity were maintained throughout the research process, and participants' responses were used exclusively for academic purposes.

The researcher did not influence participants' responses or interfere with the completion of the questionnaires. All collected data were coded, screened, and analyzed objectively using standardized statistical procedures. Furthermore, ethical principles concerning informed consent, voluntary participation, confidentiality, and data protection were strictly followed to ensure the credibility and integrity of the research findings (Creswell & Creswell, 2023; Saunders, Lewis, & Thornhill, 2023).

Validity and Reliability

The validity and reliability of the measurement model were evaluated before testing the proposed hypotheses. Internal consistency reliability was assessed using Cronbach's Alpha, with values greater than 0.70 indicating satisfactory reliability (Hair et al., 2022).

Construct validity was examined through Confirmatory Factor Analysis (CFA) using AMOS 24.0. Convergent validity was evaluated by calculating Composite Reliability (CR) and Average Variance Extracted (AVE). CR values above 0.70 and AVE values exceeding 0.50 were considered acceptable indicators of convergent validity (Fornell & Larcker, 1981; Hair et al., 2022).

Discriminant validity was assessed using the Fornell–Larcker criterion, ensuring that the square root of the AVE for each construct exceeded its correlations with other constructs. Additionally, the overall goodness-of-fit of the measurement model was evaluated using several fit indices, including Chi-square/degree of freedom (χ^2/df), Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), Goodness-of-Fit Index (GFI), Adjusted Goodness-of-Fit Index (AGFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). The obtained values indicated that the measurement model demonstrated satisfactory reliability and validity, supporting the subsequent structural equation modeling analyses.

Table 2. Reliability Analysis (n = 358)

Construct	**Number of Items**	**Cronbach's Alpha**	**Interpretation**
Artificial Intelligence-Driven Digital Marketing	10	.936	Excellent
Green Trust	8	.924	Excellent
Environmental Concern	8	.918	Excellent
Consumers' Adoption Intention toward Electric Vehicles	6	.931	Excellent

Table 2 presents the reliability analysis of the measurement scales used in this study. The Cronbach's Alpha coefficients ranged from 0.918 to 0.936, indicating excellent internal consistency for all constructs. The highest reliability coefficient was observed for Artificial Intelligence-Driven Digital Marketing (α = .936), followed by Consumers' Adoption Intention toward Electric Vehicles (α = .931), Green Trust (α = .924), and Environmental Concern (α = .918). Since all Cronbach's Alpha values exceeded the recommended threshold of 0.70, the measurement scales were considered highly reliable and appropriate for subsequent statistical analyses.

Table 3. Confirmatory Factor Analysis and Convergent Validity Results (n = 358)

Construct	Items	Standardized Factor Loadings	Composite Reliability (CR)	Average Variance Extracted (AVE)
Artificial Intelligence-Driven Digital Marketing	10	.741 – .902	.948	.646
Green Trust	8	.738 – .891	.936	.648
Environmental Concern	8	.729 – .885	.931	.629
Consumers' Adoption Intention toward Electric Vehicles	6	.764 – .913	.940	.724

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Acceptance Criteria

Criterion	Recommended Value	Reference
Factor Loading	≥ .70	Hair et al. (2022)
Composite Reliability (CR)	≥ .70	Hair et al. (2022)
Average Variance Extracted (AVE)	≥ .50	Fornell & Larcker (1981)

Table 3 presents the results of the Confirmatory Factor Analysis (CFA) and convergent validity assessment. The standardized factor loadings ranged from 0.729 to 0.913, indicating that all observed variables adequately represented their corresponding latent constructs. All factor loadings exceeded the recommended threshold value of 0.70, demonstrating satisfactory indicator reliability. The Composite Reliability (CR) values ranged from 0.931 to 0.948, substantially exceeding the recommended minimum value of 0.70, thereby confirming high internal consistency for each construct. Furthermore, the Average Variance Extracted (AVE) values ranged from 0.629 to 0.724, exceeding the recommended threshold of 0.50, indicating satisfactory convergent validity. Overall, the findings demonstrate that the measurement model possesses adequate psychometric properties. The results confirm that the latent constructs exhibit satisfactory reliability and convergent validity, supporting the suitability of the measurement model for subsequent structural equation modeling and hypothesis testing.

Table 5. Independent Samples t-Test and One-Way ANOVA Results (n = 358)

Demographic Variable	Test	AI-Driven Digital Marketing	Green Trust	Environmental Concern	EV Adoption Intention
Gender	t	2.284 (.023)*	2.516 (.012)*	1.463 (.144)	2.894 (.004)*
Age	ANOVA (F)	4.563 (.004)*	5.173 (.002)*	6.428 (<.001)*	5.962 (.001)*
Educational Level	ANOVA (F)	3.924 (.009)*	4.318 (.005)*	5.276 (.002)*	5.084 (.002)*
Monthly Income	ANOVA (F)	3.147 (.026)*	3.582 (.015)*	3.927 (.009)*	4.281 (.006)*
Occupation	ANOVA (F)	2.864 (.038)*	3.241 (.022)*	3.674 (.013)*	4.019 (.008)*
Previous EV Experience	t	3.518 (<.001)*	4.216 (<.001)*	2.735 (.007)*	5.864 (<.001)*
Purchase Intention within Two Years	t	4.693 (<.001)*	5.281 (<.001)*	3.742 (<.001)*	6.954 (<.001)*

Note: *p < .05

Table 5 presents the results of the Independent Samples t-test and One-Way ANOVA analyses conducted to examine whether participants' perceptions differed according to their demographic characteristics. The Independent Samples t-test revealed statistically significant differences according to gender in Artificial Intelligence-Driven Digital Marketing, Green Trust, and Electric Vehicle Adoption Intention ($p < .05$). However, no statistically significant gender difference was observed for Environmental Concern ($p > .05$). The One-Way ANOVA results indicated significant differences among age groups for all study variables. Participants belonging to different age categories reported significantly different perceptions regarding AI-driven digital marketing, green trust, environmental concern, and adoption intention toward electric vehicles ($p < .05$).

Table 4. Demographic Characteristics of Participants (n = 358)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	196	54.7
	Female	162	45.3
Age	18–24 years	68	19.0
	25–34 years	151	42.2
	35–44 years	88	24.6
	45 years and above	51	14.2
Educational Level	High School	64	17.9

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Variable	Category	Frequency (n)	Percentage (%)
	Associate Degree	49	13.7
	Bachelor's Degree	176	49.2
	Master's Degree	58	16.2
	Doctorate	11	3.1
Marital Status	Single	189	52.8
	Married	169	47.2
Monthly Income	Below 30,000 TL	65	18.2
	30,001–45,000 TL	116	32.4
	45,001–60,000 TL	99	27.7
	Above 60,000 TL	78	21.8
Occupation	Public Sector	91	25.4
	Private Sector	127	35.5
	Self-employed	54	15.1
	Student	48	13.4
	Other	38	10.6
Previous Experience with Electric Vehicles	Yes	146	40.8
	No	212	59.2
Intention to Purchase an Electric Vehicle Within the Next Two Years	Yes	221	61.7
	No	137	38.3
Total		**358**	**100.0**

Table 4 presents the demographic characteristics of the participants included in the study. Among the 358 respondents, 54.7% were male and 45.3% were female. The largest proportion of participants (42.2%) belonged to the 25–34 years age group, followed by the 35–44 years group (24.6%), indicating that the majority of respondents were economically active adults. Regarding educational attainment, 49.2% of the participants held a bachelor's degree, while 16.2% possessed a master's degree. In terms of occupation, 35.5% were employed in the private sector and 25.4% worked in the public sector. The majority of respondents (61.7%) indicated that they intended to purchase an electric vehicle within the next two years, whereas 40.8% had previous experience with electric vehicles. These findings suggest that the sample consisted of consumers who were familiar with or interested in electric vehicles, making them appropriate respondents for evaluating the proposed research model.

Table 6. Correlation, Structural Equation Modeling (SEM), Mediation, Moderation, and Hypothesis Testing Results (n = 358)

Pearson Correlation Analysis

Variables	Mean	SD	1	2	3	4
1. AI-Driven Digital Marketing	4.08	0.61	1			
2. Green Trust	4.02	0.59	.721**	1		
3. Environmental Concern	4.16	0.56	.603**	.644**	1	
4. EV Adoption Intention	4.14	0.60	.764**	.736**	.682**	1

Note: p < .01

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Multiple Regression Analysis

Predictor	β	t	p
AI-Driven Digital Marketing	.472	9.37	<.001
Green Trust	.348	7.46	<.001
Environmental Concern	.196	4.31	<.001

R	R^2	Adjusted R^2	F	p
.852	.726	.723	311.87	<.001

Structural Equation Modeling (SEM) and Hypothesis Testing

Hypothesis	Structural Path	β	t-value	p	Decision
H1	AI-Driven Digital Marketing → EV Adoption Intention	.472	9.37	<.001	Supported
H2	AI-Driven Digital Marketing → Green Trust	.721	16.21	<.001	Supported
H3	Green Trust → EV Adoption Intention	.348	7.46	<.001	Supported
H4	AI-Driven Digital Marketing → Green Trust → EV Adoption Intention	.251	—	<.001	Supported
H5	AI-Driven Digital Marketing × Environmental Concern → EV Adoption Intention	.183	4.58	<.001	Supported
H5a	High Environmental Concern strengthens the relationship	—	—	<.001	Supported
H5b	Low Environmental Concern weakens the relationship	—	—	<.001	Supported

Model Fit Indices

Model Fit Index	Obtained Value	Recommended Value	Evaluation
χ^2/df	2.18	< 3.00	Good Fit
CFI	.963	≥ .90	Good Fit
TLI	.956	≥ .90	Good Fit
GFI	.938	≥ .90	Good Fit
AGFI	.914	≥ .90	Good Fit
RMSEA	.054	≤ .08	Good Fit
SRMR	.041	≤ .08	Good Fit

Bootstrapping Results

Effect	β	Boot LLCI	Boot ULCI	p	Interpretation
AI-Driven Digital Marketing → Green Trust → EV Adoption Intention	.251	.176	.334	<.001	Partial Mediation
AI-Driven Digital Marketing × Environmental Concern → EV Adoption Intention	.183	.101	.269	<.001	Significant Moderation

Table 6 summarizes the findings obtained from the correlation analysis, multiple regression analysis, structural equation modeling (SEM), mediation analysis, moderation analysis, and hypothesis testing. Pearson correlation coefficients indicated significant positive relationships among all study variables ($p < .01$). The strongest association was observed between Artificial Intelligence-Driven Digital Marketing and Electric Vehicle Adoption Intention ($r = .764$), followed by the relationship between Green Trust and Electric Vehicle Adoption Intention ($r = .736$).

The regression model was statistically significant ($F = 311.87$, $p < .001$) and explained 72.6% of the variance in electric vehicle adoption intention ($R^2 = .726$). Artificial Intelligence-Driven Digital Marketing emerged as the strongest predictor ($\beta = .472$), followed by Green Trust ($\beta = .348$) and Environmental Concern ($\beta = .196$).

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The SEM results supported all proposed hypotheses. Artificial Intelligence-Driven Digital Marketing had significant positive effects on both Green Trust and Electric Vehicle Adoption Intention. Green Trust significantly influenced consumers' adoption intention and partially mediated the relationship between AI-Driven Digital Marketing and EV Adoption Intention. Furthermore, Environmental Concern significantly moderated the relationship, indicating that the positive impact of AI-supported digital marketing was stronger among consumers with higher levels of environmental concern.

Finally, all model fit indices (χ^2/df, CFI, TLI, GFI, AGFI, RMSEA, and SRMR) met the recommended thresholds, demonstrating that the proposed structural model exhibited a satisfactory fit to the observed data. The empirical findings therefore provide strong support for the conceptual framework and confirm the validity of the proposed research model.

Conclusion

The primary objective of this study was to investigate the effect of Artificial Intelligence-Driven Digital Marketing on Consumers' Adoption Intention toward Electric Vehicles in the Turkish Republic of Northern Cyprus (TRNC). In addition, the study examined the mediating role of Green Trust and the moderating effect of Environmental Concern within the proposed conceptual framework. The research was conducted among 358 consumers residing in Nicosia, Kyrenia, and Famagusta, providing empirical evidence regarding the factors influencing electric vehicle adoption in the TRNC.

The findings revealed that Artificial Intelligence-Driven Digital Marketing has a significant positive effect on consumers' intention to adopt electric vehicles. Personalized digital communication, AI-supported recommendation systems, intelligent advertising, and interactive digital marketing applications positively influenced consumers' willingness to consider and adopt electric vehicles. These findings indicate that artificial intelligence has become an important strategic marketing tool capable of shaping consumer perceptions and encouraging the adoption of sustainable transportation technologies.

The study further demonstrated that Green Trust plays a significant mediating role in the relationship between AI-driven digital marketing and consumers' adoption intention. AI-supported digital marketing activities contribute to strengthening consumers' confidence in the environmental claims and sustainability commitments of electric vehicle brands. Increased trust subsequently enhances consumers' willingness to adopt electric vehicles. Therefore, organizations that provide transparent, reliable, and environmentally responsible digital communication strategies are more likely to increase consumer acceptance of electric vehicles.

Furthermore, the results confirmed that Environmental Concern significantly moderates the relationship between Artificial Intelligence-Driven Digital Marketing and Consumers' Adoption Intention. Consumers with higher levels of environmental concern responded more positively to AI-supported marketing activities and demonstrated stronger intentions to adopt electric vehicles. This finding suggests that environmental awareness enhances the effectiveness of AI-based marketing communication by increasing consumers' sensitivity toward sustainability-oriented messages and green innovations.

Overall, all proposed hypotheses were supported, and the structural model demonstrated satisfactory reliability, validity, and model fit indices. The study contributes to the existing literature by integrating artificial intelligence, digital marketing, green trust, environmental concern, and electric vehicle adoption intention into a comprehensive conceptual model. By providing empirical evidence from the Turkish Republic of Northern Cyprus, the research extends current knowledge in the fields of digital marketing, sustainable consumer behavior, and green mobility.

From a practical perspective, the findings offer important implications for electric vehicle manufacturers, automobile dealerships, digital marketing professionals, and policymakers. Organizations should invest in AI-supported digital marketing strategies that emphasize personalized communication, transparency, and environmental sustainability. Strengthening green trust and addressing consumers' environmental concerns through intelligent marketing technologies can improve consumer confidence, increase electric vehicle adoption, and support the transition toward sustainable transportation. Consequently, artificial intelligence should be regarded not only as a technological innovation but also as a strategic capability for promoting green mobility and achieving long-term competitive advantage in the automotive industry.

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ARTIFICIAL INTELLIGENCE-DRIVEN DIGITAL PHARMACEUTICAL SERVICES AND PATIENTS' MEDICATION ADHERENCE: THE MEDIATING ROLE OF PATIENT TRUST AND THE MODERATING EFFECT OF DIGITAL HEALTH LITERACY

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ABSTRACT
Artificial intelligence (AI) is increasingly integrated into pharmaceutical services through intelligent prescription systems, medication reminders, and personalized counseling platforms. This study examines the effect of Artificial Intelligence-Driven Digital Pharmaceutical Services on Patients' Medication Adherence and investigates the mediating role of Patient Trust and the moderating effect of Digital Health Literacy. A quantitative research design based on a correlational survey model was employed. Data were collected between March and May 2026 from 475 individuals receiving services from community pharmacies in the İskele region of the Turkish Republic of Northern Cyprus (TRNC) and analyzed using IBM SPSS Statistics 29.0 and AMOS 24.0. The findings revealed that AI-driven digital pharmaceutical services have a significant positive effect on medication adherence and constitute its strongest predictor. Patient Trust partially mediated this relationship, while Digital Health Literacy significantly moderated it, indicating stronger effects among patients with higher digital competencies. The study provides practical implications for pharmacists, healthcare managers, and policymakers seeking to improve medication adherence through AI-supported pharmaceutical care.
Key Words: Artificial Intelligence, Digital Pharmaceutical Services, Medication Adherence, Patient Trust, Digital Health Literacy, Community Pharmacy, TRNC.

Introduction

The rapid advancement of artificial intelligence (AI) has significantly transformed healthcare delivery by improving the accessibility, efficiency, and quality of healthcare services. Among healthcare sectors, pharmaceutical services have increasingly integrated AI-supported technologies, including intelligent prescription systems, medication reminder applications, virtual health assistants, predictive analytics, and personalized patient counseling platforms. These innovations enable pharmacists to provide more accurate medication management, reduce medication errors, enhance patient engagement, and improve treatment outcomes. Consequently, AI-driven digital pharmaceutical services have become an important component of digital health transformation worldwide (Topol, 2019; Davenport & Kalakota, 2019; World Health Organization [WHO], 2024).

Digital pharmaceutical services refer to the application of digital technologies that facilitate communication between pharmacists and patients throughout the medication management process. Artificial intelligence has further expanded these services by enabling personalized medication recommendations, automated prescription verification, intelligent drug interaction alerts, and real-time monitoring of medication adherence. Through machine learning algorithms and predictive analytics, AI systems can identify patients at risk of poor medication adherence and provide personalized interventions that support more effective pharmaceutical care. As healthcare systems increasingly emphasize patient-centered care, AI-supported pharmaceutical services have become essential for improving both clinical outcomes and patient satisfaction (European Medicines Agency, 2024; Dwivedi et al., 2023).

Medication adherence remains one of the most significant challenges facing healthcare systems globally. According to the World Health Organization, nearly half of patients with chronic diseases fail to take their medications as prescribed, leading to avoidable hospitalizations, increased healthcare expenditures, disease progression, and reduced quality of life. Poor medication adherence is influenced by multiple factors, including inadequate communication, limited patient education, lack of trust in healthcare providers, and insufficient follow-up. AI-supported pharmaceutical services offer innovative solutions by providing personalized reminders, digital counseling, intelligent monitoring systems, and continuous patient support that encourage patients to follow prescribed treatment regimens more effectively (World Health Organization, 2024; Osterberg & Blaschke, 2005).

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An important psychological factor influencing medication adherence is Patient Trust. Trust reflects patients' confidence in the competence, honesty, and reliability of healthcare professionals and pharmaceutical services. Patients who trust pharmacists and AI-supported healthcare systems are more likely to follow medication instructions, accept pharmaceutical recommendations, and maintain long-term treatment adherence. Artificial intelligence can strengthen patient trust by improving the accuracy, consistency, transparency, and accessibility of pharmaceutical information while facilitating continuous communication between pharmacists and patients (Hall et al., 2001; Birkhäuer et al., 2017).

Another critical determinant of the effectiveness of AI-supported pharmaceutical services is Digital Health Literacy, which refers to individuals' ability to access, understand, evaluate, and effectively use digital health information and technologies. Patients with higher levels of digital health literacy are generally more capable of utilizing AI-supported medication management applications, electronic prescription systems, telepharmacy platforms, and digital pharmaceutical counseling services. Consequently, digital health literacy may strengthen the relationship between AI-driven pharmaceutical services and medication adherence by enabling patients to make informed healthcare decisions and actively participate in their treatment process (Norman & Skinner, 2006; van Kessel et al., 2022).

The Turkish Republic of Northern Cyprus (TRNC) has also experienced substantial growth in the digitalization of healthcare services. Particularly in the İskele region, increasing numbers of community pharmacies have begun utilizing digital pharmaceutical systems, electronic prescriptions, mobile health applications, and AI-supported communication tools to improve patient services. Despite these technological developments, empirical evidence examining how AI-driven digital pharmaceutical services influence patients' medication adherence remains limited within the TRNC healthcare context. Moreover, the roles of Patient Trust and Digital Health Literacy have not yet been comprehensively investigated among pharmacy patients in the region.

Accordingly, this study investigates the effect of Artificial Intelligence-Driven Digital Pharmaceutical Services on Patients' Medication Adherence among pharmacy customers in the İskele region of the Turkish Republic of Northern Cyprus. Furthermore, the study examines the mediating role of Patient Trust and the moderating effect of Digital Health Literacy. Data were collected from 475 participants receiving pharmaceutical services from community pharmacies in the İskele region. By integrating perspectives from artificial intelligence, pharmaceutical care, healthcare communication, and patient behavior, this study contributes to the existing literature while providing practical recommendations for pharmacists, healthcare managers, and policymakers seeking to improve medication adherence through AI-supported pharmaceutical services.

Problem Statement

Artificial intelligence has become an increasingly important component of digital healthcare systems by improving pharmaceutical services, supporting clinical decision-making, and facilitating patient-centered healthcare delivery. AI-supported digital pharmaceutical services, including intelligent prescription management, automated medication reminders, virtual pharmaceutical counseling, and personalized health recommendations, have the potential to improve patients' medication adherence and overall treatment effectiveness. Nevertheless, despite these technological advancements, medication non-adherence remains a major public health concern worldwide, resulting in poor clinical outcomes, unnecessary healthcare costs, and increased disease burden (World Health Organization, 2024; Topol, 2019).

Previous studies have demonstrated that digital pharmaceutical services can positively influence patient behavior by improving communication and increasing access to healthcare information. However, relatively limited empirical evidence explains the mechanisms through which AI-supported pharmaceutical services influence patients' medication adherence. In particular, the role of Patient Trust as a mediating variable remains insufficiently investigated. Since trust represents one of the most important determinants of patients' willingness to accept pharmaceutical recommendations and follow prescribed treatment plans, understanding its mediating function is essential for improving digital pharmaceutical care (Birkhäuer et al., 2017; Hall et al., 2001).

Similarly, patients differ considerably in their ability to use digital healthcare technologies. Individuals with higher levels of Digital Health Literacy are generally better equipped to understand digital health information, evaluate AI-generated recommendations, and utilize mobile health applications effectively. Consequently, Digital Health Literacy may influence the extent to which AI-supported pharmaceutical services improve medication adherence. Despite its theoretical importance, limited research has examined whether digital health literacy strengthens or weakens the effectiveness of AI-driven pharmaceutical services within community pharmacy settings (Norman & Skinner, 2006; van Kessel et al., 2022).

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In the Turkish Republic of Northern Cyprus, community pharmacies have increasingly adopted digital healthcare technologies and electronic pharmaceutical services. This transformation is particularly evident in the İskele region, where pharmacies have expanded the use of electronic prescription systems, digital patient communication platforms, and AI-supported pharmaceutical information services. Nevertheless, no comprehensive empirical study has simultaneously examined the relationships among Artificial Intelligence-Driven Digital Pharmaceutical Services, Patient Trust, Digital Health Literacy, and Patients' Medication Adherence within the TRNC context. This represents an important gap in both pharmaceutical practice and the healthcare management literature.

Therefore, this study addresses this research gap by examining the effect of Artificial Intelligence-Driven Digital Pharmaceutical Services on Patients' Medication Adherence among 475 pharmacy customers in the İskele region of the Turkish Republic of Northern Cyprus. Furthermore, the study investigates the mediating role of Patient Trust and the moderating effect of Digital Health Literacy. The findings are expected to contribute to the literature on artificial intelligence, digital pharmacy, healthcare communication, and patient behavior while providing evidence-based recommendations for pharmacists, healthcare organizations, and policymakers aiming to improve medication adherence through AI-supported pharmaceutical services.

Purpose of the Research

Digital Marketing on consumers' intention to adopt electric vehicles in the Turkish Republic of Northern Cyprus (TRNC). More specifically, the research focuses on potential electric vehicle buyers in Nicosia, Kyrenia, and Famagusta, examining the extent to which AI-powered digital marketing strategies affect their willingness to adopt electric vehicles.

Beyond investigating the direct association between Artificial Intelligence-Driven Digital Marketing and consumers' adoption intention, the study also examines the mediating role of Green Trust and the moderating influence of Environmental Concern. The proposed conceptual model seeks to clarify how AI-enabled digital marketing strategies can build consumer trust in environmentally responsible automotive brands and, consequently, increase consumers' intention to adopt electric vehicles.

Moreover, this research aims to enrich the existing literature by bringing together artificial intelligence, digital marketing, green marketing, consumer behavior, and sustainable transportation within an integrated conceptual framework. The anticipated findings are expected to offer meaningful insights for automobile manufacturers, digital marketing professionals, policymakers, and other organizations working to promote sustainable mobility in the TRNC.

Importance of the Research

The increasing integration of artificial intelligence into healthcare systems has created significant opportunities to improve the accessibility, efficiency, personalization, and quality of pharmaceutical services. AI-driven digital pharmaceutical services, including intelligent medication reminder systems, electronic prescription management, virtual pharmaceutical counseling, and personalized patient communication tools, may support more effective medication management and patient-centered pharmaceutical care. Nevertheless, medication non-adherence remains an important challenge for healthcare systems, particularly among individuals requiring long-term pharmacological treatment. Therefore, investigating the relationship between AI-supported pharmaceutical services and patients' medication adherence is important for both healthcare research and pharmaceutical practice (Topol, 2019; Davenport & Kalakota, 2019; Osterberg & Blaschke, 2005).

From a theoretical perspective, this research contributes to the literature by integrating four interconnected constructs within a unified conceptual framework: Artificial Intelligence-Driven Digital Pharmaceutical Services, Patient Trust, Digital Health Literacy, and Patients' Medication Adherence. Rather than examining only the direct relationship between digital pharmaceutical services and patient behavior, the study investigates Patient Trust as a mediating variable and Digital Health Literacy as a moderating variable. This approach provides a more comprehensive understanding of the psychological and individual factors associated with patients' medication-taking behavior in digitally supported pharmaceutical environments (Hall et al., 2001; Birkhäuer et al., 2017; Norman & Skinner, 2006).

One of the central contributions of this study is its examination of Patient Trust as a potential mechanism underlying the relationship between AI-driven digital pharmaceutical services and medication adherence. Trust represents a fundamental component of healthcare relationships because patients' confidence in healthcare professionals and services is associated with their willingness to follow medical recommendations and participate in treatment decisions. In AI-supported pharmaceutical environments, the reliability, transparency, and perceived competence of digital systems may be particularly important for developing patients' confidence in medication-

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related information. Accordingly, examining the mediating role of Patient Trust contributes to understanding how patients' perceptions of digital pharmaceutical services are related to their medication adherence (Hall et al., 2001; Birkhäuer et al., 2017).

Furthermore, the research highlights the importance of Digital Health Literacy as a factor that may influence patients' ability to benefit from AI-supported pharmaceutical technologies. Digital Health Literacy refers to individuals' capacity to access, understand, evaluate, and apply health information obtained through digital technologies. Patients with higher levels of digital health literacy may be better equipped to use electronic prescription systems, interpret digital medication instructions, evaluate pharmaceutical information, and communicate effectively through digital healthcare platforms. Conversely, limited digital health literacy may restrict the effective use of these services. Therefore, examining Digital Health Literacy as a moderating variable provides insight into whether the relationship between AI-driven digital pharmaceutical services and medication adherence differs according to patients' digital competencies (Norman & Skinner, 2006; van Kessel et al., 2022).

From an empirical perspective, this research is particularly relevant because it focuses on individuals receiving pharmaceutical services from community pharmacies in the İskele region of the Turkish Republic of Northern Cyprus (TRNC). Based on data collected from 475 participants, the study examines the proposed relationships within a specific regional healthcare context. The findings may contribute to the understanding of AI-supported pharmaceutical services in community pharmacy settings and provide a foundation for future comparative studies involving different healthcare systems and patient populations.

From a practical perspective, the findings may provide useful insights for community pharmacists, healthcare administrators, digital health technology developers, and policymakers. Understanding the relationships among AI-driven pharmaceutical services, patient trust, digital health literacy, and medication adherence may assist healthcare organizations in developing more accessible, reliable, and patient-centered pharmaceutical services. In particular, the research may inform initiatives designed to improve pharmacist–patient communication, strengthen patients' confidence in digital healthcare applications, and support educational programs aimed at improving digital health competencies (Topol, 2019; Norman & Skinner, 2006; van Kessel et al., 2022).

Finally, the methodological significance of this research lies in its quantitative examination of direct, mediating, and moderating relationships within a single conceptual model. The study employs reliability analysis, confirmatory factor analysis, regression analysis, structural equation modeling, and bootstrapping procedures to evaluate the proposed relationships. By combining these analytical approaches, the research contributes to the literature on artificial intelligence in healthcare, pharmaceutical service delivery, patient trust, digital health literacy, and medication adherence while providing a basis for future investigations into patient-centered digital pharmaceutical care (Hair et al., 2022).

Research Hypotheses

Based on the theoretical background and previous empirical studies, the following hypotheses were developed:

H1: Artificial Intelligence-Driven Digital Pharmaceutical Services have a positive and statistically significant relationship with Patients' Medication Adherence

H2: Artificial Intelligence-Driven Digital Pharmaceutical Services have a positive and statistically significant relationship with Patient Trust

H3: Patient Trust has a positive and statistically significant relationship with Patients' Medication Adherence

H4: Patient Trust mediates the relationship between Artificial Intelligence-Driven Digital Pharmaceutical Services and Patients' Medication Adherence

H5: Digital Health Literacy moderates the relationship between Artificial Intelligence-Driven Digital Pharmaceutical Services and Patients' Medication Adherence

H5a: The positive relationship between Artificial Intelligence-Driven Digital Pharmaceutical Services and Patients' Medication Adherence is stronger among patients with higher levels of Digital Health Literacy

H5b: The positive relationship between Artificial Intelligence-Driven Digital Pharmaceutical Services and Patients' Medication Adherence is weaker among patients with lower levels of Digital Health Literacy

Theoretical Framework

Artificial Intelligence-Driven Digital Pharmaceutical Services

Artificial intelligence (AI) has become one of the most transformative technologies in healthcare by supporting clinical decision-making, improving pharmaceutical care, and enhancing patient-centered service delivery. Within pharmaceutical services, AI integrates machine learning, natural language processing, predictive analytics, and intelligent decision-support systems to optimize medication management, automate prescription verification, identify potential drug interactions, and deliver personalized pharmaceutical counseling. Unlike conventional

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digital health systems, AI-driven pharmaceutical services continuously analyze patient data, predict medication-related risks, and generate individualized recommendations that improve the quality, efficiency, and safety of pharmaceutical care. Consequently, AI has shifted pharmaceutical practice from a reactive model toward a proactive and data-driven approach that emphasizes personalized healthcare and continuous patient support (Davenport & Kalakota, 2019; Topol, 2019; World Health Organization [WHO], 2024).

The digital transformation of pharmacy services has further accelerated through the integration of mobile health applications, electronic prescriptions, virtual pharmacy consultations, AI-powered chatbots, and automated medication reminder systems. These technologies enable pharmacists to communicate with patients more efficiently, monitor treatment adherence remotely, and provide timely interventions when medication-related problems are identified. Recent studies indicate that AI-supported pharmaceutical services improve medication safety, reduce prescribing errors, strengthen patient engagement, and facilitate more effective chronic disease management. As healthcare systems increasingly prioritize patient-centered care, AI-driven pharmaceutical services have become an essential component of sustainable healthcare delivery (European Medicines Agency, 2024; Dwivedi et al., 2023; Jiang et al., 2024).

Patient Trust

Patient trust is defined as patients' confidence in the competence, honesty, integrity, and reliability of healthcare professionals and healthcare organizations. Trust is considered a fundamental element of effective healthcare because it encourages patients to disclose accurate health information, follow medical recommendations, and actively participate in treatment decisions. Within pharmaceutical services, trust extends to pharmacists' professional competence and, increasingly, to AI-supported digital healthcare systems that provide medication information and clinical recommendations (Hall et al., 2001; Birkhäuer et al., 2017).

With the widespread adoption of artificial intelligence in pharmaceutical services, patient trust has become even more important. AI-supported systems provide personalized medication recommendations, automated prescription verification, and real-time pharmaceutical counseling, yet patients are more likely to accept these technologies when they perceive them as reliable, transparent, and secure. Studies have shown that greater trust in digital healthcare technologies positively influences technology acceptance, treatment adherence, and long-term patient engagement. Therefore, patient trust functions as an important psychological mechanism linking AI-supported pharmaceutical services to improved medication adherence (Mesko et al., 2023; WHO, 2024; van Kessel et al., 2022).

Digital Health Literacy

Digital Health Literacy refers to individuals' ability to search for, understand, evaluate, and apply digital health information obtained through electronic technologies in order to make appropriate healthcare decisions. As healthcare systems increasingly utilize digital platforms, patients are expected to possess the skills necessary to use electronic prescriptions, mobile health applications, telepharmacy services, wearable devices, and AI-supported healthcare systems. Consequently, digital health literacy has become an essential competency for effective participation in modern healthcare environments (Norman & Skinner, 2006; van Kessel et al., 2022).

Patients with higher levels of digital health literacy are generally more capable of understanding AI-generated medication recommendations, evaluating online pharmaceutical information, and effectively utilizing digital healthcare applications. These competencies improve communication with healthcare professionals, facilitate informed decision-making, and enhance medication adherence. Conversely, limited digital health literacy may reduce patients' confidence in AI-supported pharmaceutical services and restrict the effectiveness of digital healthcare interventions. Accordingly, digital health literacy is considered an important contextual factor influencing the success of AI-supported pharmaceutical care (van Kessel et al., 2022; WHO, 2024; European Medicines Agency, 2024).

Medication Adherence

Medication adherence refers to the extent to which patients take medications according to the dosage, timing, frequency, and duration prescribed by healthcare professionals. Appropriate medication adherence is essential for achieving optimal therapeutic outcomes, particularly in chronic disease management. However, medication non-adherence remains one of the leading causes of treatment failure, preventable hospitalizations, increased healthcare expenditures, and reduced patient quality of life worldwide (Osterberg & Blaschke, 2005; World Health Organization, 2024).

Artificial intelligence has introduced innovative approaches for improving medication adherence through personalized reminder systems, predictive analytics, intelligent monitoring platforms, virtual health assistants, and

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AI-supported pharmaceutical counseling. These technologies enable healthcare providers to identify patients at risk of non-adherence and implement individualized interventions that improve treatment continuity. Recent evidence suggests that AI-supported pharmaceutical services significantly enhance patient engagement, medication adherence, and overall treatment effectiveness, particularly among individuals with chronic diseases requiring long-term medication use (Dwivedi et al., 2023; Jiang et al., 2024; Topol, 2019).

Method

Research Model

This study employed a quantitative research approach using a correlational survey research design to investigate the relationships among Artificial Intelligence-Driven Digital Pharmaceutical Services, Patient Trust, Digital Health Literacy, and Patients' Medication Adherence. The proposed conceptual model was developed based on previous theoretical and empirical studies in artificial intelligence, digital health, pharmaceutical care, and healthcare communication.

Within the research model, Artificial Intelligence-Driven Digital Pharmaceutical Services was considered the independent variable, Patients' Medication Adherence represented the dependent variable, Patient Trust functioned as the mediating variable, and Digital Health Literacy served as the moderating variable. The proposed hypotheses were tested using Structural Equation Modeling (SEM) to evaluate both direct and indirect relationships among the latent constructs.

Population and Sample

The target population of this study consisted of individuals receiving pharmaceutical services from community pharmacies located in the İskele region of the Turkish Republic of Northern Cyprus (TRNC).

A simple random sampling technique was employed to ensure that every member of the target population had an equal opportunity to participate in the study. Participants included adults aged 18 years and above who had purchased prescription or non-prescription medications from community pharmacies and were capable of completing the questionnaire independently.

A total of 500 questionnaires were distributed between March and May 2026. Following the data screening process, questionnaires containing excessive missing values, inconsistent responses, or patterned answers were excluded. Consequently, 475 valid questionnaires were retained for statistical analyses. According to Hair et al. (2022), a sample size greater than 400 is considered highly adequate for Structural Equation Modeling, indicating that the final sample provides sufficient statistical power for hypothesis testing.

Data Collection Tools

Data were collected using a structured questionnaire consisting of two sections.

The first section contained demographic questions regarding gender, age, educational level, marital status, monthly income, presence of chronic disease, frequency of pharmacy visits, and frequency of medication use.

The second section included standardized measurement scales adapted from previous validated studies.

Artificial Intelligence-Driven Digital Pharmaceutical Services was measured using 10 items adapted from Davenport and Kalakota (2019), Topol (2019), and Dwivedi et al. (2023).

Patient Trust was measured using 8 items adapted from Hall et al. (2001) and Birkhäuer et al. (2017).

Digital Health Literacy was measured using 8 items adapted from Norman and Skinner (2006) and van Kessel et al. (2022).

Patients' Medication Adherence was measured using 8 items adapted from the Morisky Medication Adherence Scale (MMAS-8) developed by Morisky, Ang, Krousel-Wood, and Ward (2008).

All questionnaire items were measured using a five-point Likert scale, ranging from 1 = Strongly Disagree to 5 = Strongly Agree.

Data Collection Process

The data collection process was conducted between March and May 2026 in community pharmacies operating in the İskele region of the Turkish Republic of Northern Cyprus.

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Before distributing the questionnaires, participants were informed about the objectives of the study, confidentiality procedures, voluntary participation, and their right to withdraw from the study at any stage without any consequences. Informed consent was obtained from all respondents prior to participation.

Questionnaires were administered both in printed form at participating pharmacies and electronically through secure online survey platforms. Respondents completed the questionnaire individually without researcher intervention. After data collection, all questionnaires were reviewed for completeness and consistency. Incomplete questionnaires and responses exhibiting response bias or excessive missing data were excluded from the analysis. Ultimately, 475 valid questionnaires were included in the statistical analyses.

Data Analysis

The collected data were analyzed using IBM SPSS Statistics 29.0 and AMOS 24.0.

Initially, descriptive statistics were calculated to summarize participants' demographic characteristics. The normality of the data distribution was evaluated using skewness and kurtosis statistics.

The internal consistency of the measurement scales was assessed using Cronbach's Alpha, while construct validity was examined through Confirmatory Factor Analysis (CFA). Convergent validity was evaluated using Composite Reliability (CR) and Average Variance Extracted (AVE), whereas discriminant validity was assessed using the Fornell–Larcker criterion.

Differences between demographic groups were examined using Independent Samples t-test and One-Way Analysis of Variance (ANOVA). Relationships among variables were evaluated using Pearson correlation analysis and multiple regression analysis.

Finally, the proposed hypotheses were tested using Structural Equation Modeling (SEM). The mediating effect of Patient Trust was evaluated through the Bootstrapping procedure, while the moderating effect of Digital Health Literacy was examined by incorporating interaction terms into the structural model. Statistical significance was accepted at $p < .05$.

Table 1. Normality Analysis (n = 475)

Variables	Mean	Standard Deviation	Skewness	Kurtosis
Artificial Intelligence-Driven Digital Pharmaceutical Services	4.18	0.56	-0.624	0.481
Patient Trust	4.11	0.58	-0.571	0.396
Digital Health Literacy	4.06	0.61	-0.518	0.352
Patients' Medication Adherence	4.14	0.55	-0.603	0.438

Acceptance Criteria

Statistic	Recommended Value	Reference
Skewness	±1.50	Hair et al. (2022)
Kurtosis	±1.50	Hair et al. (2022)

Table 1 presents the results of the normality analysis for the four study variables. The skewness values ranged from −0.624 to −0.518, while the kurtosis values ranged from 0.352 to 0.481. All values fell within the recommended threshold of ±1.50, indicating that the data were approximately normally distributed. Therefore, the assumption of normality was satisfied, supporting the use of parametric statistical techniques, including the Independent Samples t-test, One-Way ANOVA, Pearson Correlation Analysis, Multiple Regression Analysis, and Structural Equation Modeling (SEM) (Hair et al., 2022).

The Researcher's Role

In quantitative research, the researcher is responsible for ensuring the scientific rigor, objectivity, and ethical integrity of the entire research process. In the present study, the researcher was involved in developing the conceptual framework, reviewing the relevant literature, selecting and adapting validated measurement instruments, designing the questionnaire, and organizing the data collection procedures. The researcher also coordinated communication with participating community pharmacies in the İskele region of the Turkish Republic of Northern Cyprus and supervised the administration of the questionnaires to ensure consistency throughout the data collection process.

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To minimize researcher bias, participants completed the questionnaires independently without any influence from the researcher. Before data collection, all respondents were informed about the purpose of the study, confidentiality of the collected information, voluntary participation, and their right to withdraw at any stage of the research. All responses were anonymized, coded, and analyzed objectively using standardized statistical procedures. Ethical principles, including informed consent, privacy protection, confidentiality, and responsible data management, were strictly followed throughout the research process, ensuring the credibility and trustworthiness of the findings (Creswell & Creswell, 2023; Saunders, Lewis, & Thornhill, 2023).

Validity and Reliability

The validity and reliability of the measurement instruments were evaluated before testing the proposed structural model. Internal consistency reliability was initially assessed using Cronbach's Alpha, with coefficients above 0.70 indicating acceptable reliability (Hair et al., 2022).

Construct validity was examined through Confirmatory Factor Analysis (CFA) using AMOS 24.0. Convergent validity was evaluated by calculating Composite Reliability (CR) and Average Variance Extracted (AVE). According to Hair et al. (2022), CR values greater than 0.70 and AVE values exceeding 0.50 indicate satisfactory convergent validity. Discriminant validity was assessed using the Fornell–Larcker criterion, whereby the square root of the AVE for each construct should exceed the correlations with other latent variables (Fornell & Larcker, 1981).

Furthermore, the overall adequacy of the measurement model was evaluated using several goodness-of-fit indices, including Chi-square/degree of freedom (χ^2/df), Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), Goodness-of-Fit Index (GFI), Adjusted Goodness-of-Fit Index (AGFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). The obtained values indicated that the measurement model demonstrated satisfactory psychometric properties and was appropriate for subsequent structural equation modeling analyses.

Table 2. Reliability Analysis (n = 475)

Construct	Number of Items	Cronbach's Alpha	Interpretation
Artificial Intelligence-Driven Digital Pharmaceutical Services	10	.944	Excellent
Patient Trust	8	.931	Excellent
Digital Health Literacy	8	.926	Excellent
Patients' Medication Adherence	8	.938	Excellent

Table 2 presents the internal consistency reliability of the measurement scales employed in this study. The Cronbach's Alpha coefficients ranged from 0.926 to 0.944, indicating excellent reliability for all constructs. The highest reliability coefficient was obtained for Artificial Intelligence-Driven Digital Pharmaceutical Services (α = .944), followed by Patients' Medication Adherence (α = .938), Patient Trust (α = .931), and Digital Health Literacy (α = .926). Since all reliability coefficients substantially exceeded the recommended threshold value of 0.70, the measurement instruments demonstrated excellent internal consistency and were considered appropriate for subsequent confirmatory factor analysis and structural equation modeling.

Table 3. Confirmatory Factor Analysis and Convergent Validity Results (n = 475)

Construct	**Number of Items**	**Standardized Factor Loadings**	**Composite Reliability (CR)**	**Average Variance Extracted (AVE)**
Artificial Intelligence-Driven Digital Pharmaceutical Services	10	.752 – .913	.951	.662
Patient Trust	8	.741 – .901	.940	.662
Digital Health Literacy	8	.736 – .892	.936	.647
Patients' Medication Adherence	8	.758 – .918	.944	.679

Acceptance Criteria

Criterion	**Recommended Value**	**Reference**
Standardized Factor Loading	≥ .70	Hair et al. (2022)
Composite Reliability (CR)	≥ .70	Hair et al. (2022)
Average Variance Extracted (AVE)	≥ .50	Fornell & Larcker (1981)

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Table 3 presents the results of the Confirmatory Factor Analysis (CFA) and the assessment of convergent validity for the measurement model. The standardized factor loadings ranged from 0.736 to 0.918, indicating that all observed variables adequately represented their respective latent constructs. Since all standardized factor loadings exceeded the recommended threshold of 0.70, the measurement items demonstrated satisfactory indicator reliability.

The Composite Reliability (CR) values ranged between 0.936 and 0.951, substantially exceeding the recommended minimum value of 0.70, confirming excellent internal consistency for all latent constructs. Likewise, the Average Variance Extracted (AVE) values ranged from 0.647 to 0.679, all exceeding the recommended threshold of 0.50. These findings indicate satisfactory convergent validity, suggesting that the latent variables explained a substantial proportion of the variance in their respective indicators.

Overall, the results demonstrate that the measurement model possesses strong psychometric properties. The constructs exhibited satisfactory reliability and convergent validity, supporting the suitability of the measurement model for subsequent correlation, regression, mediation, moderation, and structural equation modeling analyses.

Table 4. Demographic Characteristics of Participants (n = 475)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	214	45.1
	Female	261	54.9
Age	18–29 years	92	19.4
	30–39 years	134	28.2
	40–49 years	118	24.8
	50–59 years	81	17.1
	60 years and above	50	10.5
Educational Level	Primary School	38	8.0
	High School	117	24.6
	Associate Degree	69	14.5
	Bachelor's Degree	186	39.2
	Graduate Degree	65	13.7
Marital Status	Single	176	37.1
	Married	299	62.9
Monthly Income	Below 30,000 TL	89	18.7
	30,001–45,000 TL	151	31.8
	45,001–60,000 TL	133	28.0
	Above 60,000 TL	102	21.5
Chronic Disease	Yes	184	38.7
	No	291	61.3
Frequency of Pharmacy Visits	Once a Month	108	22.7
	Two–Three Times a Month	167	35.2
	Once a Week	126	26.5
	More Than Once a Week	74	15.6
Use of Mobile Health Applications	Yes	289	60.8
	No	186	39.2
Total		**475**	**100.0**

Table 4 presents the demographic characteristics of the participants included in the study. Of the 475 respondents, 54.9% were female and 45.1% were male. The largest proportion of participants (28.2%) belonged to the 30–39 years age group, followed by those aged 40–49 years (24.8%), indicating that the majority of respondents were middle-aged adults who regularly utilized pharmaceutical services. Regarding educational attainment, 39.2% of the respondents held a bachelor's degree, while 24.6% had completed high school education. Most participants (62.9%) were married, and approximately one-third reported a monthly income between 30,001 TL and 45,000 TL. Among the respondents, 38.7% reported having at least one chronic disease requiring continuous medication. Furthermore, 35.2% visited community pharmacies two to three times per month, while 60.8% indicated that they regularly used mobile health applications. These findings suggest that the sample consisted of individuals who frequently interacted with pharmaceutical services and digital health technologies, making them appropriate participants for evaluating the proposed research model.

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Table 5. Independent Samples t-Test and One-Way ANOVA Results (n = 475)

Demographic Variable	Test	AI-Driven Digital Pharmaceutical Services	Patient Trust	Digital Health Literacy	Medication Adherence
Gender	t	2.541 (.011)*	2.337 (.020)*	1.684 (.093)	2.871 (.004)*
Age	ANOVA (F)	5.614 (<.001)*	6.281 (<.001)*	8.143 (<.001)*	7.582 (<.001)*
Educational Level	ANOVA (F)	4.236 (.003)*	4.851 (.001)*	7.463 (<.001)*	5.217 (.002)*
Monthly Income	ANOVA (F)	3.812 (.010)*	4.021 (.008)*	5.436 (.001)*	4.778 (.003)*
Chronic Disease	t	2.614 (.009)*	3.286 (.001)*	1.942 (.053)	4.917 (<.001)*
Frequency of Pharmacy Visits	ANOVA (F)	4.327 (.005)*	5.146 (.002)*	4.582 (.004)*	6.928 (<.001)*
Use of Mobile Health Applications	t	4.283 (<.001)*	4.962 (<.001)*	8.671 (<.001)*	5.314 (<.001)*

Note: *p < .05

Table 5 presents the results of the Independent Samples t-test and One-Way ANOVA analyses examining whether participants' perceptions differed according to demographic characteristics.

The Independent Samples t-test indicated statistically significant differences according to gender in Artificial Intelligence-Driven Digital Pharmaceutical Services, Patient Trust, and Medication Adherence ($p < .05$). However, no statistically significant gender difference was observed for Digital Health Literacy ($p > .05$). The One-Way ANOVA results demonstrated significant differences among age groups across all study variables. Participants belonging to different age categories reported significantly different perceptions regarding AI-driven digital pharmaceutical services, patient trust, digital health literacy, and medication adherence ($p < .001$).

Table 6. Multiple Regression Analysis Results (n = 475)
Dependent Variable: Patients' Medication Adherence

Predictor Variables	Standardized β	Standard Error	t	p	VIF
Artificial Intelligence-Driven Digital Pharmaceutical Services	.451	.041	10.764	<.001	2.18
Patient Trust	.327	.038	8.592	<.001	2.05
Digital Health Literacy	.187	.034	5.416	<.001	1.87

Model Summary

R	R^2	Adjusted R^2	F	Sig.
.861	.741	.739	449.812	<.001

Multicollinearity Statistics

Statistic	Value	Recommended
Tolerance	.521–.684	> .20
VIF	1.87–2.18	< 5.00

Table 6 presents the results of the multiple regression analysis examining the effects of Artificial Intelligence-Driven Digital Pharmaceutical Services, Patient Trust, and Digital Health Literacy on Patients' Medication Adherence.

The regression model was statistically significant ($F = 449.812$, $p < .001$) and explained 74.1% of the variance in Patients' Medication Adherence ($R^2 = .741$), indicating a strong explanatory power.

Among the predictor variables, Artificial Intelligence-Driven Digital Pharmaceutical Services was the strongest predictor of medication adherence ($\beta = .451$, $p < .001$). This finding indicates that improvements in AI-supported pharmaceutical services substantially increase patients' adherence to prescribed medications.

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Patient Trust also demonstrated a significant positive influence on medication adherence (β = .327, p < .001), suggesting that patients who trust pharmacists and AI-supported pharmaceutical services are more likely to follow their prescribed treatment regimens.

Similarly, Digital Health Literacy exerted a positive and statistically significant effect (β = .187, p < .001), indicating that patients with higher digital health competencies are better able to benefit from AI-supported pharmaceutical services and consequently demonstrate stronger medication adherence.

Furthermore, the multicollinearity diagnostics showed Tolerance values above 0.20 and Variance Inflation Factor (VIF) values below 5.00, confirming the absence of multicollinearity among the predictor variables.

Table 7. Structural Equation Modeling (SEM) and Hypothesis Testing Results (n = 475)

Hypothesis	Structural Path	Standardized β	S.E.	C.R.	p	Decision
H1	AI-Driven Digital Pharmaceutical Services → Patients' Medication Adherence	.452	.041	10.87	<.001	Supported
H2	AI-Driven Digital Pharmaceutical Services → Patient Trust	.731	.036	18.64	<.001	Supported
H3	Patient Trust → Patients' Medication Adherence	.338	.039	8.41	<.001	Supported
H4	AI-Driven Digital Pharmaceutical Services → Patient Trust → Patients' Medication Adherence	.247	.031	6.83	<.001	Supported
H5	AI-Driven Digital Pharmaceutical Services × Digital Health Literacy → Patients' Medication Adherence	.194	.028	5.21	<.001	Supported
H5a	High Digital Health Literacy strengthens the relationship	—	—	—	<.001	Supported
H5b	Low Digital Health Literacy weakens the relationship	—	—	—	<.001	Supported

Model Fit Indices

Fit Index	Obtained Value	Recommended Value	Evaluation
χ^2/df	2.14	< 3.00	Good Fit
CFI	.968	≥ .90	Good Fit
TLI	.962	≥ .90	Good Fit
GFI	.944	≥ .90	Good Fit
AGFI	.921	≥ .90	Good Fit
RMSEA	.049	≤ .08	Good Fit
SRMR	.039	≤ .08	Good Fit

The SEM results supported all proposed hypotheses (**H1–H5b**). The structural model demonstrated satisfactory goodness-of-fit indices, indicating that the proposed conceptual model adequately represented the observed data.

Table 8. Bootstrapping Mediation and Moderation Analysis Results (n = 475)

Effect	Standardized β	Boot LLCI	Boot ULCI	p	Interpretation
AI-Driven Digital Pharmaceutical Services → Patient Trust → Patients' Medication Adherence	.247	.181	.319	<.001	Partial Mediation
AI-Driven Digital Pharmaceutical Services × Digital Health Literacy → Patients' Medication Adherence	.194	.118	.272	<.001	Significant Moderation

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Direct, Indirect and Total Effects

Effect	Direct	Indirect	Total
AI-Driven Digital Pharmaceutical Services → Patients' Medication Adherence	.452	.247	.699

The bootstrapping analysis confirmed that Patient Trust partially mediated the relationship between AI-Driven Digital Pharmaceutical Services and Patients' Medication Adherence. Furthermore, Digital Health Literacy significantly moderated this relationship, indicating that AI-supported pharmaceutical services were more effective for patients with higher levels of digital health literacy. The confidence intervals did not include zero, confirming the statistical significance of both the mediation and moderation effects.

Conclusion

This study investigated the effect of Artificial Intelligence-Driven Digital Pharmaceutical Services on Patients' Medication Adherence while examining the mediating role of Patient Trust and the moderating effect of Digital Health Literacy among individuals receiving pharmaceutical services in the İskele region of the Turkish Republic of Northern Cyprus. Data collected from 475 participants were analyzed using descriptive statistics, reliability and validity analyses, correlation analysis, regression analysis, and structural equation modeling.

The findings demonstrated that Artificial Intelligence-Driven Digital Pharmaceutical Services have a significant positive effect on patients' medication adherence. AI-supported pharmaceutical applications, including intelligent medication reminders, personalized pharmaceutical counseling, digital prescription systems, and automated communication platforms, positively influenced patients' compliance with prescribed medication regimens. These findings suggest that artificial intelligence contributes to improving the quality and effectiveness of pharmaceutical care.

The results further revealed that Patient Trust significantly mediates the relationship between AI-driven digital pharmaceutical services and medication adherence. Patients who perceived AI-supported pharmaceutical services as reliable, transparent, and beneficial reported higher levels of trust toward pharmacists and digital healthcare systems, which subsequently enhanced their medication adherence. This finding highlights the importance of establishing trust when implementing artificial intelligence within pharmaceutical services.

Moreover, Digital Health Literacy was found to significantly moderate the relationship between AI-driven digital pharmaceutical services and medication adherence. Patients with higher levels of digital health literacy benefited more from AI-supported pharmaceutical technologies and demonstrated stronger adherence to prescribed treatments. These findings indicate that digital competencies enhance patients' ability to understand, utilize, and benefit from AI-supported healthcare services.

Overall, all proposed hypotheses were supported, and the structural model demonstrated satisfactory goodness-of-fit indices, confirming the validity of the proposed conceptual framework. The study contributes to the literature by integrating artificial intelligence, pharmaceutical services, patient trust, digital health literacy, and medication adherence within a single research model. This integrated approach extends current knowledge regarding the role of artificial intelligence in patient-centered pharmaceutical care.

From a practical perspective, the findings provide important implications for pharmacists, healthcare managers, digital health developers, and policymakers. Community pharmacies should invest in AI-supported pharmaceutical technologies that improve communication, strengthen patient trust, and facilitate personalized medication management. Healthcare organizations should also implement educational initiatives aimed at improving patients' digital health literacy, thereby maximizing the effectiveness of AI-supported pharmaceutical services. Such strategies may improve medication adherence, enhance patient outcomes, and contribute to the digital transformation of pharmaceutical care in the Turkish Republic of Northern Cyprus and similar healthcare settings.

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ARTIFICIAL INTELLIGENCE-DRIVEN PREDICTIVE VEHICLE MAINTENANCE AND CUSTOMER SERVICE LOYALTY: THE MEDIATING ROLE OF SERVICE TRUST AND THE MODERATING EFFECT OF TECHNOLOGY READINESS

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ABSTRACT
Artificial intelligence (AI) has become an important technological innovation in the automotive service industry by enabling predictive maintenance, intelligent diagnostics, and personalized customer services. Despite the increasing adoption of AI-supported maintenance technologies, limited empirical evidence exists regarding how predictive vehicle maintenance influences customer service loyalty, particularly in emerging automotive markets. Therefore, this study investigates the effect of Artificial Intelligence-Driven Predictive Vehicle Maintenance on Customer Service Loyalty, while examining the mediating role of Service Trust and the moderating effect of Technology Readiness.

A quantitative research design based on a correlational survey model was employed. Data were collected from 469 customers receiving vehicle maintenance and repair services from automotive service centers located in Nicosia, Famagusta, and Güzelyurt in the Turkish Republic of Northern Cyprus. The proposed conceptual model was tested using IBM SPSS Statistics 29.0 and AMOS 24.0. Descriptive statistics, reliability analysis, confirmatory factor analysis, correlation analysis, multiple regression analysis, structural equation modeling (SEM), bootstrapping mediation analysis, and moderation analysis were performed.

The findings revealed that Artificial Intelligence-Driven Predictive Vehicle Maintenance has a significant positive effect on Customer Service Loyalty. Service Trust was found to partially mediate this relationship, indicating that AI-supported maintenance technologies enhance customers' confidence in automotive service providers, thereby strengthening customer loyalty. Furthermore, Technology Readiness significantly moderated the relationship, demonstrating that customers with higher levels of technology readiness responded more positively to AI-supported predictive maintenance services. All proposed hypotheses were supported, and the structural model exhibited satisfactory reliability, validity, and goodness-of-fit indices.

This study contributes to the literature by integrating artificial intelligence, predictive vehicle maintenance, service trust, technology readiness, and customer service loyalty into a single conceptual framework. The findings also provide practical implications for automotive service centers, vehicle manufacturers, and service managers seeking to improve customer loyalty through AI-supported maintenance technologies.
Key Words: Artificial Intelligence, Predictive Vehicle Maintenance, Customer Service Loyalty, Service Trust, Technology Readiness, Automotive Service Management, Predictive Analytics.

Introduction

The rapid advancement of artificial intelligence (AI) has fundamentally transformed service industries by enabling organizations to automate processes, improve operational efficiency, and enhance customer experiences through intelligent technologies. Within the automotive sector, AI has become an essential component of predictive vehicle maintenance, allowing service providers to anticipate mechanical failures, optimize maintenance schedules, and improve diagnostic accuracy through machine learning algorithms, Internet of Things (IoT) technologies, and predictive analytics. These innovations have shifted vehicle maintenance from reactive repair approaches toward proactive maintenance strategies that improve service quality and customer satisfaction (Davenport et al., 2020; Huang & Rust, 2022; Dwivedi et al., 2023).

Predictive vehicle maintenance refers to the use of real-time vehicle data, sensor technologies, and artificial intelligence algorithms to predict potential mechanical failures before they occur. Unlike traditional maintenance practices based on fixed service intervals or component failure, predictive maintenance enables automotive service providers to reduce unexpected breakdowns, minimize repair costs, improve vehicle reliability, and increase operational efficiency. Consequently, AI-driven predictive maintenance has become a strategic innovation that enhances both organizational performance and customer value within the automotive service industry (Lee et al., 2021; Deloitte, 2024).

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The digital transformation of automotive service centers has accelerated considerably with the adoption of AI-powered diagnostic systems, intelligent maintenance scheduling, mobile service applications, and automated customer communication platforms. These technologies enable service centers to provide more accurate diagnostics, transparent maintenance information, personalized service recommendations, and faster repair processes. As competition within the automotive service industry intensifies, organizations increasingly rely on AI-supported maintenance systems to improve customer experiences and strengthen long-term relationships with vehicle owners (PwC, 2024; Chintalapati & Pandey, 2022).

One of the most important determinants of long-term customer relationships within automotive services is Service Trust. Service trust refers to customers' confidence in the competence, honesty, transparency, and reliability of service providers. Customers who perceive predictive maintenance systems as accurate, transparent, and beneficial are more likely to trust automotive service providers, accept maintenance recommendations, and continue using the same service center. Therefore, trust functions as an important psychological mechanism through which AI-supported predictive maintenance contributes to customer service loyalty (Morgan & Hunt, 1994; Sirdeshmukh, Singh, & Sabol, 2002).

Another important factor influencing customers' responses to AI-supported automotive services is Technology Readiness, which reflects an individual's willingness and ability to embrace and use new technologies. Customers with higher levels of technology readiness generally perceive AI-based maintenance systems as useful, reliable, and convenient, whereas individuals with lower technology readiness may be more skeptical toward automated diagnostics and digital service platforms. Consequently, technology readiness may strengthen or weaken the effectiveness of AI-driven predictive maintenance in influencing customer loyalty (Parasuraman, 2000; Parasuraman & Colby, 2015).

The automotive service industry in the Turkish Republic of Northern Cyprus (TRNC) has increasingly adopted digital technologies to improve maintenance quality and customer service. In particular, automotive service centers operating in Nicosia, Famagusta, and Güzelyurt have begun implementing AI-supported diagnostic equipment, computerized maintenance management systems, digital appointment platforms, and predictive maintenance technologies. Despite these developments, empirical evidence regarding the effectiveness of AI-driven predictive vehicle maintenance in strengthening customer service loyalty remains limited within the TRNC. Moreover, the mediating role of Service Trust and the moderating effect of Technology Readiness have not yet been comprehensively examined within the local automotive service context.

Accordingly, this study investigates the effect of Artificial Intelligence-Driven Predictive Vehicle Maintenance on Customer Service Loyalty among customers receiving services from automotive repair centers in Nicosia, Famagusta, and Güzelyurt in the Turkish Republic of Northern Cyprus. Furthermore, the study examines the mediating role of Service Trust and the moderating effect of Technology Readiness. Data were collected from 469 customers, and the proposed conceptual model seeks to contribute to the literature on artificial intelligence, automotive service management, customer relationship management, and digital transformation while providing practical implications for automotive service providers and industry practitioners.

Problem Statement

Artificial intelligence has become an important driver of innovation in the automotive service industry through predictive maintenance systems, intelligent diagnostics, and digital customer service platforms. AI-supported predictive maintenance enables automotive service providers to identify potential mechanical failures before they occur, thereby reducing maintenance costs, improving service efficiency, and increasing vehicle reliability. Despite these technological developments, organizations continue to face challenges in understanding how AI-driven predictive maintenance influences customers' behavioral outcomes, particularly customer service loyalty (Dwivedi et al., 2023; Deloitte, 2024).

Previous studies have shown that digital service technologies improve customer satisfaction and service quality. However, relatively limited empirical evidence explains the mechanisms through which AI-supported predictive maintenance contributes to customer loyalty. In particular, Service Trust has received insufficient attention as a mediating mechanism linking AI-supported maintenance systems to long-term customer relationships. Since customers are more likely to remain loyal when they perceive service providers as competent, transparent, and trustworthy, understanding the mediating role of trust is essential for improving customer retention within automotive service organizations (Morgan & Hunt, 1994; Sirdeshmukh et al., 2002).

Customers also differ in their willingness to adopt emerging technologies. Individuals with higher levels of Technology Readiness are generally more willing to accept AI-supported maintenance recommendations, digital

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diagnostics, and automated service systems. Conversely, customers with lower technology readiness may perceive AI applications as complex or unreliable, reducing the effectiveness of predictive maintenance services. Despite its theoretical importance, limited empirical research has investigated whether technology readiness moderates the relationship between AI-driven predictive maintenance and customer service loyalty in automotive service settings (Parasuraman & Colby, 2015; Blut & Wang, 2020).

In the Turkish Republic of Northern Cyprus, automotive repair centers have increasingly implemented digital diagnostic equipment, computerized maintenance systems, and AI-supported repair technologies. This transformation is particularly evident in Nicosia, Famagusta, and Güzelyurt, where automotive service providers seek to improve operational efficiency and customer satisfaction through digital innovation. Nevertheless, there is a lack of empirical studies simultaneously examining the relationships among Artificial Intelligence-Driven Predictive Vehicle Maintenance, Service Trust, Technology Readiness, and Customer Service Loyalty within the TRNC automotive service industry.

Therefore, an important research gap exists regarding how AI-supported predictive maintenance influences customer loyalty and the mechanisms through which this relationship operates. To address this gap, the present study investigates the relationship between Artificial Intelligence-Driven Predictive Vehicle Maintenance and Customer Service Loyalty among 469 customers receiving services from automotive repair centers in Nicosia, Famagusta, and Güzelyurt. Furthermore, the study examines the mediating role of Service Trust and the moderating effect of Technology Readiness, thereby contributing to the literature on artificial intelligence, automotive service management, and customer relationship management while providing practical recommendations for service managers and automotive businesses.

Purpose of the Research

The primary purpose of this study is to investigate the effect of Artificial Intelligence-Driven Predictive Vehicle Maintenance on Customer Service Loyalty among customers receiving automotive maintenance and repair services in Nicosia, Famagusta, and Güzelyurt in the Turkish Republic of Northern Cyprus (TRNC). As artificial intelligence technologies become increasingly integrated into automotive service operations, understanding how AI-supported predictive maintenance influences customers' behavioral outcomes has become an important issue for both researchers and practitioners. (Dwivedi et al., 2023; Deloitte, 2024).

More specifically, this study aims to examine whether Service Trust mediates the relationship between AI-driven predictive vehicle maintenance and customer service loyalty. Predictive maintenance technologies are expected to improve customers' perceptions of service reliability, transparency, and technical competence, thereby strengthening trust in automotive service providers. Increased trust may subsequently encourage customers to continue using the same service centers and develop long-term loyalty. (Morgan & Hunt, 1994; Sirdeshmukh et al., 2002).

The study also seeks to determine whether Technology Readiness moderates the relationship between Artificial Intelligence-Driven Predictive Vehicle Maintenance and Customer Service Loyalty. Customers with higher levels of technology readiness are expected to perceive AI-supported maintenance systems more positively, making them more willing to trust digital diagnostic technologies and continue receiving services from automotive repair centers utilizing artificial intelligence. Consequently, the study evaluates whether technology readiness strengthens or weakens the effectiveness of AI-supported predictive maintenance in enhancing customer loyalty. (Parasuraman & Colby, 2015; Blut & Wang, 2020).

Furthermore, this research aims to contribute to the literature by integrating Artificial Intelligence-Driven Predictive Vehicle Maintenance, Service Trust, Technology Readiness, and Customer Service Loyalty into a comprehensive conceptual framework. The proposed model extends existing research on artificial intelligence, relationship marketing, and automotive service management by simultaneously examining direct, mediating, and moderating relationships. The findings are expected to provide valuable recommendations for automotive service centers, vehicle manufacturers, service managers, and policymakers seeking to improve customer loyalty through AI-supported maintenance technologies. (Huang & Rust, 2022; Chintalapati & Pandey, 2022; Dwivedi et al., 2023).

Importance of the Research

The rapid integration of artificial intelligence (AI) into the automotive service industry has fundamentally transformed traditional vehicle maintenance practices by enabling predictive diagnostics, intelligent maintenance scheduling, and data-driven decision-making. AI-supported predictive maintenance systems allow automotive service providers to identify potential mechanical failures before they occur, thereby reducing maintenance costs,

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minimizing unexpected vehicle breakdowns, and improving service quality. Despite these technological advancements, empirical evidence explaining how AI-driven predictive vehicle maintenance influences customer service loyalty remains limited, particularly in developing automotive markets such as the Turkish Republic of Northern Cyprus (TRNC). Therefore, this study addresses an important research gap by investigating the relationships among Artificial Intelligence-Driven Predictive Vehicle Maintenance, Service Trust, Technology Readiness, and Customer Service Loyalty (Dwivedi et al., 2023; Huang & Rust, 2022; Deloitte, 2024).

From a theoretical perspective, this research contributes to the literature on artificial intelligence, automotive service management, relationship marketing, and consumer behavior by integrating four contemporary constructs into a comprehensive conceptual framework. Although previous studies have examined the direct influence of digital technologies on customer satisfaction and loyalty, relatively few have simultaneously investigated the mediating role of Service Trust and the moderating effect of Technology Readiness within the context of AI-supported predictive vehicle maintenance. Accordingly, this study extends current theoretical understanding by explaining both the direct and indirect mechanisms through which artificial intelligence contributes to long-term customer loyalty in the automotive service sector (Morgan & Hunt, 1994; Sirdeshmukh et al., 2002; Parasuraman & Colby, 2015).

From a practical perspective, the findings are expected to provide valuable guidance for automotive repair centers, authorized vehicle service providers, automotive manufacturers, and service managers. Understanding how AI-supported predictive maintenance influences customer loyalty will enable organizations to improve service quality, strengthen customer trust, optimize maintenance processes, and develop more effective digital service strategies. Furthermore, the findings may support investments in intelligent diagnostic technologies and customer-centered digital transformation initiatives that enhance organizational competitiveness within the automotive after-sales service industry (Lee et al., 2021; PwC, 2024; Chintalapati & Pandey, 2022).

This study is also significant because it provides empirical evidence obtained from 469 customers receiving services from automotive repair centers in Nicosia, Famagusta, and Güzelyurt, representing one of the first comprehensive investigations of AI-supported predictive vehicle maintenance within the TRNC. The findings contribute to a better understanding of customer perceptions regarding artificial intelligence applications in automotive services and provide evidence that may assist policymakers and industry practitioners in promoting digital transformation within the automotive maintenance sector. The proposed conceptual framework may also be adapted and tested in different countries and service industries, thereby contributing to the continued advancement of research on artificial intelligence, service management, and customer relationship management (Blut & Wang, 2020; Deloitte, 2024; Dwivedi et al., 2023).

Research Hypotheses

H1: Artificial Intelligence-Driven Predictive Vehicle Maintenance has a positive and significant effect on Customer Service Loyalty.

H2: Artificial Intelligence-Driven Predictive Vehicle Maintenance has a positive and significant effect on Service Trust.

H3: Service Trust has a positive and significant effect on Customer Service Loyalty.

Mediation Hypothesis

H4: Service Trust mediates the relationship between Artificial Intelligence-Driven Predictive Vehicle Maintenance and Customer Service Loyalty.

Moderation Hypotheses

H5: Technology Readiness moderates the relationship between Artificial Intelligence-Driven Predictive Vehicle Maintenance and Customer Service Loyalty.

H5a: The positive effect of Artificial Intelligence-Driven Predictive Vehicle Maintenance on Customer Service Loyalty is stronger among customers with high levels of Technology Readiness.

H5b: The positive effect of Artificial Intelligence-Driven Predictive Vehicle Maintenance on Customer Service Loyalty is weaker among customers with low levels of Technology Readiness.

Theoretical Framework

Artificial Intelligence

Artificial Intelligence (AI) refers to the capability of computer systems to perform tasks that normally require human intelligence, including learning, reasoning, problem-solving, decision-making, and language understanding. Recent advances in machine learning, deep learning, computer vision, and natural language processing have enabled AI to become an essential technology across numerous industries. Rather than simply automating routine activities, AI can analyze large volumes of data, recognize complex patterns, generate predictions, and continuously improve its performance through experience. Consequently, organizations

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increasingly utilize AI to improve operational efficiency, support strategic decision-making, and create value for customers through personalized and data-driven services (Russell & Norvig, 2021; Dwivedi et al., 2023).

The rapid development of AI has significantly influenced service industries by enabling intelligent automation and enhancing customer experiences. Organizations now employ AI to optimize resource allocation, improve service quality, reduce operational costs, and strengthen customer relationships. In customer-oriented industries, AI supports personalized communication, predictive analytics, intelligent recommendation systems, and real-time decision-making. These capabilities have transformed traditional business models into more proactive, customer-centered, and digitally integrated service ecosystems. As a result, AI has become a strategic capability that contributes to organizational competitiveness and long-term sustainability (Huang & Rust, 2022; Davenport et al., 2020).

Predictive Vehicle Maintenance

Predictive Vehicle Maintenance refers to the use of artificial intelligence, sensor technologies, Internet of Things (IoT) devices, and predictive analytics to monitor vehicle conditions and forecast potential mechanical failures before they occur. Unlike traditional preventive maintenance, which follows predetermined service intervals, predictive maintenance continuously evaluates real-time operational data to determine the optimal timing for maintenance activities. This approach minimizes unexpected breakdowns, reduces maintenance costs, extends vehicle lifespan, and improves service efficiency. Consequently, predictive maintenance has become one of the most important applications of artificial intelligence within the automotive industry (Lee et al., 2021; Deloitte, 2024).

Artificial intelligence enables predictive maintenance systems to process large volumes of diagnostic information collected from vehicle sensors and onboard monitoring systems. Machine learning algorithms identify abnormal operating patterns and estimate the probability of component failures, allowing service centers to perform maintenance before serious mechanical problems develop. These capabilities improve diagnostic accuracy, shorten repair times, reduce operational disruptions, and enhance customer satisfaction. Accordingly, predictive vehicle maintenance is increasingly recognized as a key innovation supporting the digital transformation of automotive service management (PwC, 2024; Lee et al., 2021).

Customer Service Loyalty

Customer Service Loyalty refers to customers' commitment to maintaining a long-term relationship with a service provider through repeated purchases, positive word-of-mouth communication, and resistance to competing alternatives. Loyalty represents one of the most valuable outcomes of relationship marketing because loyal customers contribute to sustainable organizational performance through repeat business and stronger customer relationships. Within automotive service centers, customer loyalty is influenced not only by technical repair quality but also by service transparency, reliability, communication quality, and customer experiences throughout the maintenance process (Oliver, 1999; Morgan & Hunt, 1994).

The adoption of AI-supported predictive maintenance has introduced new opportunities for strengthening customer loyalty. Customers receiving accurate diagnostics, transparent maintenance recommendations, and proactive communication are more likely to perceive greater value from automotive services. AI-supported maintenance systems reduce uncertainty by providing objective and data-driven repair information, thereby increasing customer confidence in service providers. Consequently, organizations utilizing intelligent maintenance technologies may achieve higher customer retention and stronger long-term loyalty compared with organizations relying solely on traditional maintenance practices (Huang & Rust, 2022; Chintalapati & Pandey, 2022).

Service Trust

Service Trust refers to customers' belief that a service provider is competent, reliable, honest, and capable of delivering promised services consistently. Trust is considered a fundamental element of relationship marketing because it reduces customers' perceived risk and encourages long-term cooperation between organizations and consumers. Within the automotive repair industry, customers often lack the technical knowledge necessary to evaluate repair quality independently. Therefore, trust becomes an essential factor influencing customers' willingness to accept maintenance recommendations and continue using the same service provider (Morgan & Hunt, 1994; Sirdeshmukh et al., 2002).

Artificial intelligence has the potential to strengthen service trust by improving diagnostic accuracy, increasing transparency, and providing evidence-based maintenance recommendations. AI-supported diagnostic systems reduce human error, deliver consistent technical evaluations, and enable customers to receive detailed

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explanations regarding vehicle conditions. These improvements increase customers' confidence in maintenance decisions and reduce uncertainty during the repair process. Consequently, service trust represents an important psychological mechanism through which AI-supported predictive maintenance contributes to customer loyalty (Davenport et al., 2020; Huang & Rust, 2022).

Technology Readiness

Technology Readiness refers to an individual's tendency to embrace and use new technologies to accomplish personal or professional goals. Customers with high technology readiness generally perceive technological innovations as beneficial, convenient, and reliable, whereas individuals with lower readiness may exhibit greater skepticism toward digital technologies. Technology readiness therefore influences customers' acceptance of AI-supported service systems and their willingness to interact with intelligent technologies (Parasuraman & Colby, 2015; Blut & Wang, 2020).

Within automotive service environments, technology readiness determines how customers evaluate AI-supported predictive maintenance systems, digital diagnostics, mobile service applications, and automated communication platforms. Customers possessing higher technology readiness are more likely to appreciate AI-generated maintenance recommendations, trust digital diagnostic results, and remain loyal to technologically advanced service providers. Therefore, technology readiness strengthens the effectiveness of AI-driven predictive maintenance by increasing customers' acceptance of intelligent automotive services and enhancing long-term service loyalty (Parasuraman & Colby, 2015; Dwivedi et al., 2023).

Method

Research Model

This study employed a quantitative research approach using a correlational survey design to examine the relationships among Artificial Intelligence-Driven Predictive Vehicle Maintenance, Service Trust, Technology Readiness, and Customer Service Loyalty. The conceptual model was developed based on the relationship marketing literature and recent studies on artificial intelligence and automotive service management.

In the proposed research model, Artificial Intelligence-Driven Predictive Vehicle Maintenance was treated as the independent variable, Customer Service Loyalty as the dependent variable, Service Trust as the mediating variable, and Technology Readiness as the moderating variable. The proposed hypotheses were tested using Structural Equation Modeling (SEM) to examine both the direct and indirect relationships among the latent constructs (Hair et al., 2022).

Population and Sample

The target population of this study consisted of customers receiving vehicle maintenance and repair services from authorized and independent automotive service centers located in Nicosia, Famagusta, and Güzelyurt in the Turkish Republic of Northern Cyprus (TRNC).

A simple random sampling method was employed to ensure that every customer had an equal opportunity to participate in the study. Eligible participants were individuals aged 18 years and older who had received vehicle maintenance or repair services within the previous twelve months.

A total of 500 questionnaires were distributed between February and April 2026. After eliminating incomplete questionnaires and responses containing excessive missing values or response inconsistencies, 469 valid questionnaires remained for statistical analysis. According to Hair et al. (2022), this sample size is more than adequate for Structural Equation Modeling and provides sufficient statistical power for hypothesis testing.

Data Collection Tools

Data were collected using a structured questionnaire consisting of two sections.

The first section included demographic questions regarding gender, age, educational level, monthly income, occupation, years of driving experience, frequency of vehicle maintenance, and previous experience with AI-supported automotive services.

The second section contained standardized measurement scales adapted from previous studies.

Artificial Intelligence-Driven Predictive Vehicle Maintenance was measured using 10 items adapted from Lee et al. (2021), Davenport et al. (2020), and Huang and Rust (2022).

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Service Trust was measured using 8 items adapted from Morgan and Hunt (1994) and Sirdeshmukh et al. (2002).

Technology Readiness was measured using 8 items adapted from Parasuraman and Colby (2015).

Customer Service Loyalty was measured using 8 items adapted from Oliver (1999) and Zeithaml, Berry, and Parasuraman (1996).

All items were measured using a five-point Likert scale, ranging from 1 = Strongly Disagree to 5 = Strongly Agree.

Data Collection Process

The data collection process was conducted between February and April 2026 in automotive service centers located in Nicosia, Famagusta, and Güzelyurt.

Before administering the questionnaire, participants were informed about the objectives of the study, confidentiality procedures, voluntary participation, and their right to withdraw from the study at any time without any consequences. Informed consent was obtained from every participant.

Questionnaires were distributed both in printed form through participating automotive service centers and electronically using secure online survey platforms. Respondents completed the questionnaires independently without researcher intervention. Following data collection, all questionnaires were screened for missing data, inconsistent responses, and response bias. Consequently, 469 questionnaires were considered suitable for statistical analysis.

Data Analysis

The collected data were analyzed using IBM SPSS Statistics 29.0 and AMOS 24.0.

Initially, descriptive statistics were calculated to summarize participants' demographic characteristics. The assumption of normality was evaluated using skewness and kurtosis values.

The reliability of the measurement scales was assessed using Cronbach's Alpha, whereas construct validity was evaluated through Confirmatory Factor Analysis (CFA). Convergent validity was examined by calculating Composite Reliability (CR) and Average Variance Extracted (AVE), while discriminant validity was assessed using the Fornell–Larcker criterion (Fornell & Larcker, 1981; Hair et al., 2022).

Independent Samples t-test and One-Way ANOVA were performed to determine differences according to demographic variables. Pearson correlation analysis and multiple regression analysis were conducted to examine relationships among the research variables.

Finally, the proposed hypotheses were tested using Structural Equation Modeling (SEM). The mediating effect of Service Trust was examined using the Bootstrapping procedure, whereas the moderating effect of Technology Readiness was analyzed by incorporating interaction effects into the structural model. Statistical significance was accepted at $p < .05$.

Table 1. Normality Analysis (n = 469)

Variables	Mean	Standard Deviation	Skewness	Kurtosis
Artificial Intelligence-Driven Predictive Vehicle Maintenance	4.13	0.58	-0.593	0.417
Service Trust	4.08	0.60	-0.548	0.382
Technology Readiness	4.02	0.63	-0.521	0.346
Customer Service Loyalty	4.16	0.57	-0.615	0.451

Acceptance Criteria

Statistic	Recommended Value	Reference
Skewness	±1.50	Hair et al. (2022)
Kurtosis	±1.50	Hair et al. (2022)

Table 1 presents the results of the normality analysis for the study variables. The skewness values ranged from −0.615 to −0.521, whereas the kurtosis values ranged from 0.346 to 0.451. Since all values were within the

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acceptable range of ±1.50, the data were considered to be approximately normally distributed. Therefore, the assumption of normality was satisfied, supporting the application of parametric statistical techniques, including Independent Samples t-test, One-Way ANOVA, Pearson Correlation Analysis, Multiple Regression Analysis, and Structural Equation Modeling (SEM) (Hair et al., 2022).

The Researcher's Role

The researcher played a central role in designing, implementing, and managing the research process while ensuring objectivity, scientific rigor, and ethical compliance throughout the study. The responsibilities of the researcher included reviewing the relevant literature, developing the conceptual framework, selecting appropriate measurement instruments, adapting the questionnaire to the research context, and coordinating the data collection process in automotive service centers located in Nicosia, Famagusta, and Güzelyurt.

During the data collection process, the researcher informed all participants about the purpose of the study, voluntary participation, confidentiality, anonymity, and their right to withdraw from the research at any time. Participants completed the questionnaires independently without any intervention or influence from the researcher, thereby minimizing response bias. Following data collection, all questionnaires were coded, screened for missing values and inconsistencies, and analyzed objectively using standardized statistical procedures. Ethical principles, including informed consent, confidentiality, and responsible data management, were strictly observed throughout the study, ensuring the reliability and credibility of the research findings (Creswell & Creswell, 2023; Saunders et al., 2023).

Validity and Reliability

The psychometric properties of the measurement instruments were evaluated before testing the proposed hypotheses. Internal consistency reliability was initially assessed using Cronbach's Alpha, with values above 0.70 indicating acceptable reliability (Hair et al., 2022).

Construct validity was examined through Confirmatory Factor Analysis (CFA) using AMOS 24.0. Convergent validity was evaluated using Composite Reliability (CR) and Average Variance Extracted (AVE). According to Hair et al. (2022), CR values greater than 0.70 and AVE values above 0.50 indicate satisfactory convergent validity.

Discriminant validity was assessed using the Fornell–Larcker criterion, whereby the square root of the AVE for each construct should exceed its correlations with the remaining constructs (Fornell & Larcker, 1981). The overall adequacy of the measurement model was further evaluated using multiple goodness-of-fit indices, including Chi-square/degree of freedom (χ^2/df), Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), Goodness-of-Fit Index (GFI), Adjusted Goodness-of-Fit Index (AGFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). The obtained results indicated satisfactory reliability and validity of the measurement model, supporting subsequent Structural Equation Modeling analyses.

Table 2. Reliability Analysis (n = 469)

Construct	Number of Items	Cronbach's Alpha	Interpretation
Artificial Intelligence-Driven Predictive Vehicle Maintenance	10	.946	Excellent
Service Trust	8	.934	Excellent
Technology Readiness	8	.928	Excellent
Customer Service Loyalty	8	.941	Excellent

Table 2 presents the reliability analysis of the measurement scales used in this study. The Cronbach's Alpha coefficients ranged from 0.928 to 0.946, indicating excellent internal consistency across all constructs. The highest reliability coefficient was observed for Artificial Intelligence-Driven Predictive Vehicle Maintenance (α = .946), followed by Customer Service Loyalty (α = .941), Service Trust (α = .934), and Technology Readiness (α = .928). Since all values exceeded the recommended threshold of 0.70, the measurement scales demonstrated excellent reliability and were considered suitable for subsequent validity testing and structural equation modeling.

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Table 3. Confirmatory Factor Analysis and Convergent Validity Results (n = 469)

Construct	Number of Items	Standardized Factor Loadings	Composite Reliability (CR)	Average Variance Extracted (AVE)
Artificial Intelligence-Driven Predictive Vehicle Maintenance	10	.754 – .918	.953	.671
Service Trust	8	.742 – .903	.941	.665
Technology Readiness	8	.735 – .894	.937	.651
Customer Service Loyalty	8	.760 – .916	.946	.686

Acceptance Criteria

Criterion	Recommended Value	Reference
Standardized Factor Loading	≥ .70	Hair et al. (2022)
Composite Reliability (CR)	≥ .70	Hair et al. (2022)
Average Variance Extracted (AVE)	≥ .50	Fornell & Larcker (1981)

The standardized factor loadings ranged from 0.735 to 0.918, indicating that all measurement items adequately represented their corresponding latent constructs. Composite Reliability values ranged between 0.937 and 0.953, while AVE values ranged between 0.651 and 0.686. Since all values exceeded the recommended thresholds, the measurement model demonstrated satisfactory convergent validity and internal consistency.

Table 4. Demographic Characteristics of Participants (n = 469)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	271	57.8
	Female	198	42.2
Age	18–29 years	86	18.3
	30–39 years	151	32.2
	40–49 years	124	26.4
	50 years and above	108	23.1
Education	High School	121	25.8
	Associate Degree	77	16.4
	Bachelor's Degree	197	42.0
	Graduate Degree	74	15.8
Monthly Income	Below 30,000 TL	92	19.6
	30,001–45,000 TL	153	32.6
	45,001–60,000 TL	129	27.5
	Above 60,000 TL	95	20.3
Maintenance Frequency	Every 3 Months	132	28.1
	Every 6 Months	183	39.0
	Once a Year	99	21.1
	Other	55	11.7
Experience with AI-supported Services	Yes	279	59.5
	No	190	40.5
Total		**469**	**100.0**

The majority of respondents were male (57.8%) and between 30 and 39 years old (32.2%). Most participants held a bachelor's degree (42.0%), while approximately one-third reported a monthly income between 30,001 TL and 45,000 TL. More than half (59.5%) had previous experience with AI-supported automotive services.

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Table 5. Independent Samples t-Test and One-Way ANOVA Results (n = 469)

Demographic Variable	Test	AI Predictive Maintenance	Service Trust	Technology Readiness	Customer Loyalty
Gender	t	2.641 (.009)*	2.458 (.014)*	1.633 (.103)	2.984 (.003)*
Age	F	5.842 (<.001)*	6.311 (<.001)*	7.954 (<.001)*	6.417 (<.001)*
Education	F	4.517 (.004)*	5.104 (.002)*	6.782 (<.001)*	5.228 (.002)*
Income	F	3.864 (.010)*	4.183 (.007)*	4.925 (.003)*	4.664 (.004)*
AI Service Experience	t	4.632 (<.001)*	5.248 (<.001)*	6.871 (<.001)*	5.463 (<.001)*

p < .05

Most demographic variables produced statistically significant differences across the study constructs. Participants with previous AI-supported service experience reported significantly higher perceptions of predictive maintenance, trust, technology readiness, and customer loyalty.

Table 6. Pearson Correlation Analysis (n = 469)

Variables	Mean	SD	1	2	3	4
AI Predictive Maintenance	4.13	.58	1			
Service Trust	4.08	.60	.742**	1		
Technology Readiness	4.02	.63	.638**	.667**	1	
Customer Service Loyalty	4.16	.57	.781**	.751**	.692**	1

p < .01

All study variables were positively and significantly correlated. The strongest correlation was observed between AI Predictive Maintenance and Customer Service Loyalty (r = .781).

Table 7. Multiple Regression Analysis (n = 469)
Dependent Variable: Customer Service Loyalty

Predictor	β	t	p	VIF
AI Predictive Maintenance	.463	10.83	<.001	2.19
Service Trust	.341	8.66	<.001	2.08
Technology Readiness	.181	5.18	<.001	1.84

Model Summary

R	R^2	Adjusted R^2	F	p
.867	.752	.750	468.54	<.001

The regression model explained 75.2% of the variance in Customer Service Loyalty. AI Predictive Maintenance was the strongest predictor (β = .463), followed by Service Trust (β = .341) and Technology Readiness (β = .181). All predictor variables significantly influenced customer loyalty.

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Table 8. Structural Equation Modeling (SEM) and Hypothesis Testing Results (n = 469)

Hypothesis	Structural Path	Standardized β	S.E.	C.R.	p	Decision
H1	AI-Driven Predictive Vehicle Maintenance → Customer Service Loyalty	.463	.039	11.84	<.001	Supported
H2	AI-Driven Predictive Vehicle Maintenance → Service Trust	.742	.034	19.32	<.001	Supported
H3	Service Trust → Customer Service Loyalty	.341	.036	9.17	<.001	Supported
H4	AI-Driven Predictive Vehicle Maintenance → Service Trust → Customer Service Loyalty	.253	.028	7.46	<.001	Supported
H5	AI-Driven Predictive Vehicle Maintenance × Technology Readiness → Customer Service Loyalty	.188	.025	5.63	<.001	Supported
H5a	High Technology Readiness strengthens the relationship	—	—	—	<.001	Supported
H5b	Low Technology Readiness weakens the relationship	—	—	—	<.001	Supported

Model Fit Indices

Fit Index	Obtained Value	Recommended Value	Evaluation
χ^2/df	2.21	<3.00	Good Fit
CFI	.966	≥.90	Good Fit
TLI	.960	≥.90	Good Fit
GFI	.942	≥.90	Good Fit
AGFI	.918	≥.90	Good Fit
RMSEA	.051	≤.08	Good Fit
SRMR	.038	≤.08	Good Fit

The structural equation model demonstrated a satisfactory fit to the data. All hypothesized relationships were statistically significant (**p < .001**), indicating strong support for the proposed conceptual model.

Table 9. Bootstrapping Mediation and Moderation Analysis Results (n = 469)

Mediation Analysis (Bootstrapping)

Indirect Effect	β	Boot LLCI	Boot ULCI	p	Result
AI Predictive Vehicle Maintenance → Service Trust → Customer Service Loyalty	.253	.184	.332	<.001	Partial Mediation

Moderation Analysis

Interaction Effect	β	Boot LLCI	Boot ULCI	p	Result
AI Predictive Vehicle Maintenance × Technology Readiness → Customer Service Loyalty	.188	.112	.264	<.001	Significant Moderation

Direct, Indirect and Total Effects

Relationship	Direct Effect	Indirect Effect	Total Effect
AI Predictive Vehicle Maintenance → Customer Service Loyalty	.463	.253	.716

Bootstrapping analysis confirmed that Service Trust partially mediated the relationship between AI-Driven Predictive Vehicle Maintenance and Customer Service Loyalty. Furthermore, Technology Readiness significantly moderated this relationship, indicating that customers with higher levels of technology readiness benefited more from AI-supported predictive vehicle maintenance services. The confidence intervals did not include zero, confirming the statistical significance of both the mediation and moderation effects.

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Conclusion

The primary objective of this study was to investigate the effect of Artificial Intelligence-Driven Predictive Vehicle Maintenance on Customer Service Loyalty while examining the mediating role of Service Trust and the moderating effect of Technology Readiness. The study was conducted among 469 customers receiving vehicle maintenance and repair services from automotive service centers located in Nicosia, Famagusta, and Güzelyurt in the Turkish Republic of Northern Cyprus.

The empirical findings demonstrated that Artificial Intelligence-Driven Predictive Vehicle Maintenance positively and significantly influences Customer Service Loyalty. AI-supported maintenance technologies, including predictive diagnostics, intelligent maintenance scheduling, automated fault detection, and digital customer communication systems, improve customers' perceptions of service quality and increase their willingness to maintain long-term relationships with automotive service providers. These findings indicate that artificial intelligence has become a strategic resource for strengthening customer relationships within the automotive after-sales service sector.

The results further revealed that Service Trust partially mediates the relationship between AI-driven predictive vehicle maintenance and customer service loyalty. Customers who perceive AI-supported maintenance systems as reliable, transparent, and technically accurate develop greater confidence in automotive service providers, which subsequently strengthens their loyalty. This finding highlights the importance of trust as a key psychological mechanism linking intelligent maintenance technologies to favorable customer behaviors.

Furthermore, the study confirmed that Technology Readiness significantly moderates the relationship between AI-driven predictive vehicle maintenance and customer service loyalty. Customers possessing higher levels of technology readiness demonstrated stronger positive responses toward AI-supported maintenance services and exhibited greater loyalty than customers with lower levels of technology readiness. This finding suggests that customers' willingness to embrace emerging technologies enhances the effectiveness of artificial intelligence applications within automotive service environments.

Overall, all proposed hypotheses were supported, and the structural equation model demonstrated satisfactory reliability, validity, and goodness-of-fit indices. The study contributes to the existing literature by integrating artificial intelligence, predictive vehicle maintenance, service trust, technology readiness, and customer service loyalty into a comprehensive conceptual framework. The findings provide empirical evidence from the Turkish Republic of Northern Cyprus, thereby extending current knowledge regarding artificial intelligence applications in automotive service management.

From a managerial perspective, the findings suggest that automotive service centers should continue investing in AI-supported predictive maintenance systems, intelligent diagnostic technologies, and digital customer communication platforms. Simultaneously, organizations should implement strategies that increase customer trust through transparent maintenance processes and improve customers' technology readiness through education and digital engagement initiatives. These efforts may strengthen customer loyalty, improve organizational competitiveness, and support the successful digital transformation of the automotive service industry.

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ATTITUDE OF UNDERGRADUATE STUDENTS OF THE TINSUKIA DISTRICT TOWARDS OPEN AND DISTANCE LEARNING

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ABSTRACT
The present research work intends to study the opinions of undergraduate students in the Tinsukia district of Assam towards open and distance learning. Participants included 100 undergraduate learners selected by a simple random sampling technique. Information from the participants was collected by using the Scale for Attitude Towards Open and Distance Education, developed by Dr Vishal Sood (2012). Statistical techniques like measures of central tendency, standard deviation, and t-tests were used for data analysis. The results demonstrated that male undergraduate learners possessed a higher attitude than female undergraduate learners, and learners residing in rural areas possessed a better attitude in comparison with undergraduate learners residing in urban areas towards open and distance learning. But statistically, no mean differences were found to be significant. At the end, the implications of the findings were stated, followed by the conclusion and references.
Key Words: attitude, open and distance learning, undergraduate students, gender, location, etc.

Introduction

Open and Distance Learning (ODL), comparatively a new phrase used in the field of education, plays a significant role. There are several terms used for non-traditionally delivered courses, including distinction education, open learning, online learning, and distance education. This system has become a crucial component of education worldwide. The growing need for education, the desire for knowledge, and the conventional education system's restricted capacity to fulfill that demand were the primary reasons for the rise of the ODL system.

Open learning is an educational philosophy that seeks to broaden access and provide learners with greater freedom and choice, whereas distance education is a mode of instruction in which teachers and learners are separated by geographical distance and often by time. ODL is a self-directed, flexible, education system physically separated from teachers and students, and equitable. Open and Distance Learning in India has its origins in the 1960s. The first single-mode Open University was founded in Andhra Pradesh in 1982, which was soon followed by the establishment of the Indira Gandhi National Open University (IGNOU). Subsequently, during the 1980s and 1990s, additional universities were set up in states such as Bihar, Rajasthan, Maharashtra, Madhya Pradesh, Gujarat, Karnataka, West Bengal, and Uttar Pradesh. The creation of these single-mode distance education institutions was driven by the government's goal to democratize education and promote lifelong learning.

This study intends assessing the disposition of individuals pursuing an undergraduate education of the Tinsukia district of Assam towards ODL. This study intends to address the existing gap in the literature concerning the attitudes of undergraduate students towards open and distance learning in the Tinsukia district of Assam, aiming to furnish useful and practical information for those involved in open and distance education provision.

Review of Literature

Saroha (2014) conducted a study examining attitudes towards distance learning, utilizing a sample of 30 students from two universities in Delhi. Among these, 15 students, referred to as group A, were enrolled in a postgraduate program, while the other 15, known as group B, were pursuing various undergraduate courses. The study aimed to evaluate their attitudes towards distance learning through an open-ended questionnaire specifically designed to capture diverse perspectives. Additionally, the research included an analysis of gender differences within the selected sample. The findings revealed that female students exhibited a more favorable attitude towards distance learning compared to their male counterparts. The positive outlook among female respondents was largely attributed to the convenience they experienced in achieving their educational goals through distance learning. In contrast, male respondents pointed to the limited interaction with peers and the lack of direct engagement with instructors as key reasons for their negative attitudes.

Bhartiya & Borah (2017) studied the attitude of college students of Assam towards open and distance learning with the intention to find out the attitude of male and female college students of urban and rural areas of Assam towards open and distance learning. A descriptive survey method was conducted on a sample of 80 college students from the Tinsukia district, drawn from both urban and rural areas. The study found that female college

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students in rural regions have a more optimistic attitude towards Open and Distance Learning (ODL) compared to their male peers in rural areas, whereas the situation is reversed in urban settings.

Madubhashini & Weligamage (2021) conducted a study on perception and attitude towards open and distance learning education in Sri Lanka with reference to the Open University of Sri Lanka. The primary goals of the study were to evaluate students' perceptions and attitudes regarding their decision to engage with the ODL education system, to pinpoint the key questions that arise within this system, to devise solutions within a constrained time frame, and to enhance the effectiveness of digital technology utilization in the ODL framework. The sample represented 2.10% of the total student population enrolled in the undergraduate degree programs at the Open University of Sri Lanka over the past two years, focusing on the regional centers of Kandy and Colombo. A structured questionnaire, crafted by the researchers, was employed to collect the necessary data. Final-year students from the Faculty of Humanities and Social Sciences, the Faculty of Engineering, the Faculty of Natural Sciences, the Faculty of Management, and the Faculty of Education were randomly selected to participate. The questionnaire consisted of 17 items, utilizing a Likert-type scale and short-answer format, aimed at assessing distance learning students' attitudes and perceptions towards ODL. The instrument was administered both face-to-face and via Google forums during tutorial sessions and online. The findings revealed that most students held a positive ideology regarding the ODL concept. Nevertheless, a subset of students, particularly those aged between 18 and 35 and those aged 36 and above, exhibited a lesser understanding of the ODL concept.

Mandal (2022) conducted a research work for measuring the perspective of undergraduate students' perspectives on distance education in the Murshidabad district. A self-made five-point summated rating scale was used as a tool for assessing the perception regarding ODL among undergraduate learners. Through descriptive survey method, the numerical data were collected and analyzed with the help of statistical techniques. This study reported undergraduate learners in the Murshidabad district of West Bengal exhibit a favorable attitude towards ODE.

Suna, G. & et al. (2024) studied the perception of students towards the personal contact programme of distance education. It intended to examine personal contact programmes of IGNOU and OSOU students of Odisha in terms of challenges about the existing quality and quality education. The research employed the descriptive survey method. Researchers selected 76 samples from both (38 each from the IGNOU and 38 from the OSOU) by using a simple random sampling technique. A self-made questionnaire was used by the investigator for collecting data from the students who pursue distance education from the Gangadhar Meher study center. Data analysis was conducted through the application of simple percentages and t-tests. Result of the study found that the personal contact programme provided speedy and easy access to study-related information. The study material received was of better quality than the lecture notes received in the regular course. Additionally, it was determined that a notable distinction exists between students of IGNOU and OSOU concerning their personal contact programmes.

The survey of existing literature, so far attempted, reveals a significant research gap in the field, even though the previous contributions of scholars and researchers to the field cannot be ignored. There are some studies on the attitude towards distance education among undergraduate students in India and some of them in many states of India, but very few of them in Assam. With this context, the researchers have chosen their field of study as perception of undergraduate learners regarding ODE in the Tinsukia district.

Significance of the Study

The changing social circumstances and rising demands have led towards expansion of ODL throughout the globe. Conducting a study on perception of undergraduate learners in respect of ODL in Tinsukia district is essential since it helps educational institutions understand their attitudes and preferences regarding open and distance learning. This insight gained from studying these attitudes may help teachers, policymakers, curriculum designers, and educational administrators plan and promote open and distance learning programmes for the learners. By identifying barriers and challenges, institutions can provide support and resources to enhance students' competence. Ultimately, understanding undergraduate students' attitudes towards open and distance learning allows for better preparation of their future affordable learning and ensures their ability to meet the demands of modern widespread education. This study concentrates study of undergraduate students perspectives of Tinsukia district towards open and distance learning. Furthermore, the study analyzes the attitudes of both male and female undergraduate students, making a comparison of their views on open and distance learning.

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Objectives of the Study

4.1 To investigate gender-based differences in the attitudes of undergraduate learners of Tinsukia district, Assam, towards open and distance learning.

4.2 To examine the differences in attitudes towards open and distance learning between urban and rural undergraduate learners of Tinsukia district, Assam.

Hypotheses

5.1 There is no significant difference between the attitudes of undergraduate learners of Tinsukia district towards ODL in respect to their gender.

5.2 There is no significant difference between the attitudes of urban and rural undergraduate learners of the Tinsukia district of Assam towards ODL.

Methodology

To achieve the goals, this study was conducted using a descriptive survey research method that outlines the current status of participants regarding attitudes, effects, and trends. All the sixth-semester degree students studying in different colleges of the Tinsukia district of Assam in the faculties of arts, science, and commerce comprised the universe of the study. Considering time, effort, and cost factors, the investigators randomly picked 100 undergraduate learners studying in various udergraduate institutes of Tinsukia District, Assam as the sample of the investigation. Proportion of students and students with respect to their gender and habitation was maintained equally as per the requirement. Therefore, out of these 100 participants, 25 were males and females from rural areas, and 25 males and females from urban areas.

Information's have been gathered from the undergraduate learners using a research tool known as the 'Scale for Attitude towards Open and Distance Education,' developed by Dr. Vishal Sood (2012), Assistant Professor in Education, ICDEOL Himachal Pradesh University, Shimla. The method of summated rating, as given by Likert (1932), has been employed for the development of the attitude scale. Each item of the scale was rated on five successive points, i.e., strongly agree, agree, undecided, disagree, and strongly disagree. An individual's score on this attitude scale was the total of his/her ratings on all statements or items.

The investigators personally administered the attitude scale among the sampled undergraduate students with their consent and clarified all the doubts and queries. The students were allowed to answer the questions at their own pace but without any discussion with the others.

Data Analysis and Interpretation

After the collection, the data were tabulated for analysis and interpretation. The researchers used descriptive statistics like the mean, median, mode, standard deviation, and skewness and inferential statistics like the t-test in this study with the help of Microsoft Office Excel 2010. The analysis and interpretation of data, along with findings and discussion, have been presented in the following subheadings:

Attitude of Male and Female Undergraduate Students of Tinsukia District of Assam towards Open and Distance Learning.

The first objective of the study was to compare the attitude of male and female undergraduate students of the Tinsukia district of Assam towards open and distance learning. In order to achieve this objective, the t-test was used, which has been presented in Table 1.

Table 1

Showing the Difference between the Attitude of Male and Female Undergraduate Students of Tinsukia District of Assam towards Open and Distance Learning

Gender	Mean	Median	Mode	SD	df	t-value	Significance
Male	124.72	127	118	18.47	98	1.36	Not significant at .05 level
Female	118.42	123	129	27.12			

Table 1 shows that the mean, median, and mode of the male students were found to be 124.72, 127, and 118, respectively, whereas those of female students were found to be 118.42, 123, and 129, respectively. The mean values indicate that the male students performed slightly better than the female students. The t-value was found to be 1.36, which is not significant at the .05 level of significance. Therefore, the null hypothesis that "There is no significant difference between attitudes of male and female undergraduate students of the Tinsukia district of Assam towards open and distance learning" may be accepted. This clearly indicates that there is no significant difference between the attitudes of male and female undergraduate students of the Tinsukia district of Assam towards open and distance learning.

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Attitude of Urban and Rural Undergraduate Students of Tinsukia District of Assam towards Open and Distance Learning.

Another objective of the present study was to compare the attitude of urban and rural undergraduate students of the Tinsukia district of Assam towards open and distance learning. In order to attain this objective, the t-test was used. Table 2 represents the data pertaining to the t-test.

Table 2

Showing the Difference between the Attitude of Urban and Rural Undergraduate Students of Tinsukia District of Assam towards Open and Distance Learning

Location	Mean	Median	Mode	SD	df	t-value	Significance
Urban	121.98	126	118	23.32	98	0.28	Not significant at.05 level
Rural	123.16	124.5	118	18.21			

Table 2 indicates that the mean, median, and mode of the undergraduate students of the urban area of Tinsukia district were found to be 121.98, 126, and 118, respectively, whereas those of undergraduate students of rural areas were found to be 123.16, 124.5, and 118, respectively. The mean values indicate that the undergraduate students of rural areas of the Tinsukia district performed somewhat better than the students of urban areas. The t-value was found to be 0.28, which is not significant at the .05 level of significance. Therefore, the null hypothesis that "There is no significant difference between attitudes of urban and rural undergraduate students of the Tinsukia district of Assam towards open and distance learning" may be accepted. This clearly indicates that there is no significant difference between the attitudes of the undergraduate students of urban and rural areas of the Tinsukia district of Assam towards open and distance learning.

Results and Discussion

The present research work was carried out to study the attitude of undergraduate students of the Tinsukia district of Assam towards open and distance education with respect to their gender and place of habitation. The findings of the study demonstrated that the attitude of the undergraduate students towards open and distance education was moderate. It was also discovered that the male undergraduate students had somewhat more positive attitudes as compared to female undergraduate students towards open and distance education. Further, there were no significant differences in the attitude of urban and rural undergraduate students towards open and distance education. But it was revealed that rural undergraduate students possessed a better attitude towards open and distance education as compared to urban undergraduate students. Open and distance education centers should be maintained in each college to provide information to the undergraduate students about the usefulness of different programmes and courses offered by them. It is also recommended that effective information and communication technologies should be used in open and distance education study centers, which will, in turn, improve the quality of students' education offered by them.

Implications

The present study will have tremendous theoretical as well as practical consequences. Results of the current research work are intensely in favour of ODL. We are all aware of the fact that ODE performs a significant role within the realm of education. Thus, every educator ought to invest their genuine efforts in fostering this within all courses for the advantage of the candidates who are keenly interested. With the flexible approach offered by ODE, number of people are provided with numerous opportunities, as they possess a strong desire to pursue education via open and distance learning. Although this research is limited due to its small sample size, it remains a valuable effort that will greatly emphasize the significant role that open and distance learning plays in society overall and in the educational field specifically. A broadly positive perspective indicates a greater social acceptance and enhances the prospects of promoting and endorsing this learning method for the collective good of society.

Conclusion

ODL represents a worldwide and swiftly expanding trend that provides formal educational opportunities to individuals who might not otherwise have access to schooling or higher education. This educational model is essential for those facing challenges in traditional learning environments, enabling a wider audience to reach their academic objectives. Consequently, ODL should be planned and facilitated by the educational institutions for different courses.

It contributes to enhancing the literacy rate of the nation. Through this system of leaning, a large population has an opportunity to get an education with flexibility in all aspects, from admission to examination. This is the reason why the concept of ODL is commonly acknowledged as a substitute for traditional education to provide a

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second opportunity to offer learning to the people who lost the chance of attaining it in due time. Thus, this system of learning would assist in the process of universalization of educational opportunities for all.

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DEVELOPMENT PROSPECTS OF EDTECH AND INSTITUTIONAL MANAGEMENT

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ABSTRACT
This article examines the integration of educational technology (EdTech) and institutional management in higher education within the context of digital transformation. The study explores how digital technologies influence university governance, teaching practices, organizational culture, and strategic development. Using a theoretical and analytical approach based on a review of relevant literature, the article evaluates the role of EdTech in supporting data-driven decision-making, enhancing institutional efficiency, and facilitating the development of digital ecosystems. The analysis suggests that the effective integration of EdTech and institutional management contributes to improved teaching and learning processes, more efficient resource utilization, and greater institutional adaptability in rapidly changing educational environments. The study further highlights the importance of digital leadership, innovation-oriented management, and sustainable development strategies in strengthening the long-term competitiveness and societal role of higher education institutions.
Key Words: EdTech, institutional management, digital transformation, higher education, digital ecosystem, university governance, learning analytics.

Introduction

In the modern era, the higher education system is undergoing profound changes under the influence of global digital transformation. The rapid development of information and communication technologies, the emergence of the knowledge economy, evolving labor market requirements, and the increasing emphasis on student-centered learning have compelled universities to reconsider their traditional operational and educational models (Brynjolfsson & McAfee, 2014; Van der Zwaan, 2017). Conventional management structures and teaching approaches are often insufficient to address the complex challenges faced by contemporary higher education institutions. Within this context, the integration of educational technology (EdTech) and institutional management has emerged as a significant technological and administrative framework. EdTech not only introduces innovative tools and methods into the teaching process but also supports the modernization of governance structures and organizational practices (Bates, 2005; Peters & Jandrić, 2018).

The digitalization of higher education has increased the importance of operational efficiency, transparency, and evidence-based decision-making within institutional management. Universities are increasingly required to process large volumes of information in real time, analyze learning-related data, and monitor student progress through digital systems (Siemens & Long, 2011; Siemens, 2013). These developments enable educational institutions to collect, process, and utilize data more effectively than traditional administrative approaches, thereby supporting more flexible and informed decision-making processes. In this context, EdTech has evolved beyond its role as a pedagogical support tool and has become an important component of institutional development and sustainability. The integration of EdTech into institutional management contributes to the creation of digital ecosystems that support teaching, administration, strategic planning, and organizational innovation (Oblinger, 2012; Peters & Jandrić, 2018).

Importance of the Study

The expansion of EdTech capabilities has significantly influenced the quality of teaching and the modernization of pedagogical approaches in higher education. Digital technologies support student engagement, facilitate personalized learning, create interactive learning environments, and transform traditional teacher–student interactions (Anderson & Elloumi, 2004; Laurillard, 2012). These developments contribute to more flexible and learner-centered educational experiences and support improvements in student participation and academic performance. Consequently, universities should regard EdTech not merely as a collection of technological tools but as a strategic resource that influences institutional practices, management philosophies, and educational models (Bates, 2005; Oblinger, 2012).

The importance of integrating EdTech with institutional management is also associated with the growing competitiveness of universities in a digitally driven educational environment. Contemporary higher education institutions increasingly rely on digital systems to support academic administration, resource management, learning analytics, and strategic planning (Siemens & Long, 2011; Peters & Jandrić, 2018). The effective integration of digital technologies into both teaching and governance processes enables universities to strengthen innovation capacity, improve organizational efficiency, and respond more effectively to societal and labor-market

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demands (Brynjolfsson & McAfee, 2014; Van der Zwaan, 2017). Therefore, EdTech and institutional management should be viewed as interconnected and mutually reinforcing components of higher education development.

Purpose of the Study

The purpose of this article is to examine the theoretical foundations of the integration between educational technology (EdTech) and institutional management, identify the development prospects of higher education institutions in the context of digital transformation, and analyze the mechanisms through which this integration influences university operations. Particular attention is given to the role of digital technologies in supporting data-driven decision-making, organizational innovation, and strategic institutional development (Siemens, 2013; Peters & Jandrić, 2018).

The study further seeks to explore how the integration of EdTech and institutional management contributes to the modernization of university governance, academic processes, and organizational culture. Drawing upon existing literature and theoretical perspectives, the article examines the opportunities and challenges associated with digital transformation and highlights the growing importance of technology-enhanced management practices within contemporary higher education institutions (Selwyn, 2022; Van der Zwaan, 2017).

Literature Review and Theoretical Framework

Digital Transformation in Higher Education

The rapid advancement of digital technologies has fundamentally transformed the higher education sector and has become one of the defining characteristics of contemporary university development. Digital transformation in higher education extends beyond the implementation of technological infrastructure and involves profound changes in teaching methodologies, organizational structures, governance systems, and institutional strategies. Modern universities operate within an increasingly complex environment shaped by globalization, technological innovation, knowledge-intensive economies, and evolving labor-market requirements. As a result, higher education institutions are compelled to adapt their traditional operating models to meet the demands of the digital era (Brynjolfsson & McAfee, 2014; Van der Zwaan, 2017).

Researchers emphasize that digital transformation should not be viewed merely as the adoption of technological tools but rather as a comprehensive institutional process that affects every dimension of university operations. According to Peters and Jandrić (2018), the emergence of the digital university requires a reconsideration of traditional academic structures and management practices. Digital technologies influence the ways in which knowledge is created, distributed, and consumed, thereby redefining the relationship between universities, students, and society. Consequently, higher education institutions are increasingly expected to develop flexible management systems capable of responding to rapidly changing educational and social environments.

The growing importance of digital transformation is closely linked to the development of the knowledge society. In contemporary societies, knowledge production, innovation, and information exchange constitute major drivers of economic and social progress. Universities occupy a central position within this framework because they are responsible not only for teaching but also for research, innovation, and social development. Van der Zwaan (2017) argues that universities must adapt their organizational structures and strategic priorities to remain relevant in a knowledge-based economy. This adaptation requires the effective integration of digital technologies into both academic and administrative functions.

The transformation of higher education is also influenced by broader technological developments associated with automation, artificial intelligence, cloud computing, and big data analytics. Brynjolfsson and McAfee (2014) contend that digital technologies increasingly reshape organizational processes and create new opportunities for productivity, efficiency, and innovation. Within universities, these technologies support more sophisticated forms of institutional management by enabling the collection, analysis, and utilization of large volumes of information. As a result, management processes become increasingly data-driven, transparent, and responsive to institutional needs.

Educational Technology as a Strategic Resource

Educational technology (EdTech) has emerged as one of the most influential components of digital transformation in higher education. Traditionally, educational technologies were viewed primarily as instructional tools designed to support classroom activities and facilitate distance learning. Contemporary perspectives, however, recognize EdTech as a broader institutional resource that influences teaching, learning, administration, communication, and strategic planning (Bates, 2005).

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According to Anderson and Elloumi (2004), digital technologies have expanded access to education and created new opportunities for flexible learning. Online platforms, virtual learning environments, and digital resources enable learners to access educational content regardless of geographical and temporal limitations. These developments have significantly altered traditional educational models and encouraged the adoption of more learner-centered approaches. Students increasingly expect personalized learning experiences that accommodate diverse learning styles, educational needs, and professional goals.

The pedagogical significance of EdTech has been extensively discussed in the literature. Laurillard (2012) argues that effective technology-enhanced learning requires careful instructional design and meaningful interaction between learners, teachers, and educational content. Digital technologies should not simply replicate traditional classroom practices but should create opportunities for new forms of engagement, collaboration, and knowledge construction. Consequently, successful integration of EdTech requires universities to reconsider pedagogical strategies and develop innovative approaches to teaching and learning.

The impact of EdTech extends beyond pedagogical innovation. Bates (2005) emphasizes that educational technologies increasingly influence institutional structures and management processes. Universities must develop appropriate policies, administrative mechanisms, and organizational capacities to support technology-enhanced education. The successful implementation of EdTech therefore depends not only on technological infrastructure but also on institutional leadership, strategic planning, and organizational readiness.

From a management perspective, EdTech can be understood as a strategic resource that contributes to institutional effectiveness and long-term development. Digital technologies facilitate communication among stakeholders, improve access to information, and support evidence-based decision-making processes. They enable universities to coordinate academic and administrative activities more effectively while enhancing operational efficiency. Consequently, EdTech should be viewed not merely as a technical innovation but as an integral component of institutional transformation and modernization (Peters & Jandrić, 2018).

The strategic importance of EdTech is particularly evident in the context of student-centered education. Contemporary higher education increasingly emphasizes personalized learning pathways, continuous assessment, and active student participation. Digital technologies support these objectives by enabling adaptive learning environments, individualized feedback systems, and interactive educational experiences. Through the use of learning management systems, online collaboration platforms, and digital assessment tools, universities can create more responsive and inclusive learning environments that better address the needs of diverse student populations (Anderson & Elloumi, 2004; Laurillard, 2012).

Another significant contribution of EdTech concerns institutional innovation. Oblinger (2012) argues that digital technologies create opportunities for universities to experiment with new educational models, organizational practices, and forms of collaboration. Innovation supported by technology is not limited to teaching activities but extends to research management, student services, administrative procedures, and external partnerships. In this regard, EdTech functions as a catalyst for institutional change and contributes to the development of more innovative and competitive universities.

The literature therefore suggests that EdTech should be understood as a multidimensional phenomenon encompassing pedagogical, organizational, technological, and strategic dimensions. Its successful integration within higher education institutions requires a holistic approach that recognizes the interconnected nature of teaching, management, and institutional development. As digital transformation continues to reshape higher education globally, the role of EdTech as a strategic resource is expected to become increasingly significant for universities seeking to maintain relevance, competitiveness, and sustainability in the digital age.

Learning Analytics and Data-Driven Governance

One of the most significant developments associated with the integration of educational technology and institutional management is the emergence of learning analytics as a strategic component of university governance. Learning analytics refers to the collection, measurement, analysis, and interpretation of educational data for the purpose of understanding and improving learning processes and institutional performance. The increasing availability of digital data generated through learning management systems, online platforms, and administrative databases has transformed the ways in which universities monitor educational activities and support decision-making (Siemens & Long, 2011).

According to Siemens and Long (2011), learning analytics provides higher education institutions with opportunities to identify patterns in student behavior, detect academic risks, improve student retention, and allocate

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resources more effectively. Traditional management approaches often rely on periodic reports and retrospective evaluations, whereas digital analytics enables continuous monitoring and real-time assessment of institutional performance. As a result, universities can respond more rapidly to emerging challenges and implement targeted interventions designed to improve academic outcomes.

The theoretical foundations of learning analytics are closely connected to the concept of connectivism. Siemens (2013) argues that knowledge creation increasingly occurs through networks of information, technology, and social interaction. Within this framework, digital technologies serve not only as tools for delivering information but also as mechanisms for generating knowledge through the analysis of data and relationships. Learning analytics therefore represents a practical application of connectivist principles within institutional management and educational practice.

The integration of analytics into university governance has significant implications for strategic decision-making. Through the systematic collection and analysis of academic indicators, universities can obtain detailed information regarding student engagement, course effectiveness, faculty performance, and institutional efficiency. This information supports evidence-based decision-making and reduces reliance on assumptions or subjective evaluations. Consequently, institutional leaders are better equipped to identify priorities, allocate resources, and formulate strategic plans aligned with organizational objectives (Siemens & Long, 2011).

Learning analytics also contributes to the personalization of education. Digital systems enable universities to monitor individual learning trajectories and provide targeted support based on students' specific needs. Early identification of learning difficulties allows instructors and administrators to implement preventive measures before academic problems become critical. Such capabilities contribute to improved educational outcomes and strengthen the overall effectiveness of institutional support systems (Siemens, 2013).

From a broader perspective, learning analytics demonstrates how digital technologies transform institutional management into a more systematic and data-driven process. Universities increasingly depend on analytical systems to evaluate performance, measure progress toward strategic goals, and ensure accountability. As higher education becomes more complex and competitive, the role of analytics in institutional governance is expected to continue expanding.

Systems Theory and Institutional Integration

The integration of EdTech and institutional management can also be understood through the lens of systems theory. According to the systems approach, organizations consist of interconnected components whose effectiveness depends upon coordination, communication, and mutual interaction. Universities represent complex systems composed of academic departments, administrative units, research centers, student services, and external stakeholders. Effective institutional performance requires continuous interaction among these elements.

Within traditional university structures, communication between different organizational units is often fragmented, resulting in delays, inefficiencies, and inconsistencies in decision-making. Digital technologies help overcome these limitations by creating integrated information environments that facilitate coordination across institutional boundaries. Through shared digital platforms, information can flow more efficiently among students, faculty members, administrators, and external partners, thereby improving organizational coherence and operational effectiveness (Peters & Jandrić, 2018).

The systems perspective highlights the importance of viewing educational technology not as an isolated component but as part of a larger institutional ecosystem. Academic, administrative, and strategic functions are increasingly interconnected through digital infrastructures that support communication, collaboration, and information exchange. Consequently, successful implementation of EdTech requires alignment among technological capabilities, organizational structures, and institutional objectives.

Digital ecosystems play an essential role in supporting this integration. A digital ecosystem can be defined as a unified environment in which technological platforms, users, data resources, and institutional processes interact within a common framework. Peters and Jandrić (2018) emphasize that the digital university depends upon the development of such ecosystems to coordinate educational and administrative activities effectively. Within these environments, information becomes more accessible, organizational processes become more transparent, and decision-making becomes more responsive to institutional needs.

The systems approach also emphasizes feedback mechanisms. Continuous feedback enables organizations to evaluate performance, identify weaknesses, and adapt to changing conditions. Digital technologies strengthen

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these capabilities by providing real-time information regarding educational and administrative activities. Consequently, universities can engage in ongoing assessment and improvement processes that support long-term institutional development.

Organizational Adaptability and Innovation-Oriented Management

The rapid pace of technological change has increased the importance of organizational adaptability within higher education institutions. Universities operate within dynamic environments characterized by changing student expectations, evolving labor-market demands, technological innovation, and increasing international competition. Under such conditions, institutional success depends largely upon the ability to adapt effectively to new circumstances.

Traditional management models are often characterized by rigid structures and slow decision-making processes. While such approaches may provide stability, they frequently struggle to respond effectively to rapidly changing environments. Digital technologies support greater organizational flexibility by enabling institutions to access information more quickly, identify emerging trends, and implement changes more efficiently (Brynjolfsson & McAfee, 2014).

Adaptability is closely connected to innovation-oriented management. Innovation-oriented management emphasizes continuous improvement, experimentation, and the development of new organizational capabilities. Rather than focusing exclusively on maintaining existing structures, innovative institutions actively seek opportunities for transformation and growth. Within higher education, this approach encourages universities to adopt new technologies, redesign educational processes, and develop more effective management practices (Oblinger, 2012).

Educational technology serves as an important catalyst for innovation within universities. Digital platforms facilitate collaboration, support knowledge sharing, and create opportunities for the development of new educational models. The adoption of online learning systems, digital assessment tools, and virtual collaboration environments illustrates how technological innovation can transform both academic and administrative activities. These developments contribute to the creation of more agile institutions capable of responding to changing educational and societal needs.

Innovation-oriented management also influences organizational culture. Successful digital transformation requires a culture that values experimentation, learning, and continuous improvement. University leaders play a crucial role in fostering such environments by encouraging technological adoption, supporting professional development, and promoting collaboration among stakeholders. Institutions that cultivate innovation-oriented cultures are generally better positioned to implement digital transformation initiatives successfully and achieve sustainable competitive advantages (Peters & Jandrić, 2018).

Furthermore, innovation within higher education extends beyond teaching and learning. Digital technologies influence research activities, student services, administrative procedures, and external partnerships. Consequently, EdTech contributes not only to educational improvement but also to broader institutional modernization. Through the integration of innovation-oriented management principles and digital technologies, universities can enhance their adaptability, strengthen organizational resilience, and support long-term strategic development.

The relationship between adaptability and innovation demonstrates that EdTech should not be viewed solely as a technological resource. Rather, it represents a strategic instrument that enables universities to respond effectively to environmental changes, improve institutional performance, and pursue sustainable growth in an increasingly digital world.

Methodology

This study employs a qualitative theoretical and analytical research approach to examine the integration of educational technology (EdTech) and institutional management in higher education. The methodological framework is designed to explore digital transformation as both a technological process and an institutional phenomenon affecting academic activities, administrative operations, governance structures, and strategic development.

The research is based on an extensive review and analysis of scholarly literature addressing educational technology, digital transformation, university governance, learning analytics, organizational change, and innovation-oriented management. Relevant theoretical perspectives and conceptual frameworks were examined to

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identify the principal factors influencing the adoption and effective integration of EdTech within higher education institutions.

To achieve the objectives of the study, several complementary analytical methods were employed. First, theoretical analysis was used to examine existing concepts and approaches related to digital transformation, educational technologies, and institutional management. Second, comparative analysis was applied to evaluate traditional management models alongside emerging digitally enabled governance approaches and to identify their respective strengths, limitations, and development prospects. Third, synthesis was employed to integrate findings from different theoretical perspectives and scholarly sources in order to establish a comprehensive understanding of the relationship between EdTech and institutional management.

The study also incorporates elements of content analysis through the systematic examination of academic publications and conceptual literature. This approach enabled the identification of recurring themes, challenges, opportunities, and strategic implications associated with the digital transformation of higher education institutions. Particular attention was given to issues related to learning analytics, digital ecosystems, organizational adaptability, digital leadership, innovation, and sustainable institutional development.

The chosen methodological approach provides a comprehensive framework for understanding how the integration of EdTech and institutional management contributes to the modernization of university governance, the improvement of educational processes, and the long-term development of higher education institutions in the digital era.

Discussion

The analysis of the literature and theoretical perspectives demonstrates that the integration of educational technology (EdTech) and institutional management has become a defining feature of contemporary higher education development. Digital transformation affects not only teaching and learning processes but also the governance structures, strategic priorities, and organizational culture of universities. As higher education institutions operate in increasingly dynamic and technology-driven environments, the effective integration of EdTech has emerged as a critical factor influencing institutional adaptability, competitiveness, and long-term sustainability.

One of the principal findings of this study is that EdTech should be understood as more than a collection of digital tools used to support educational activities. Contemporary educational technologies function as strategic resources that facilitate communication, improve information management, strengthen institutional coordination, and support evidence-based decision-making. Through learning analytics, digital platforms, and integrated information systems, universities are able to monitor academic performance, optimize resource allocation, and respond more effectively to emerging challenges. Consequently, the integration of EdTech contributes to the modernization of both academic and administrative processes.

The analysis further indicates that successful digital transformation depends on the alignment of technological innovation with institutional management practices. The adoption of digital technologies alone does not guarantee improved educational outcomes or organizational effectiveness. Universities must simultaneously develop appropriate governance models, leadership capacities, organizational cultures, and strategic frameworks capable of supporting technological change. Institutional readiness, staff competencies, and a commitment to continuous innovation therefore play essential roles in determining the effectiveness of EdTech integration.

Another important observation concerns the growing significance of digital ecosystems within higher education institutions. Integrated digital environments facilitate cooperation among students, faculty members, administrators, and external stakeholders while supporting the efficient flow of information across organizational structures. Such ecosystems contribute to greater transparency, operational efficiency, and institutional flexibility. They also strengthen universities' capacity to respond to social, economic, and technological changes while supporting innovation and knowledge creation.

The analysis additionally highlights the importance of addressing social and ethical dimensions associated with digital transformation. Issues related to digital equality, accessibility, privacy, and data security increasingly influence the successful implementation of educational technologies. Universities must therefore balance technological innovation with broader social responsibilities and ensure that digital transformation contributes to inclusive and equitable educational development. Sustainable integration of EdTech requires not only technological advancement but also the establishment of ethical frameworks that protect the interests of students, faculty members, and other stakeholders.

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Overall, the findings suggest that the integration of EdTech and institutional management represents a comprehensive transformation process that reshapes the operational mechanisms of higher education institutions. Universities that successfully combine technological innovation with effective governance practices are better positioned to improve educational quality, enhance organizational performance, and strengthen their contribution to the development of the knowledge society.

Conclusion

This study examined the integration of educational technology (EdTech) and institutional management within the context of digital transformation in higher education. The analysis focused on the theoretical foundations, strategic implications, and development prospects associated with the adoption of digital technologies in university governance and academic operations. By exploring existing literature and relevant theoretical perspectives, the study sought to explain how EdTech influences institutional structures, management processes, and educational practices.

The findings indicate that EdTech has evolved beyond its traditional role as a pedagogical support tool and has become an essential component of institutional development. The integration of digital technologies into university management contributes to improved communication, more effective decision-making, enhanced resource utilization, and greater organizational adaptability. Furthermore, learning analytics, digital ecosystems, and innovation-oriented management approaches provide higher education institutions with new opportunities to strengthen their competitiveness and respond more effectively to changing educational and societal demands.

The study also demonstrates that successful digital transformation requires a holistic approach that integrates technological, organizational, strategic, and social dimensions. The effectiveness of EdTech depends not only on the availability of digital infrastructure but also on leadership capacity, organizational culture, institutional readiness, and the development of sustainable governance practices. In this regard, the integration of EdTech and institutional management should be viewed as a long-term strategic process rather than a purely technological initiative.

As higher education continues to evolve in response to technological progress and the expansion of the knowledge economy, universities will increasingly depend on digitally enabled forms of governance and learning. Consequently, the development of comprehensive strategies that support the effective integration of EdTech into institutional management will remain an important priority for higher education institutions. Future research may further explore practical implementation models, comparative institutional experiences, and the long-term impacts of digital transformation on university performance and educational quality.

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TECHNOLOGY OF LEARNING FREE VERSE IN THE 21ST CENTURY

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ABSTRACT
In the globalized world, along with other fields of science, literature, which is the art of words, and its teaching technology have significantly benefited from the rapidly developing technological environment. The article examines new pedagogical and technological approaches used in the process of learning free verse in the 21st century, and examines the role of innovative teaching technologies. Constantly changing digital technologies have brought new methods to the teaching process, developed interactivity and student-oriented learning strategies in the mastery of poetic examples. The unique structure of the free verse form, far from traditional meter and standard rhyme, opens up great opportunities for students to develop analytical thinking and a creative approach when combined with interactive learning technologies. The research study examines multimedia tools, online platforms, interactive learning methods, virtual collaboration, digital analysis methods, and project-based mastery models that enable students to master poetic examples more deeply, improve their academic writing skills, and develop their creative potential. In addition, comparative analyses were conducted with traditional methods of studying free verse in the teaching of literature, the advantages of digital approaches based on modern learning technologies and the emerging problems were brought to the level of discussion. The conclusions obtained give reason to say that the use of new learning technologies makes the mastery of free verse effective, memorable, interesting, reveals the individual creative abilities of students, and leads to the formation of their necessary skills in accordance with the requirements set in modern lessons. The article also presents optimal approaches and pedagogical recommendations to ensure the effectiveness of studying free verse.
Key Words: free verse, learning technologies, innovative approach, online platforms, interactive methods, multimedia, digital approach

Introduction

Free verse, as a poetic form far removed from traditional rhyme and meter, provides an invaluable opportunity to develop students' creative potential and language skills (Taylor, 2018). New educational theories, especially constructivism and multidisciplinary learning approaches, are encouraging the use of modern technologies in teaching literature (Lee, 2021).

Although the use of traditional lessons in teaching free verse makes it possible to convey the technical features of the work, it is not enough to achieve effectiveness in mastering emotional poetic shades. In this sense, innovative approaches and technologies that come to the rescue develop the characteristics of mastery, creative thinking, and presentation in students.

The use of modern learning technologies in teaching includes advantages such as individual learning orientation, access to digital platforms, interactivity in student-teacher relationships, etc.

Adaptation to the application of innovative technologies in teaching free verse, which is far from the standard size in terms of structure and content, has not been late, but rather has been convenient and quick.

Free verse poetry, which opens up wide opportunities for the poet to freely convey his inner world, thoughts, and aesthetic worldview, is a form far removed from traditional rhyme, meter, standard structure, and patterns. Teaching free verse poetry creates the basis for increasing students' creative abilities and developing analytical thinking, as they learn to comfortably comment on the processes taking place in society and many issues in general, and perfect their artistic and aesthetic tastes.

Aim

The main goal of the article is to investigate the impact of a wide range of new educational technologies on the mastery of free verse examples in modern times, to reveal theoretical and practical approaches applied in the teaching process, and at the same time to determine the impact of digital platforms on the poetic thinking, creative and analytical thinking of students. In addition, it is to analyze the role of teachers in the process of teaching free verse, existing strategies, and innovative methods that are of great importance for improving the quality of education.

The goal is manifested both at the theoretical and practical levels. The theoretical goal is to create a theoretical basis for the use of new technologies in teaching poetic examples and to link it with creative learning theories. The practical goal includes issues such as analyzing the impact of the application of new educational technologies on

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the teaching process, developing methodological recommendations for teachers, and increasing the creative abilities of students.

While implementing the goal, certain questions may arise:
• What are the ways to apply modern technologies in teaching free poetry?
• How does the use of innovative technologies in the teaching process affect the development of students' creative abilities?
• What is the effectiveness of a modern lesson based on traditional lessons and new learning technologies?
• What problems and limitations may be encountered when using new technologies?
Such an approach increases the scientificity of the research and at the same time creates conditions for giving practical recommendations (Adams & Clark, 2020).

Significance
In modern times, the study of free verse poetry is of particular importance. As this genre allows students to freely express their thoughts, form their language and style characteristics, and improve their aesthetic taste (Smith & Brown, 2019).

The application of new teaching tools makes the teaching process more efficient and effective, and increases the motivation of students.

The importance of technologies applied in the teaching process is manifested in several ways.

• Developing students' creative abilities. Multimedia, online platforms, and interactive methods expand students' self-expression capabilities (Adams & Clark, 2020).

• Increasing student-teacher collaboration. The use of new technologies regulates teacher-student relationships and creates conditions for the dynamism of the educational process. (Johnson, 2020).

• Developing skills appropriate to new literature. Students read, write, analyze, and prepare creative projects from poetic samples.

Thus, teaching free verse is important in terms of pedagogical and intellectual development, and the application of new technologies increases the efficiency of this process.

Theoretical Framework
As is known, the 21st century is a period of rapid development of information and communication technologies. The technological revolution, which has led to radical changes, has not remained without its impact on all spheres of life, including education, and in one way or another, on the technology of teaching subjects - the issues of teaching literature. The application of new learning technologies creates the basis for easy and memorable mastering of free verse poetry, ensures interactivity, creates high motivation in students, and most importantly, makes them love literature.

It should be noted that in the current era, it is difficult to imagine the study of free verse poetry without new learning technologies. The application of digital technologies in the educational process creates conditions for students to understand the subject in an audio-visual format, to better remember it, to demonstrate activity in discussions, to reveal and improve their creative potential. This also leads to the regulation of teacher-student relations, the creation of an atmosphere of mutual cooperation. Such an approach to the educational process allows teachers to observe the dynamics of the development of students, to assess their creative potential, and to optimize the educational process. Modern technologies include online platforms related to education, various multimedia tools, libraries where electronic resources are concentrated, virtual environments, etc. Thus, the application of these technologies in the study of free verse in the 21st century makes the teaching process more effective and efficient.

The above gives grounds to say that new technologies create conditions for the study of free verse in a more orderly, scientific, and contemporary manner.

The use of technologies applied in teaching free verse is implemented in various directions. Let's look at a few of them.

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One of the widespread forms of these technologies is multimedia tools, or multimedia resources. The presentation of free verse examples using audio-video materials, slides, etc. increases attention and interest in the lesson, and helps to analyze the poem in detail. With the support of these tools, students not only read the poem, but also visually and aurally master it. This, as an effective direction, leads to both revealing an individual approach and group discussion, reaching general conclusions, and comparing and mastering the language and style features of poets.

Online platforms play a unique role in teaching free verse. Platforms such as Google Classroom, Moodle, Wattpad, etc. allow students to share their poems, get acquainted with the writings of their colleagues, as well as the opinions and recommendations of the other party. At the same time, the platforms create a favorable environment for the formation of academic writing skills, and encourage the development of analytical thinking in students.

A wide space can also be allocated to the use of creative projects in teaching free verse. Presenting the topic together with multimedia and visual presentation reveals and develops the creative potential of the student. This direction has many advantages. Thus, students master the technique of project preparation, the ability to present their work is formed, technical skills are also revealed, and artistic and aesthetic taste is formed.

Theoretically, free verse is based on the following principles:
• Freedom of rhyme and meter;
• Internal harmony that is consistent with the rhythm and dynamics of the words;
• The use of natural speech flow in poetic text;
• Wide possibilities for the use of symbols and metaphors.
The digital environment makes it more realistic and effective to analyze the rhythm, structure, and content of a poetic example (Miller, 2022).

Literature Review
Research on the topic shows that free verse teaching is more effective when supported by modern technology. The following studies further support this idea:

- Taylor (2018) states that digital poetry tools enhance free verse writing skills.
- Smith & Brown (2019) notes that free verse provides a more flexible teaching opportunity than traditional poetic forms.
- Lee (2021) emphasizes that multimedia tools enhance emotional understanding in students learning poetic examples.
- Miller (2022) states that digital platforms make poetic discussions more effective among students.
- Adams & Clark (2020) analyzes how new technologies affect the creative process and emphasizes the motivating role of digital learning environments.

Methodology
The methodological foundations of the research work include:
• Analytical approach
The structure, rhythm and symbolism of free verse are analyzed and presented to the students.
• Multimedia and visual-descriptive tools
Video clips are shown, and analysis of audio materials is presented.
• Online platforms
Students write, share and receive feedback on platforms such as Google Classroom, Padlet, Moodle.
• Evaluation criteria

- ✓ Creativity
- ✓ Language and style
- ✓ Metaphorical thinking
- ✓ Sense of rhythm
- ✓ Analytical analysis skills

Let's look at an example:
If the world suddenly lights up
If the sun suddenly rises one night,
If the world lights up all white;
City by city, street by street,
Room by room lights up,
We'll see whose hand
comes out of whose pocket.
Who bows and bows

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and leaves whose house.
If the sun suddenly rises one night,
If we see a thousand hidden sins,
If they can't cover them,
If we see this world naked,
We'll feel dizzy,
Maybe our minds will be confused.
Maybe everyone will suddenly turn their heads
and run away from the world.
So who will stay in this world,
Who will raise the children?!
...It's good that this world of ours
is slowly lighting up... (Ramiz Rovshan, 2021)

By using the above-mentioned methods in teaching literature, the study of free verse can be made more effective and memorable.

This approach creates a unified model that is aligned with both traditional and modern learning standards.

Findings and Discussion

The study shows that 21st century technologies make the study of free verse more dynamic, accessible, and creative. Multimedia tools facilitate the perception of the emotional layers of poetry, online platforms allow students to share their poetic experiences, and interactive applications serve to strengthen analytical skills. This integration creates new opportunities for both teachers and students, as well as for the teaching of literature in general.

Although the role of technologies in the teaching of free verse in the 21st century is great, the process faces a number of difficulties. These problems are related to both infrastructure, the characteristics of the learning environment, and pedagogical approaches.

In the 21st century, the study of free verse has entered a new stage with the widespread application of technologies. Multimedia, interactive, and digital platforms make the teaching of poetic examples more lively and interesting. New technologies, which overcome the limitations of traditional teaching methods, form the aesthetic taste of students, strengthen their analytical thinking and creative potential.

Theoretical and practical studies suggest that new learning technologies are not only an auxiliary tool in teaching free verse, but also a key component of mastery. However, there are difficulties such as technological problems, teacher training, and distraction. However, these difficulties can be overcome with the right approach.

As a result, the study of free verse in the 21st century requires the mutual integration of traditional methods and digital technologies. This approach ensures a deeper approach of students to poetry, the development of poetic analytical skills, and the formation of free thinking in creativity.

Teachers should use technology not only as a means of demonstration, but also as an interactive learning tool. Traditional methods should be combined with new digital technological tools.

Digital competence training should be organized for teachers in educational institutions. The use of special platforms for teaching poetic examples should be taught.

Students' creative thinking should be developed. Creative tasks, creative projects, visual activities should be used in the mastering of free poetry. This develops students' aesthetic taste and analytical skills.

Online platforms should be used systematically. Lesson plans, discussions, and task mechanisms should be standardized on Google Classroom, Moodle or other platforms, and digital resources should be prepared in advance.

Group work and individual tasks should be widely applied in teaching free poetry. This develops students' collective and specific poetic thinking.

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It is possible to increase students' interest in poetic creativity by organizing online meetings and seminars with contemporary poets.

The application of modern technologies gives reason to say that the main mission of teaching is not to transmit information, but to create a creative process that leads to student-teacher interactivity.

Thus, the technologies applied in the process of studying free verse in the 21st century open up modern opportunities in teaching literature, increase the efficiency of the teaching process, and pave the way for interactivity. This creates the basis for the development of not only the content in the teaching process, but also the development of creative abilities in students, the acquisition of necessary knowledge and skills, the formation of analytical thinking, and artistic and aesthetic taste. In this sense, the application of modern technologies is one of the main effective tools that stimulate the realization of the main mission set.

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THE CONTRIBUTION OF AZERBAIJANI PHILOSOPHERS TO THE METHODOLOGY OF TEACHING PHYSICS: HISTORICAL PERSPECTIVES AND MODERN EDUCATIONAL TRANSFORMATIONS

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ABSTRACT
This article explores the contribution of Azerbaijani philosophers to the methodology of teaching physics by examining the interplay between philosophical thought, educational theory, and contemporary pedagogical practice. Grounded in the philosophy of science and education, the study adopts a qualitative, theory-driven approach that integrates thematic content analysis, historical–interpretive analysis, and comparative synthesis of relevant scholarly literature. The findings indicate that Azerbaijani philosophical traditions have significantly influenced physics education by emphasizing the epistemological foundations of scientific knowledge, the nature of science, and the humanistic aims of education. Historically, Azerbaijani philosophers contributed to shaping physics teaching methodologies that balanced scientific rigor with moral, cultural, and civic values, particularly during periods of educational transformation. In the modern context, these philosophical perspectives align with international trends in science education, including constructivist learning, inquiry-based instruction, and argumentation-centered pedagogy. The study demonstrates that Azerbaijani contributions do not merely mirror global models but offer a culturally grounded and integrative framework that enriches the methodology of teaching physics. By highlighting the enduring relevance of philosophical reflection in physics education, the article underscores the potential of national intellectual traditions to inform innovative and reflective teaching practices in contemporary educational systems.
Key Words: philosophy of education; physics education methodology; Azerbaijani philosophers; nature of science; science education reform

Introduction

The methodology of teaching physics has never been a purely technical or content-driven enterprise; rather, it has always been deeply rooted in philosophical assumptions about knowledge, reality, cognition, and the nature of science itself. Contemporary science education research emphasizes that effective physics teaching requires not only mastery of scientific concepts but also an understanding of how scientific knowledge is generated, justified, and communicated within specific cultural and historical contexts (Lederman, 2018; Matthews, 2015). From this perspective, philosophy functions as a foundational framework that shapes curricular goals, pedagogical strategies, and learners' epistemological development in physics education (Taber, 2015; McComas, 2020).

Within this broader discourse, Azerbaijani philosophical thought occupies a distinctive position due to its synthesis of Eastern intellectual traditions, Soviet epistemology, and modern educational reforms. Azerbaijani philosophers and educators have historically engaged with questions of scientific rationality, national identity, and the social mission of education, thereby influencing approaches to science and physics teaching at both conceptual and methodological levels (Abbasov, 2017; Huseynov, 2018). Their contributions extend beyond abstract theorization, informing practical pedagogical models that integrate worldview formation, critical reasoning, and ethical responsibility into the teaching of natural sciences. Such an approach resonates with constructivist and sociocultural theories of learning, which emphasize the role of cultural mediation, dialogue, and social interaction in the construction of scientific knowledge (Driver et al., 2014; Vygotsky, 2012).

In recent decades, global transformations in science education—characterized by an increased focus on the nature of science, argumentation, and interdisciplinary thinking—have further highlighted the relevance of philosophical foundations in physics pedagogy (Erduran, 2020; Osborne, 2018). These trends align closely with the historical and modern contributions of Azerbaijani philosophers, whose ideas support a holistic vision of physics education that connects scientific concepts with historical development, philosophical reflection, and contemporary societal challenges. Therefore, the purpose of this article is to examine the contribution of Azerbaijani philosophers to the methodology of teaching physics through a dual lens: historical perspectives and modern educational transformations. By situating Azerbaijani thought within the international literature on philosophy of science education, the study aims to demonstrate its enduring relevance for developing reflective, conceptually grounded, and culturally responsive physics teaching practices (Holton, 2016; Erduran & Dagher, 2014).

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Theoretical Framework

The theoretical framework of this study is grounded in the intersection of philosophy of science, educational philosophy, and contemporary theories of science learning, with a particular focus on physics education. At its core, the framework assumes that the teaching of physics is inseparable from underlying epistemological and ontological views about the nature of scientific knowledge. Philosophers of science have long argued that scientific laws and theories are not merely neutral reflections of reality but are historically situated constructs shaped by paradigms, conceptual models, and methodological norms (Kuhn, 2012; Holton, 2016). Consequently, physics education must engage learners not only with established results but also with the philosophical processes through which scientific knowledge evolves.

A central component of this framework is the concept of the **nature of science (NOS)**, which has become a key organizing principle in modern science education. NOS emphasizes the tentative, theory-laden, and socially embedded character of scientific knowledge, challenging purely positivist and transmission-based models of instruction (Lederman, 2018; McComas, 2020). Integrating NOS into physics teaching encourages students to understand physical laws as explanatory models rather than immutable truths, thereby fostering deeper conceptual understanding and critical thinking. Azerbaijani philosophers and educators, particularly in the post-Soviet context, have contributed to this perspective by linking scientific rationality with cultural values, ethical responsibility, and national educational goals (Abbasov, 2017; Huseynov, 2018).

The framework also draws on **constructivist and sociocultural theories of learning**, which view knowledge construction as an active, socially mediated process. According to these theories, learners build scientific understanding through interaction, dialogue, and the use of cultural tools, including language and symbolic systems (Driver et al., 2014; Vygotsky, 2012). In physics education, this implies a shift from algorithmic problem-solving toward inquiry-based learning, conceptual modeling, and argumentation. Philosophical reflections on science play a crucial role in this shift by helping learners articulate assumptions, evaluate evidence, and justify claims within a coherent epistemic framework (Erduran, 2020; Osborne, 2018).

Another key dimension of the theoretical framework is the role of **history and philosophy of science (HPS)** as a pedagogical resource. Research has shown that incorporating historical case studies and philosophical analysis into physics instruction enhances students' understanding of core concepts, the development of scientific ideas, and the human dimensions of scientific practice (Matthews, 2015, 2020; Niaz, 2016). This approach aligns with Azerbaijani philosophical traditions that emphasize the unity of scientific knowledge, moral education, and societal progress, thereby reinforcing the relevance of national intellectual heritage within modern physics pedagogy (Alizadeh & Mammadov, 2019).

Finally, the framework acknowledges the influence of democratic and reflective educational ideals, particularly those associated with progressive education. Education is viewed not only as knowledge transmission but as a means of cultivating reflective, responsible, and critically minded citizens capable of engaging with scientific and technological challenges (Dewey, 2016). From this standpoint, the contribution of Azerbaijani philosophers to physics education methodology can be understood as part of a broader effort to harmonize scientific rigor with humanistic values. Together, these theoretical perspectives provide a coherent foundation for analyzing how philosophical thought has shaped, and continues to shape, the methodology of teaching physics in Azerbaijan within both historical and contemporary educational contexts.

Literature Review

The literature on the methodology of teaching physics demonstrates a strong and growing consensus that effective science education is inseparable from philosophical reflection on the nature of scientific knowledge, learning, and teaching. Early and contemporary studies in science education emphasize that understanding physics requires more than procedural competence; it requires engagement with the epistemological foundations of science, including how theories are constructed, validated, and revised over time (Kuhn, 2012; Holton, 2016). Within this context, the philosophy of science has been increasingly recognized as a critical resource for shaping pedagogical approaches that promote conceptual understanding and scientific reasoning.

A substantial body of research focuses on the **nature of science (NOS)** as a core component of science and physics education. Scholars argue that students' misconceptions about physics often stem from naïve realist or absolutist views of scientific knowledge, which can be addressed through explicit instruction on NOS principles (Lederman, 2018; McComas, 2020). Studies by Erduran and Dagher (2014) and Allchin (2017) further demonstrate that philosophical perspectives on science—such as theory-ladenness, the role of models, and the social dimensions of scientific practice—enhance learners' ability to critically evaluate scientific claims. These findings provide a theoretical justification for embedding philosophical discussions within physics curricula.

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Another prominent strand of the literature examines **constructivist and sociocultural approaches** to physics teaching. Research in this area highlights that scientific knowledge is actively constructed through interaction, discourse, and guided inquiry rather than passively received (Driver et al., 2014). Drawing on sociocultural theory, Vygotsky (2012) emphasizes the role of language, mediation, and social context in cognitive development, a perspective that has been widely applied in physics education to support collaborative learning and conceptual change. These approaches align with philosophical arguments that knowledge is context-dependent and shaped by human activity, reinforcing the relevance of philosophy in physics pedagogy.

The integration of **history and philosophy of science (HPS)** into physics education has also been extensively explored. Matthews (2015, 2020) and Niaz (2016) provide evidence that historical case studies and philosophical analysis of scientific revolutions help students grasp abstract physical concepts and appreciate the dynamic nature of scientific progress. Such approaches challenge linear and ahistorical presentations of physics content, instead portraying science as a human endeavor influenced by cultural, social, and intellectual factors. This line of research is particularly relevant for educational systems seeking to balance global scientific standards with national intellectual traditions.

Within the Azerbaijani and broader post-Soviet context, scholars have addressed the relationship between philosophy, education, and national identity. Abbasov (2017) argues that educational philosophy in Azerbaijan has played a central role in integrating scientific rationality with cultural values and civic responsibility. Complementing this view, Huseynov (2018) highlights how post-Soviet science education reforms have drawn on philosophical foundations to redefine educational aims and methodologies. Alizadeh and Mammadov (2019) specifically emphasize the contribution of philosophical thought to the development of physics education methodology, noting its influence on curriculum design, teacher preparation, and instructional strategies.

Recent studies further underscore the importance of **argumentation and reflective practice** in science and physics education. Erduran (2020) and Osborne (2018) demonstrate that argumentation-based instruction, grounded in philosophical reasoning, supports deeper understanding of scientific concepts and enhances students' ability to justify and critique knowledge claims. Similarly, research on teacher education highlights that philosophical and pedagogical reflection is essential for preparing physics teachers capable of implementing inquiry-based and learner-centered approaches (Taber, 2015; Aydın & Mirici, 2021).

Overall, the reviewed literature indicates that philosophy serves as a unifying framework connecting epistemology, pedagogy, and cultural context in physics education. While international research provides robust theoretical and empirical support for this integration, studies focusing on Azerbaijani philosophical contributions remain relatively limited. This gap underscores the need for systematic analysis of how Azerbaijani philosophers have influenced the methodology of teaching physics, particularly in light of contemporary educational transformations.

Methodology

This study adopts a **qualitative, theory-driven research design** aimed at examining the contribution of Azerbaijani philosophers to the methodology of teaching physics through historical and contemporary perspectives. Given the conceptual and interpretive nature of the research problem, the methodology is grounded in **philosophical analysis, systematic literature review, and comparative interpretive synthesis**, which are widely recognized approaches in research on science education and philosophy of education (Matthews, 2015; Taber, 2015).

Research Design

The research follows a **conceptual–analytical framework**, focusing on the analysis of philosophical ideas, educational theories, and pedagogical models rather than empirical experimentation. This design is appropriate for investigating how philosophical thought informs methodological principles in physics education, particularly in relation to epistemology, the nature of science, and learning theory (Kuhn, 2012; Lederman, 2018). The study is exploratory and explanatory in nature, aiming to identify patterns, conceptual links, and theoretical implications rather than to test hypotheses.

Data Sources and Selection Criteria

The primary data sources consist of peer-reviewed journal articles and scholarly books included in the predefined reference list. These sources were selected based on their relevance to four key thematic domains:

1. philosophy of science and education,
2. methodology of physics and science teaching,
3. history and philosophy of science in education, and

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4. Azerbaijani and post-Soviet educational thought.

All sources meet international academic standards and provide theoretical or analytical insights into the relationship between philosophy and physics education (Abbasov, 2017; Huseynov, 2018; Erduran & Dagher, 2014). The exclusive use of this curated reference set ensures conceptual coherence and consistency in the analytical process.

Analytical Procedures

The analysis was conducted in three interrelated stages. First, a **thematic content analysis** was applied to identify recurring philosophical concepts relevant to physics education, such as scientific rationality, epistemological assumptions, constructivism, and the nature of science (McComas, 2020; Allchin, 2017). Second, a **historical–interpretive analysis** was employed to trace how these concepts have been articulated and adapted within Azerbaijani philosophical and educational discourse, particularly in the context of national identity and educational reform (Abbasov, 2017; Alizadeh & Mammadov, 2019). Third, a **comparative synthesis** was undertaken to relate Azerbaijani contributions to dominant international frameworks in science education, including constructivist, sociocultural, and argumentation-based approaches (Driver et al., 2014; Erduran, 2020).

Validity and Trustworthiness

To enhance the trustworthiness of the study, **theoretical triangulation** was employed by integrating multiple philosophical and pedagogical perspectives drawn from the literature. Consistency was ensured through systematic cross-referencing of concepts across sources and careful alignment between the theoretical framework and analytical categories (Matthews, 2020; Osborne, 2018). Rather than statistical validity, the study emphasizes **conceptual validity**, achieved through transparent reasoning, coherent argumentation, and alignment with established theories in science education and educational philosophy.

Ethical Considerations and Limitations

As a theoretical and literature-based study, the research does not involve human participants and therefore does not raise issues related to informed consent or data confidentiality. However, the study acknowledges certain limitations, including its reliance on published sources and the interpretive nature of philosophical analysis. While this approach allows for deep conceptual insight, it may not fully capture classroom-level practices, which could be addressed in future empirical research on physics teaching methodologies informed by Azerbaijani philosophical thought (Aydın & Mirici, 2021; Dewey, 2016).

In sum, the adopted methodology provides a rigorous and coherent basis for analyzing how philosophical ideas originating in Azerbaijani intellectual traditions contribute to the development and transformation of physics teaching methodology within a modern educational context.

Findings and Discussion

This section presents the findings derived from the application of the three methodological approaches outlined earlier—**thematic content analysis**, **historical–interpretive analysis**, and **comparative synthesis**. The results are organized in table-based form to ensure analytical clarity and to demonstrate how each method contributes to understanding the role of Azerbaijani philosophers in shaping the methodology of teaching physics. Each table is followed by a focused discussion.

Findings from Thematic Content Analysis

The thematic content analysis identified recurring philosophical themes that directly inform physics teaching methodology. These themes reflect both global trends in science education and context-specific Azerbaijani contributions.

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Table 1. Key Philosophical Themes and Their Methodological Implications for Physics Teaching

Philosophical theme	Core idea	Methodological implication for physics teaching	Supporting sources
Nature of science (NOS)	Scientific knowledge is tentative, model-based, and theory-laden	Teaching physics through models, explanations, and critical evaluation rather than rote laws	Lederman (2018); McComas (2020); Erduran & Dagher (2014)
Constructivism	Knowledge is actively constructed by learners	Use of inquiry-based learning, conceptual change strategies, and student-centered instruction	Driver et al. (2014); Vygotsky (2012)
Argumentation	Scientific knowledge advances through reasoned debate	Integration of argumentation, evidence-based reasoning, and justification tasks in physics lessons	Erduran (2020); Osborne (2018)
Humanistic orientation	Science education serves moral and civic development	Linking physics concepts with ethical reflection and societal relevance	Dewey (2016); Abbasov (2017)

Thematic analysis reveals that Azerbaijani philosophical perspectives align closely with international NOS-oriented and constructivist approaches. However, a distinctive feature is the explicit emphasis on the humanistic and civic role of science education, which broadens physics teaching beyond conceptual mastery toward value-oriented learning. This supports a methodology where physics is taught as both an explanatory science and a cultural achievement.

Findings from Historical–Interpretive Analysis

The historical–interpretive method highlights how Azerbaijani philosophical thought has evolved and influenced educational methodology across different periods.

Table 2. Historical Stages of Azerbaijani Philosophical Influence on Physics Education Methodology

Period	Dominant philosophical orientation	Influence on physics teaching methodology	Key references
Soviet period	Scientific rationalism, materialism	Emphasis on systematic knowledge, formal logic, and law-based instruction	Kuhn (2012); Huseynov (2018)
Post-Soviet transition	Reinterpretation of philosophy and national identity	Curriculum revision integrating critical thinking and cultural context	Abbasov (2017); Huseynov (2018)
Contemporary reforms	Integrative and reflective philosophy of education	Inquiry-based, argumentation-driven, and learner-centered physics teaching	Alizadeh & Mammadov (2019); Aydın & Mirici (2021)

The historical analysis demonstrates a clear shift from rigid, content-heavy instruction toward reflective and student-centered methodologies. Azerbaijani philosophers played a mediating role in this transition by reconciling inherited scientific rigor with emerging educational values such as autonomy, critical inquiry, and cultural relevance. This evolution mirrors global reform trends while preserving national intellectual continuity.

Findings from Comparative Synthesis

The comparative synthesis situates Azerbaijani contributions within the broader international literature on physics and science education.

Table 3. Comparison of Azerbaijani Philosophical Contributions with International Frameworks

Dimension	International science education frameworks	Azerbaijani philosophical contribution	Key sources
Epistemological stance	Emphasis on NOS and paradigm awareness	Integration of NOS with national and cultural perspectives	Lederman (2018); Abbasov (2017)
Pedagogical focus	Inquiry, modeling, argumentation	Inquiry enriched with ethical and civic dimensions	Erduran (2020); Dewey (2016)
Teacher education	Reflective and research-informed practice	Philosophy as a core component of teacher professional identity	Taber (2015); Aydın & Mirici (2021)
Role of history & philosophy	Contextualizing scientific concepts	Systematic use of philosophical reflection in curriculum design	Matthews (2015, 2020); Niaz (2016)

The comparative findings indicate that Azerbaijani philosophical thought does not merely replicate international

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models but **contextualizes and extends them**. By embedding physics education within broader philosophical and cultural narratives, Azerbaijani approaches contribute a distinctive model of methodological enrichment that balances global standards with local intellectual traditions.

Integrated Discussion of Findings

Across all three methodological approaches, the findings converge on several key conclusions. First, philosophy functions as a **structuring principle** in physics education methodology, shaping how content is selected, organized, and taught. Second, Azerbaijani philosophers have contributed a **holistic vision** of physics teaching that integrates epistemology, pedagogy, and values education. Finally, the table-based analyses demonstrate that these contributions remain highly relevant in the context of modern educational transformations, particularly those emphasizing inquiry, argumentation, and reflective practice.

Taken together, the findings suggest that the methodology of teaching physics in Azerbaijan has been significantly enriched by philosophical thought, offering a model that is both internationally aligned and culturally grounded.

Conclusion

This study has examined the contribution of Azerbaijani philosophers to the methodology of teaching physics through a comprehensive analysis of historical perspectives and modern educational transformations. Drawing on a clearly defined theoretical framework and a qualitative, theory-driven methodology, the findings demonstrate that philosophical thought has played a central and enduring role in shaping how physics is conceptualized, taught, and learned within the Azerbaijani educational context.

The analysis shows that Azerbaijani philosophers have consistently emphasized the epistemological foundations of scientific knowledge, aligning physics education with broader reflections on the nature of science, rational inquiry, and human cognition. By integrating philosophical perspectives into physics pedagogy, they have contributed to moving instruction beyond the transmission of formulas and laws toward a deeper engagement with scientific reasoning, modeling, and explanation. This approach resonates with contemporary international trends that highlight the importance of the nature of science, constructivist learning, and argumentation in science education (Lederman, 2018; McComas, 2020; Erduran, 2020).

Historically, Azerbaijani philosophical thought has acted as a mediating force during periods of educational change, particularly in the transition from Soviet-era instructional models to post-Soviet and contemporary reforms. Philosophers and educators played a key role in reconciling inherited scientific rigor with emerging pedagogical values such as critical thinking, learner autonomy, and cultural relevance (Abbasov, 2017; Huseynov, 2018). As a result, the methodology of teaching physics in Azerbaijan has evolved into a more reflective and student-centered practice, while maintaining a strong commitment to conceptual coherence and scientific accuracy.

In the context of modern educational transformations, the contribution of Azerbaijani philosophers remains highly relevant. Their emphasis on the unity of science, culture, and ethics provides a holistic framework for physics education that supports not only cognitive development but also the formation of responsible and critically minded citizens. This humanistic orientation, combined with inquiry-based and argumentation-driven methodologies, offers a distinctive model that enriches international discussions on physics education reform (Dewey, 2016; Matthews, 2020; Aydın & Mirici, 2021).

In conclusion, the study underscores that Azerbaijani philosophical contributions to the methodology of teaching physics represent a valuable and underexplored intellectual resource. By systematically integrating these ideas into contemporary physics education, educators and curriculum designers can enhance conceptual understanding, foster critical and reflective thinking, and ensure that physics teaching remains both scientifically rigorous and culturally meaningful. Future research may build on these findings through empirical classroom studies, further exploring how philosophical frameworks can be operationalized in physics teaching practice and teacher education programs.

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THE EFFECTIVENESS OF LEARNING TAXONOMIES IN THE TEACHING OF THE AZERBAIJAN LANGUAGE

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ABSTRACT
In the contemporary pedagogical environment, there is an increasing need for systematic and scientifically grounded approaches to enhance the efficiency of the learning process. In this context, learning taxonomies, particularly Bloom's taxonomy, serve as a significant methodological framework in the teaching of the Azerbaijani language. Taxonomies allow students to approach the language not merely as a set of grammatical rules but as a complex system of skills encompassing various levels of cognitive activity. In Azerbaijani language lessons, the primary goal is not only the transmission of knowledge but also the development of students' abilities to think critically, make connections, analyze, demonstrate creativity, and apply knowledge. Therefore, the application of taxonomies directly influences the quality of the learning process. Bloom's taxonomy structures cognitive activity across six levels—knowledge, comprehension, application, analysis, synthesis, and evaluation—providing teachers with a structured model for lesson planning and assessment. In the teaching of Azerbaijani, this model proves especially effective in areas such as text analysis, speech culture, writing skills, and the acquisition of language rules. Through the use of the taxonomy, students do not merely memorize information; they internalize it, apply it in new situations, analyze texts, establish logical connections between ideas, and justify their own viewpoints.

Research indicates that lesson models incorporating taxonomies enhance students' self-expression, strengthen reflective thinking skills, and foster an interactive learning environment. In Azerbaijani language classes, this approach contributes both to the effective development of language competencies and to student-centered teaching. Taxonomies enable teachers to adopt a differentiated approach, design tasks according to students' varying levels, and ensure a more objective assessment process. Consequently, the application of learning taxonomies in the teaching of Azerbaijani is not only a methodological innovation but also an effective pedagogical tool that supports students' cognitive development, thinking flexibility, and communicative skills. The purposeful implementation of this model positively impacts the quality of language education and facilitates the cultivation of competent students who meet the demands of the twenty-first century.
Key Words: learning taxonomies, Bloom's taxonomy, educational process, language learning, communicative functions

Introduction

In the contemporary educational process, the formation of students' knowledge is not limited to the mere transmission of information. The effectiveness of teaching is closely linked to the development of students' cognitive skills, as well as their analytical and creative thinking abilities. In this context, learning taxonomies hold a significant place in both pedagogical theory and practice, as they systematically classify different levels of learning activity and enable teachers to plan lessons purposefully. The teaching of the Azerbaijani language, like that of other languages, targets not only the acquisition of grammatical rules but also the development of students' abilities to think, communicate, and express themselves through language. For this purpose, the use of taxonomies—particularly models such as Bloom, Krathwohl, Harrow, and SOLO—supports the systematic development of students' cognitive, affective, and psychomotor skills. Bloom's taxonomy facilitates the organization of learning tasks according to levels of knowledge, comprehension, application, analysis, synthesis, and evaluation. Krathwohl's taxonomy emphasizes the formation of emotions, motivation, and values, while Harrow's taxonomy focuses on the development of psychomotor skills. The SOLO taxonomy, on the other hand, assists in assessing the structure and quality of students' responses. The implementation of these taxonomies in Azerbaijani language lessons renders the teaching process more purposeful, interactive, and student-centered. They provide teachers with a structured approach for lesson planning, regulating task difficulty, and assessment, while simultaneously supporting the effective development of students' language skills and enhancing their analytical thinking and communicative competence. The primary aim of this study is to examine the effectiveness of learning taxonomies in the teaching of the Azerbaijani language, determine the role of various taxonomies in the lesson process, and evaluate their impact on the development of students' cognitive, emotional, and motor skills. Within the scope of the research, the comparative analysis of theoretical and practical approaches, along with the evaluation of lesson examples and teaching methods, will explore how these approaches contribute to the efficiency of student-centered learning. Language teaching is an instructional activity directed at forming relevant competencies in students through the interactive process between the teacher and learner. Language acquisition encompasses a set of tasks that require the development of target competencies, particularly those necessary for

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successful communicative activity. These competencies include listening to general or specific information, drafting business documents, writing personal letters, preparing congratulatory speeches, or delivering scientific presentations. Teaching methods in language education can be determined based on theoretical approaches and incorporate theoretical insights regarding the structural and communicative functions of the language. Depending on the methodology employed, the roles of the teacher and the student may vary: the teacher may act either as a corrector of errors and a more passive participant in the learning process or as a leader who directly influences the outcomes of instruction. Likewise, the student's role may range from memorizing material without understanding to fully comprehending its essence. Learning can be considered effective when information is transmitted from the teacher to the student and the knowledge acquired is enriched by the student with new insights. Language learning is a purposeful process of mastering a language, conducted both in formal settings with a teacher and independently in informal environments (Anderson & Krathwohl, 2001).

Literature Review

The process of language learning can be described through the framework of educational taxonomy. A learning taxonomy encompasses characteristic features related to the domain of learning. Among the most widely recognized taxonomies are those presented by Bloom, which cover the cognitive, psychomotor, and affective domains. These domains are of particular importance in the process of language acquisition.

Recent pedagogical studies emphasize that the integration of learning taxonomies contributes significantly to the development of higher-order thinking skills. When teachers design tasks according to hierarchical cognitive levels, students gradually move from simple recall to complex intellectual operations such as critical evaluation and creative production. In language education, this process is especially important because communicative competence requires not only knowledge of grammar but also the ability to interpret, analyze, and produce meaningful discourse.

The educational taxonomy was developed in 1956 by a group of researcher-psychologists led by the renowned American psychologist Benjamin Bloom, who specialized in teaching methods in pedagogy. In the 1960s, Bloom authored and published two significant scientific works that laid the foundation for his concept, known as Bloom's taxonomy. These works are "*Stability and Change in Human Characteristics"* and "*Taxonomy of Educational Objectives"* (Povey, 2019).

It is important to note that Bloom's taxonomy gained considerable popularity in U.S. educational institutions during the 1960s, although its application in schools declined somewhat over time due to critical perspectives.

An educational taxonomy is a system based on the principle of classifying and categorizing different levels of learning. It provides a framework that allows teachers to apply the principles of a six-stage diagram and the foundations of intellectual education in ordinary classroom settings. The levels of Bloom's taxonomy, arranged from simple to complex, include knowledge, comprehension, application, analysis, evaluation, and creative activity. All six levels belong to the cognitive domain, which relates to how the brain processes information and thought.

Another important advantage of taxonomic models is their ability to support differentiated instruction. Students possess varying levels of cognitive readiness, and the taxonomy framework allows teachers to create tasks that correspond to these differences. Lower-level tasks help learners establish basic knowledge, while higher-level tasks challenge advanced learners to synthesize ideas and formulate independent conclusions (Marzano, & Kendall, 2007). Such differentiation increases motivation and encourages active participation in the learning process.

From a methodological perspective, learning taxonomies also contribute to the transparency and objectivity of assessment. Clearly defined levels of cognitive activity allow educators to formulate measurable learning outcomes and design evaluation criteria that reflect the depth of student understanding (Richards, & Rodgers, 2014). As a result, assessment becomes not merely a measurement of memorized information but a comprehensive evaluation of students' analytical and communicative abilities.

If Bloom's taxonomy is visualized as a pyramid, the base represents the level of knowledge, which involves the ability to remember and reproduce previously learned information. Methods of demonstrating this stage include reading, repetition, and highlighting key points in textbooks and notebooks.

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The next level, comprehension, involves understanding meaning, translation, interpretation, and the ability to express information in one's own words. Methods of expression include identifying similarities and parallels, describing analogous events, and searching for information online.

The third level, application, requires the student to use previously acquired knowledge in various situations. Methods of expression at this stage involve applying methods, theories, laws, principles, and concepts in new and concrete practical contexts.

One of the central stages of Bloom's taxonomy is analysis. This stage involves breaking down material into its constituent parts and identifying similarities and differences among them. Methods of expression include identifying hidden assumptions, recognizing errors and gaps during reasoning, and distinguishing facts from consequences.

The fifth stage, synthesis, entails the ability to combine and generalize knowledge to create a new, original solution or product, such as a novel approach to a problem. Means of expression include writing presentations or essays, preparing action plans, and systematizing existing information.

At the apex of the pyramid is evaluation, which involves assessing a position, work, or study. Evaluation may include analyzing and critiquing the concepts of others, as well as assessing one's own perspective. Methods of expression include the ability to evaluate the logic of a concept and to determine the significance of specific outcomes.

Methodology

The process of language learning can be analyzed through the framework of educational taxonomy. Bloom's taxonomy, introduced in 1956, classifies learning objectives into hierarchical levels ranging from simple recall to complex evaluation and creation. This structure allows teachers to organize instructional activities systematically and design tasks that gradually increase cognitive complexity.

Findings and Discussion

Three primary approaches can be identified in language acquisition. First is the classical accumulation of knowledge through memorization, consistent with the traditions of behaviorism established in the mid-20th century. In this approach, learning relies on mechanical memorization and repetitive practice of language patterns, with skill acquisition facilitated through repeated "stimulus–response" sequences.

According to B. F. Skinner, operant conditioning or reinforcement prepares learners to use their knowledge in previously unspecified, naturally occurring situations. In operant conditioning, spontaneous behavior and unprepared reactions to unexpected circumstances are positively reinforced (Pikhart & Klimova, 2019).

The cognitive approach, based on E. Tolman, teaches learners to use their knowledge for problem-solving in communicative contexts and aims to prepare students to "navigate real-life situations appropriately" (Tsulaia, 2023). Instruction should focus on students' mental processes and actions that involve understanding and correctly applying language structures in speech.

According to the theory of the renowned American linguist Noam Chomsky, language acquisition is directly associated with the brain's internalization of language rules, resulting in progressively fewer errors. Chomsky proposed that language learning is governed by specific rules, and the child's mind applies these rules in real-world situations, enabling human cognition to handle an infinite range of communicative contexts (Krathwohl, 2002).

Cognitivism presents the learner as an active processor of information. Language acquisition occurs most effectively when students gain experience by solving problems according to their own understanding.

The primary goal of language instruction is the formation and development of students' communicative competence, which entails mastering various types of speech activities. The subject of speech activity is thought itself; in essence, every speech task is a speech–thinking task. Language serves as a tool for the formation and expression of thought. Two key methodological implications arise from this perspective. First, for the successful development of skills and abilities in any type of speech activity, each student must be provided with opportunities for active oral practice. Second, through engaging in problem-solving tasks, students' attention should be directed toward the content of their speech, placing thought at the center while using language as a tool for shaping and expressing ideas.

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The use of Bloom's taxonomy in English and other language lessons helps address these pedagogical challenges by organizing students' cognitive activity and supporting the development of oral communication skills. The cultivation of communicative competence remains a central aim of language teaching. Within the communicative approach, all tasks and exercises should inherently promote speech, emphasizing interaction and meaningful communication. E.I. Passov categorizes exercises into two types: conditional-speech and speech exercises. Conditional-speech exercises are specifically organized to develop a particular speech skill, often through repetitive practice of lexical units of the same type. In contrast, speech exercises require students to engage in cognitive–speech problem-solving during task performance.

Bloom's taxonomy facilitates the logical sequencing of speech–thinking tasks from simple to complex, stimulating motivation, engaging learners in communication, and promoting the development of higher-order thinking skills.

Krathwohl's taxonomy, developed under Bloom's guidance, focuses on the affective domain, emphasizing learners' attitudes, emotional responses, and value-based development. This taxonomy describes the sequential stages of affective growth, from information reception to the integration of values as an intrinsic part of the learner's personality (Krathwohl, 2002). At the initial stage, the student is prepared merely to receive information, focusing on listening and comprehension. In the subsequent stage, the learner actively participates and demonstrates engagement through behavior, such as contributing to discussions and forming personal viewpoints on the topic. In the third stage, value internalization occurs, whereby the student adopts specific ideas as personal beliefs and demonstrates these values in behavior. In the following stage, learners organize their values, establish priorities, and create a structured hierarchy among them. Finally, in the last stage, these values are fully integrated into the student's personality, guiding behavior, decisions, and daily choices. At this level, values cease to be mere behaviors and become central elements of character.

This structured combination of cognitive and affective taxonomies provides educators with a comprehensive framework to develop language skills that are not only functional but also meaningful, reflective, and deeply embedded in learners' personal and social contexts.

The Harrow taxonomy addresses the psychomotor domain, classifying the development of physical skills and motor coordination. This model describes a sequential progression from reflex-level movements to complex motor activities. Initially, reflexive reactions are observed in the learner. Subsequently, the learner develops basic control of physical movements, such as walking, running, and jumping. At the next stage, learners coordinate their movements with sensory information—for example, catching a ball or accurately copying a geometric figure—demonstrating the integration of perception and action. Following this, the quality indicators of physical abilities, including endurance, strength, and flexibility, are developed. At more advanced stages, the learner masters complex motor tasks requiring sequential coordination, such as playing a musical instrument, driving, or swimming. The highest stage of psychomotor development involves non-verbal communication, where the body is used expressively to convey emotions and meaning, as in dance, pantomime, or acting.

The SOLO taxonomy (Structure of the Observed Learning Outcome), developed by John Biggs and Kevin Collis, is a classification system focused on the structure and quality of learners' responses rather than the thinking process itself (Biggs & Collis, 1982). It allows educators to evaluate how a learner's response is structured, the level of integration, and the degree of generalization. At the initial stage, the learner's response may be irrelevant to the topic or absent altogether. At the next level, the learner grasps only one aspect of the topic. In subsequent stages, multiple aspects may be identified, but logical connections between them are not established. At the relational stage, learners integrate various aspects into a unified structure, demonstrating understanding of the relationships and the essence of the topic. The extended abstract stage, the highest level of SOLO, involves generating new hypotheses, extrapolating beyond the given context, and producing broader theoretical generalizations. This stage represents the pinnacle of creative, analytical, and conceptual thinking.

Table 1. Comparative Characteristics of Learning Taxonomies

Taxonomy	Domain	Main Levels	Educational Application
Bloom	Cognitive	Remember, Understand, Apply, Analyze, Evaluate, Create	Planning lessons and assessing cognitive development
Krathwohl	Affective	Receiving, Responding, Valuing, Organizing, Characterizing	Developing attitudes, motivation and value orientation
Harrow	Psychomotor	Reflexes, Basic movements, Perceptual abilities, Skilled movements	Development of motor and physical performance skills
SOLO	Cognitive structure	Pre-structural, Uni-structural, Multi-structural, Relational, Extended abstract	Evaluation of the structure and quality of students' responses

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A comparative analysis of these taxonomies demonstrates that each system organizes a different dimension of learning, providing teachers with critical analytical tools for instructional planning. Bloom's taxonomy allows teachers to evaluate students' cognitive sequencing, including what they can think, analyze, and create. Krathwohl's taxonomy monitors learners' affective and value-based development, showing what they feel and which values they internalize. Harrow's taxonomy organizes students' motor skills, coordination, and physical performance, indicating what learners can do. SOLO taxonomy provides a structured framework for assessing the depth and quality of learners' responses, offering an objective measure of response sophistication.

As an example of applying Bloom's taxonomy to the development of speech–thinking activities, a lesson model for the 4th-grade Azerbaijani language topic "Punctuation in Writing" is presented, illustrating how cognitive, affective, and psychomotor dimensions can be systematically integrated into classroom instruction.

Lesson Topic: "Punctuation in Writing"
Grade: 4
Subject: Azerbaijani Language
Method: Bloom's Taxonomy (Tasks organized across six levels)

1. Remembering
Objective: Students recall the main punctuation marks and name them.
Teacher's Activities:
- Displays punctuation marks on the board: . , : ; ? ! - " " ( )
- Provides a brief explanation; the main recall comes from students.

Student Tasks:
- List the names of the punctuation marks.
- Complete sentences:
  - "A question mark is placed at the end of …"
  - "Quotation marks are used for …"
  -

2. Understanding
Objective: Students explain the usage of punctuation marks.
Teacher's Activities:
- Writes examples on the board and asks students to explain them.

Student Tasks:
- Read the following sentences and explain correctly:

1. "Grandmother said: 'Come quickly!'" — Why are the colon and quotation marks used here?
2. "Emil, bring the book." — Explain why the comma is used.
3. "The book – is the key to knowledge." — Why is the dash used here?

3. Applying
Objective: Students correctly apply punctuation marks in new sentences.
Tasks:
- Insert appropriate punctuation marks into the following sentences:

1. Nermin said to me this morning do not forget your book
2. What beauty is this
3. Ali Leyla Samir and Gunel registered for the club
4. Atatürk said My greatest work is the Republic of Turkey

4. Analyzing
Objective: Students analyze the functional differences of punctuation marks.
Task:
- Compare the following sentences:

1. He said he will come.
2. He said: "I will come."

Questions:
- Which punctuation marks are used in each sentence?
- What is the difference in meaning between the sentences?
- Why are colon and quotation marks used in one, and a comma in the other?

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5. Evaluating
Objective: Students justify correct or incorrect usage of punctuation marks.
Task:
- Teacher displays the sentence: "Children said teacher is coming."
- Students discuss:
  - How should this sentence be written correctly?
  - Which punctuation marks are present and why?
  - What is the most correct version? Explain with reasoning.

6. Creating
Objective: Students produce original texts using punctuation marks.
Tasks:
- Students choose one option:

Option A: Write a short 3–4 sentence dialogue using quotation marks correctly.
Option B: Write a mini-story (5 sentences) using at least six different punctuation marks (., ?, !, :, –, " ").
Option C: Prepare a small announcement (e.g., "Found," "Lost," "Event") using appropriate punctuation.
Lesson Conclusion and Reflection:
- Students are asked: "Which punctuation mark was the most difficult to use today, and why?"
- Teacher summarizes students' answers and provides brief feedback.

Learning taxonomies are a powerful methodological tool for planning pedagogical activities, structuring lessons, and developing all components of learning. They allow teachers to define learning objectives precisely, design tasks that address cognitive, affective, and psychomotor domains, and conduct assessments in an objective and transparent manner. Purposeful use of these taxonomies makes learning more systematic, meaningful, and oriented toward comprehensive student development.

Conclusion and Recommendations
The study demonstrates that learning taxonomies provide an effective methodological framework for Azerbaijani language instruction. Taxonomies such as Bloom, Krathwohl, Harrow, and SOLO support the systematic development of cognitive, affective, and psychomotor aspects of learning. Their integration into classroom practice facilitates student-centered learning, enhances communicative competence, and promotes higher-order thinking skills.

The results suggest that the systematic application of taxonomies transforms language instruction from simple knowledge transmission into a comprehensive educational process aimed at developing analytical thinking, creativity, and communication abilities. Consequently, the use of learning taxonomies represents a significant step toward modernizing Azerbaijani language education in accordance with the demands of twenty-first-century pedagogy.

The application of learning taxonomies in Azerbaijani language instruction allows the language learning process to be viewed not merely as the transmission of linguistic information, but as a complex domain of development integrating students' cognitive, emotional, and motor skills. Taxonomy models such as Bloom, Krathwohl, Harrow, and SOLO provide teachers with practical, systematic, and transparent frameworks for lesson planning, task structuring, and assessment criteria. This approach enhances students' abilities not only to recall and repeat content but also to comprehend and apply new material, analyze texts, and produce creative responses.

Specifically, in Azerbaijani language lessons, the use of these taxonomies facilitates the creation of student-centered tasks with high-level thinking requirements. Bloom's taxonomy assists in planning questions and activities across different cognitive levels, while Krathwohl's taxonomy promotes affective and value-oriented development, such as establishing an emotional connection with language meaning. Harrow's taxonomy focuses on physical and motor skills, enabling attention to body language, gestures, and other psychomotor expressions during language instruction. SOLO taxonomy, in turn, serves as a scientific tool to evaluate the structure, depth, and coherence of students' responses.

Research findings indicate that the purposeful implementation of these taxonomies makes the teaching process more active, interactive, and motivating. Students not only passively receive information but also actively organize knowledge analytically, solve problems, and express their ideas creatively. Teachers can differentiate tasks according to students' needs and employ a broad range of assessment formats based on structured levels.

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Nevertheless, the effectiveness of taxonomies is accompanied by certain challenges. Integrating this approach deeply into lesson plans requires teachers to have substantial knowledge and training. Additionally, assessment criteria must be carefully developed to ensure objectivity and alignment with the taxonomy, so that student performance is measured fairly and accurately.

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THE FUNDAMENTAL LAWS OF MODERN PHYSICS AND THEIR ROLE IN EXPLAINING NATURAL PHENOMENA: A SYSTEMATIC SCIENTIFIC APPROACH

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ABSTRACT
Modern physics is built upon a set of fundamental laws that describe how matter, energy, space, and time interact across different scales of the universe. This article presents a systematic analysis of these laws—classical mechanics, electromagnetism, thermodynamics, quantum mechanics, and relativity—and examines how they collectively explain natural phenomena. Through a conceptual and literature-based approach, the study highlights that each fundamental law offers explanatory power within specific physical domains, yet complex natural systems can only be understood through the integrated application of multiple laws. The findings indicate that while classical mechanics successfully describes macroscopic motion, quantum theory governs microscopic behavior, and relativity is essential for understanding high-velocity and gravitational phenomena. By synthesizing insights from major theoretical frameworks, this article demonstrates that the unity of physical laws forms a coherent scientific foundation for interpreting natural events. The study contributes to ongoing discussions in physics education and research by offering a structured analytical perspective on how modern physics explains the workings of nature.
Key Words: modern physics, natural phenomena, fundamental laws, quantum mechanics, relativity

Introduction

Understanding natural phenomena requires a theoretical framework that is both conceptually rigorous and empirically grounded. Modern physics provides such a framework through a set of fundamental laws that describe how matter, energy, space, and time interact across different scales of the universe. These laws—ranging from classical mechanics to quantum theory and relativity—form the backbone of contemporary scientific inquiry and technological development. Their combined explanatory power allows scientists to interpret processes spanning from subatomic interactions to cosmic-scale dynamics. As noted by Anderson and Clark (2020), the evolution of physics as a discipline is driven by the search for universal principles capable of describing increasingly complex systems, especially when dealing with strong-field, high-energy, or quantum regimes.

The need for a systematic understanding of fundamental laws has grown significantly with the expansion of interdisciplinary fields such as astrophysics, nanotechnology, and computational physics. For example, Carroll (2022) emphasizes that modern relativistic systems, particularly in cosmology and gravitational physics, require an integrated interpretation of space-time geometry and dynamical evolution. Similarly, Denschlag and Nägerl (2020) highlight that quantum phenomena in ultra-cold atomic systems cannot be understood through classical paradigms alone, illustrating the importance of quantum mechanics in explaining microscopic behavior. These findings underscore the necessity of a unified conceptual framework that accounts for both classical determinism and quantum indeterminacy.

Despite the diversity of natural processes, recent literature demonstrates that many physical systems display unified patterns governed by nonlinear interactions and emergent behavior (Cosenza & López, 2019). Such studies reveal that classical laws retain remarkable predictive power at macroscopic levels, yet deviations occur as systems approach micro- and nano-scales, where Newtonian mechanics becomes insufficient (Borse et al., 2021). This transition between classical and quantum domains represents a central challenge in theoretical physics, raising questions about the boundaries of applicability of fundamental laws (Ghosh & Banerjee, 2022).

Another critical motivation for studying fundamental laws emerges from advances in thermodynamics and statistical mechanics. The irreversible behavior of natural processes and entropy generation have gained renewed attention in the context of complex physical systems (Chen & Li, 2023; Nguyen & Zhao, 2022). These investigations not only refine theoretical interpretations of energy, order, and disorder but also illustrate how thermodynamic principles constrain both classical and quantum models of nature.

Furthermore, developments in astrophysics and cosmology have highlighted the importance of relativistic corrections when modeling large-scale structures and gravitational interactions. Recent computational studies demonstrate that neglecting relativistic effects can lead to significant inaccuracies in astrophysical simulations (Kirklin & McGill, 2024). This aligns with the perspective of Müller and Schneider (2023), who argue that

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gravitational lensing and space-time curvature cannot be adequately explained without Einsteinian relativity. Such insights reinforce the idea that fundamental physical laws operate across interconnected scales rather than in isolation.

Equally important is the renewed philosophical debate surrounding the interpretation of quantum probability and its implications for reality, which Lombardi and Fortin (2020) identify as a core conceptual challenge. Hossenfelder and Palmer (2020) further argue that limitations and symmetries in modern physics should be reconsidered to avoid misinterpretations about the completeness of existing models. These debates illustrate that understanding the laws of physics is not merely a technical endeavor but an epistemological one.

In addition, contemporary research into dark matter and multi-scale physical modeling continues to reshape the modern scientific landscape. Schmidt and Weiner (2019) show that interactions beyond the Standard Model require modified approaches to physical constraints, while Wang and Xu (2024) propose unified models that bridge classical and quantum frameworks to explain natural phenomena across scales. Electromagnetic field behavior in extreme environments, as explored by Fang and Wu (2021), also highlights the evolving relevance of Maxwell's equations in modern technological applications. These developments collectively indicate that fundamental laws remain central to advancing scientific frontiers.

In sum, the contemporary scientific environment demands a systematic and integrated understanding of the fundamental laws of physics. While each law possesses its own domain of explanatory power, their synergistic application is essential for interpreting the complexity of natural systems. This article therefore aims to synthesize recent theoretical advances to demonstrate how modern physics provides the conceptual structure necessary for understanding natural phenomena across micro-, meso-, and macro-scales.

Theoretical Framework

The fundamental laws of modern physics form a multilayered conceptual structure that explains natural phenomena across micro-, meso-, and macro-scales. Classical mechanics, electromagnetism, thermodynamics, quantum mechanics, and relativity each provide distinct explanatory capabilities, yet together they create a unified scientific framework. Contemporary research emphasizes that these theories are not independent entities but interdependent models that collectively describe the behavior of matter and energy. Their integration is therefore essential for understanding complex systems that cannot be explained by a single physical law alone (Anderson & Clark, 2020).

Classical mechanics remains the foundational description of motion and force in macroscopic environments. Newtonian laws successfully explain the behavior of objects ranging from simple pendulums to planetary orbits. However, recent theoretical analyses show that as systems are reduced to the micro- and nano-scale, deviations from classical predictions emerge, revealing intrinsic limitations of Newtonian modeling. These discrepancies highlight the boundary at which classical determinism gives way to quantum mechanical behavior, indicating the need for improved multi-scale models (Borse et al., 2021).

Electromagnetism provides another pillar of modern physics by describing the interaction of electric and magnetic fields through Maxwell's equations. These equations unify previously separate domains and serve as the theoretical foundation for optics, wireless communication, and plasma physics. Modern studies demonstrate that electromagnetic interactions play a crucial role in high-energy environments, where field dynamics govern processes such as particle acceleration and radiation emission. As a result, electromagnetism continues to serve as an indispensable tool for interpreting both natural and engineered physical systems (Fang & Wu, 2021).

Thermodynamics forms the conceptual basis for understanding energy transfer, entropy, and irreversibility in natural processes. The second law of thermodynamics, in particular, describes the directionality of time through entropy increase, providing a mathematical explanation for the observed irreversibility of natural phenomena. Recent analyses of complex systems show that entropy production is not merely a macroscopic effect but emerges from microscopic fluctuations that shape the dynamics of physical systems. This connection between microscopic randomness and macroscopic order highlights the importance of thermodynamic principles for understanding natural behavior across scales (Chen & Li, 2023; Nguyen & Zhao, 2022).

Quantum mechanics describes the behavior of matter and energy at atomic and subatomic levels, introducing probabilistic interpretations that differ fundamentally from classical physics. Research on strong-field quantum dynamics reveals that the behavior of particles under extreme conditions cannot be approximated by classical equations, requiring a fully quantum-mechanical treatment. Moreover, discussions on quantum probability interpretation illustrate that the quantum world demands not only new mathematical tools but also revised

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epistemological perspectives, distinguishing it sharply from classical determinism (Anderson & Clark, 2020; Lombardi & Fortin, 2020).

Relativity theory expands the physical framework to include systems traveling at high velocities or subjected to strong gravitational fields. Einstein's theories revolutionized the understanding of space, time, and gravity, demonstrating that these elements form a single dynamic geometry rather than independent phenomena. Contemporary astrophysical research confirms that relativistic corrections are required for accurate modeling of cosmic structures, gravitational lensing, and orbital decay. These insights show that classical gravity is insufficient for describing large-scale or high-energy environments, thus affirming relativity's essential role in modern physics (Carroll, 2022; Müller & Schneider, 2023; Kirklin & McGill, 2024).

Beyond established frameworks, research on dark matter and multi-scale physical modeling suggests that current laws may not fully describe the universe. Studies of particle interactions beyond the Standard Model indicate that unknown forces or symmetries may influence cosmic evolution. Similarly, attempts to unify classical and quantum models reveal the need for broader theoretical structures that account for phenomena across multiple scales. These emerging perspectives point to fundamental gaps in existing theories and highlight the ongoing evolution of physical law as science advances (Schmidt & Weiner, 2019; Wang & Xu, 2024; Hossenfelder & Palmer, 2020).

Literature Review

Research on the fundamental laws of modern physics consistently emphasizes the need for an integrated theoretical framework to explain natural phenomena. Studies in strong-field quantum dynamics demonstrate that physical behavior under extreme conditions deviates substantially from classical predictions, highlighting the importance of quantum formulations for accurately modeling microscopic interactions. Anderson and Clark (2020) show that strong-field environments reveal nonlinear quantum processes that cannot be captured by traditional approximations, establishing quantum mechanics as a central explanatory tool for high-intensity physical systems (Anderson & Clark, 2020).

Classical mechanics continues to serve as the primary model for macroscopic dynamics; however, its limitations become evident when physical systems approach micro- and nano-scale dimensions. Borse, Singh, and Kumar (2021) compare Newtonian predictions with observed behaviors in reduced-scale systems and demonstrate significant deviations, marking the boundary where classical laws lose accuracy. Their findings reinforce the theoretical requirement for quantum-classical bridging models in modern physics (Borse et al., 2021).

Electromagnetic theory remains another central pillar of the physical sciences. Recent studies describe how Maxwell's equations maintain predictive accuracy even in high-energy environments, where electromagnetic field interactions dominate system behavior. Fang and Wu (2021) show that modern applications of electromagnetism—including particle accelerators and high-frequency transmission systems—continue to validate the robustness of Maxwell's formulations. These results confirm the sustained relevance of electromagnetism in contemporary physics research (Fang & Wu, 2021).

Thermodynamics has also seen significant conceptual expansion in recent years, particularly in studies of entropy and irreversible behavior. Chen and Li (2023) analyze entropy generation in complex systems and argue that thermodynamic principles remain foundational for understanding energy flows across both natural and engineered systems. Complementary research by Nguyen and Zhao (2022) illustrates how microscopic thermal fluctuations influence macroscopic entropy patterns, highlighting the bridge between thermodynamic and statistical mechanical descriptions. These studies collectively reinforce the enduring centrality of thermodynamics in modeling natural processes (Chen & Li, 2023; Nguyen & Zhao, 2022).

In the domain of quantum mechanics, theoretical and philosophical debates continue to shape contemporary understanding. Lombardi and Fortin (2020) examine the conceptual basis of quantum probability and argue that quantum behavior challenges classical interpretations of causality and determinism. Meanwhile, Ghosh and Banerjee (2022) explore the transition between classical and quantum regimes, identifying conceptual and mathematical limitations in current formulations. Together, these studies provide a deeper perspective on the epistemological and theoretical challenges inherent in quantum physics research (Lombardi & Fortin, 2020; Ghosh & Banerjee, 2022).

Relativity theory continues to play a crucial role in explaining gravitational and cosmological phenomena. Carroll (2022) provides a comprehensive analysis of spacetime geometry and relativistic system evolution, demonstrating that relativistic models are indispensable for understanding cosmic-scale dynamics. Empirical

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evidence further strengthens this argument: Müller and Schneider (2023) show that gravitational lensing behavior cannot be explained without general relativity, while Kirklin and McGill (2024) demonstrate that relativistic corrections are essential for accurate astrophysical simulations. This body of literature affirms relativity's dominant role in modern gravitational modeling (Carroll, 2022; Müller & Schneider, 2023; Kirklin & McGill, 2024).

Beyond established classical and quantum frameworks, emerging studies explore areas where existing physical laws may be incomplete. Research on dark matter, for example, reveals that standard physical models fail to account for certain large-scale cosmic observations. Schmidt and Weiner (2019) show that interactions involving dark matter require modified theoretical assumptions, opening new discussions on the boundaries of current physical laws. Similarly, Wang and Xu (2024) propose unified physical models bridging classical and quantum regimes, suggesting that multi-scale theoretical frameworks may be necessary for a more complete understanding of natural phenomena. Hossenfelder and Palmer (2020) expand this conversation by questioning long-held assumptions about the limits and symmetries of physical theory. Collectively, these studies point toward evolving directions in fundamental physics research (Schmidt & Weiner, 2019; Wang & Xu, 2024; Hossenfelder & Palmer, 2020).

Methodology

This study employs a qualitative and theory-driven methodological design aimed at synthesizing the fundamental laws of modern physics and evaluating their explanatory capacity across different natural phenomena. Three complementary research methods were selected due to their suitability for conceptual, cross-framework, and multi-scale scientific analysis: systematic literature analysis**,** theoretical comparative modeling**, and** multi-scale conceptual integration**.** These methods are standard in contemporary physics scholarship, especially when bridging classical, quantum, and relativistic frameworks.

Systematic Literature Analysis

The first method involves a structured and systematic review of high-impact scientific literature on fundamental physical laws, drawing exclusively from peer-reviewed articles in physics, cosmology, quantum mechanics, thermodynamics, and electromagnetic theory. This review identifies core theoretical principles, evaluates major empirical findings, and maps areas of conceptual convergence and divergence. The approach is guided by recent studies that emphasize the importance of integrating multi-domain scientific insights to improve theoretical understanding of natural systems. For example, findings on quantum dynamics, thermodynamic entropy, and relativistic corrections provide essential inputs for constructing unified models of physical behavior (Anderson & Clark, 2020; Chen & Li, 2023; Kirklin & McGill, 2024).

Theoretical Comparative Modeling

The second method applies comparative modeling across classical, quantum, thermodynamic, and relativistic frameworks. This involves evaluating how each physical law performs in explaining specific natural phenomena—such as microscopic fluctuations, macroscopic motion, strong-field interactions, gravitational distortions, and electromagnetic behavior. By comparing explanatory domains and limitations, the study identifies which physical laws dominate at particular scales and conditions. Contemporary research validates this methodological approach: classical mechanics is found to be reliable at macroscopic scales but insufficient at micro-levels, while quantum mechanics and relativity increasingly dominate as systems become more energetic or gravitationally complex (Borse et al., 2021; Ghosh & Banerjee, 2022; Müller & Schneider, 2023).

Multi-Scale Conceptual Integration

The third method synthesizes theoretical insights into a unified conceptual framework capable of explaining natural phenomena across micro-, meso-, and macro-scales. This requires integrating principles from quantum mechanics, electromagnetism, thermodynamics, and relativity into cohesive explanatory models. Such multi-scale approaches are becoming increasingly important in modern physics, particularly in studies of dark matter, spacetime curvature, and quantum–classical transitions. Recent research demonstrates that bridging scales is essential for constructing accurate and comprehensive models of physical reality, reinforcing the need for integrative methodologies (Schmidt & Weiner, 2019; Wang & Xu, 2024; Hossenfelder & Palmer, 2020).

Findings and Discussion

The findings of this study reveal that the three selected methods—systematic literature analysis**,** theoretical comparative modeling**,** and multi-scale conceptual integration—provide complementary insights into the explanatory power of the fundamental laws of modern physics. Each methodological lens illuminated different structural, conceptual, and empirical dimensions of how physical laws function across natural phenomena. The

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following subsections present the key findings from the application of each method, accompanied by interpretive discussion and summary tables.

Findings from Systematic Literature Analysis

The systematic review demonstrated that the explanatory scope of fundamental physical laws varies significantly depending on the domain and scale of the phenomena under consideration. The literature shows that:

- Quantum mechanics is indispensable for describing particle-level and strong-field interactions, where classical laws fail to capture probabilistic and nonlocal behaviors (Anderson & Clark, 2020).
- Thermodynamics and statistical mechanics remain essential for understanding irreversibility, entropy production, and complexity in natural systems (Chen & Li, 2023; Nguyen & Zhao, 2022).
- Relativistic frameworks are required to accurately model high-gravity and high-velocity environments encountered in astrophysics (Carroll, 2022; Kirklin & McGill, 2024).

These findings highlight the fragmented but complementary nature of physical laws in contemporary scientific discourse.

Table 1. Application Results of Systematic Literature Analysis

Analytical Domain	Key Finding	Real-World Scientific Application	Reference
Strong-field quantum dynamics	Classical laws are insufficient	Modeling electron motion under intense laser fields	Anderson & Clark, 2020
Entropy and irreversibility	Entropy linked to microscopic fluctuations	Optimization of thermal systems and energy transfer	Chen & Li, 2023; Nguyen & Zhao, 2022
Relativistic corrections	Spacetime curvature must be included	Gravitational lensing, cosmic structure modeling	Carroll, 2022; Kirklin & McGill, 2024

The review confirms that no single physical law provides a universal explanatory framework. Instead, natural systems require a layered interpretation, where laws apply conditionally based on scale and energy regime. Systematic analysis thus serves as a critical tool for mapping how the fundamental laws collectively build a coherent but non-uniform description of nature.
(Anderson & Clark, 2020; Chen & Li, 2023; Nguyen & Zhao, 2022; Carroll, 2022; Kirklin & McGill, 2024).

Findings from Theoretical Comparative Modeling

The comparative modeling approach revealed significant differences in the predictive and explanatory strengths of classical, quantum, and relativistic frameworks. The findings demonstrate that:

- Classical mechanics remains highly effective for macroscopic, low-energy environments, though it breaks down at atomic scales (Borse et al., 2021).
- Quantum mechanics successfully accounts for probabilistic micro-dynamics, non-classical trajectories, and discrete energy states (Ghosh & Banerjee, 2022; Lombardi & Fortin, 2020).
- Relativistic laws dominate in regions involving intense gravity and near-light-speed motion, such as black holes and neutron stars (Müller & Schneider, 2023).

This comparison shows that each physical law occupies its own domain of validity, reinforcing the need for cross-framework modeling.

Table 2. Comparative Modeling Outcomes

Physical Model	Applicable Domain	Comparative Outcome	Reference
Classical mechanics	Low-energy, macroscopic systems	Fails at microscopic scales	Borse et al., 2021
Quantum mechanics	Atomic and subatomic systems	Deterministic → probabilistic shift	Ghosh & Banerjee, 2022; Lombardi & Fortin, 2020
Relativity	High-gravity, high-velocity systems	Replaces classical gravity	Müller & Schneider, 2023

The modeling results demonstrate that physical laws are not competing but complementary frameworks. Their boundaries are defined not by inconsistency but by shifts in scale, energy, and interaction strength. Comparative modeling therefore clarifies the structural architecture of modern physics as a layered system of theories.
(Borse et al., 2021; Ghosh & Banerjee, 2022; Lombardi & Fortin, 2020; Müller & Schneider, 2023).

Findings from Multi-Scale Conceptual Integration

The multi-scale integration method revealed that unifying micro-, meso-, and macro-scale laws provides a deeper explanatory perspective than examining each scale independently.
Key insights include:

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- Observations of dark matter and cosmic dynamics indicate limitations in current physical models and the need for new cross-scale theories (Schmidt & Weiner, 2019).
- The quantum–classical boundary remains one of the most significant conceptual challenges, requiring integrative modeling approaches (Wang & Xu, 2024).
- Symmetry laws and invariance principles may require revision as new high-precision data emerges (Hossenfelder & Palmer, 2020).

These findings show that integration across scales is essential for constructing physically coherent and predictive models.

Table 3. Multi-Scale Integration Results

Scale Level	Phenomenon Clarified	Integration Outcome	Reference
Micro (quantum)	Quantum indeterminacy	Classical limits not inherently built-in → need for unified models	Wang & Xu, 2024
Macro (thermodynamics & EM)	Energy transfer, field interactions	Combined analysis explains emergent complexity	Chen & Li, 2023
Cosmic (gravity & dark matter)	Deviations in gravitational behavior	Existing laws require extension	Schmidt & Weiner, 2019; Hossenfelder & Palmer, 2020

The integration findings suggest that nature operates through multi-layered but interconnected physical mechanisms. No scale exists in isolation; instead, micro-level uncertainties, meso-level energy structures, and cosmic-scale curvature co-evolve within a unified physical reality.(Schmidt & Weiner, 2019; Wang & Xu, 2024; Hossenfelder & Palmer, 2020; Chen & Li, 2023).

The overall findings from the three methodological approaches reveal that the fundamental laws of modern physics function not as isolated or competing frameworks, but as complementary systems that collectively shape our understanding of natural phenomena. Each law—whether rooted in classical mechanics, quantum theory, thermodynamics, electromagnetism, or relativity—contributes uniquely to the broader explanatory landscape. Their strengths become most visible when applied within the specific physical regimes they were designed to describe, demonstrating that scientific coherence arises from coordinated application rather than theoretical dominance.

A recurring insight across the analyses is the scale-dependent nature of physical laws. No single framework maintains universal validity across micro, meso, and macro domains. Classical mechanics remains effective for macroscopic, low-energy systems, yet loses accuracy at quantum scales, where probabilistic behavior becomes dominant. Conversely, quantum mechanics excels at describing subatomic dynamics but cannot independently explain gravitational curvature or long-range cosmological processes. This scale-sensitivity underscores the necessity of contextual application, where each law is evaluated according to the spatial, temporal, and energetic conditions of the system being studied.

The study also highlights the central role of emergent phenomena—such as strong-field quantum effects, entropy-driven irreversibility, and spacetime curvature—in exposing the boundaries of existing theories. These emergent processes reveal interactions that cannot be reduced to a single law or mathematical model. Instead, they require integrative approaches capable of bridging conceptual gaps between frameworks. For example, entropy generation links microscopic fluctuations to macroscopic thermodynamic behavior, while gravitational lensing connects local spacetime geometry to large-scale cosmic structure. Such cross-scale relationships demonstrate that advancing physical theory depends on identifying the mechanisms that unify rather than separate levels of description.

Finally, the results indicate that the future direction of physics increasingly lies in developing hybrid theoretical models that combine quantum, thermodynamic, electromagnetic, and relativistic principles. As empirical observations become more precise and experimental technologies probe deeper into extreme physical environments, existing theories must adapt through synthesis rather than replacement. Modern challenges—such as modeling quantum gravity, explaining dark matter, or unifying entropy across scales—demand frameworks that integrate multiple physical laws into coherent structures. These hybrid models will form the foundation of a more complete and interconnected understanding of natural phenomena, reflecting the intrinsically multi-layered structure of the physical universe.

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Conclusion

This study set out to examine how the fundamental laws of modern physics—classical mechanics, quantum theory, thermodynamics, electromagnetism, and relativity—collectively contribute to the scientific explanation of natural phenomena. By applying three complementary methods—systematic literature analysis, theoretical comparative modeling, and multi-scale conceptual integration—the research has shown that these laws form an interconnected and mutually reinforcing system rather than isolated theoretical constructs.

The findings demonstrate that each physical law possesses a distinct domain of applicability, and no single framework is sufficient to account for the full complexity of the natural world. Classical mechanics remains indispensable for understanding macroscopic motion and everyday physical interactions, yet it fails to capture quantum-level uncertainties or relativistic effects near massive bodies. Quantum mechanics excels at describing microscopic and strong-field phenomena, whereas relativity provides the necessary corrections for high-velocity and gravitational environments. Thermodynamics and statistical physics link these domains by explaining irreversibility, energy distribution, and emergent behaviors that arise from the interaction of many particles.

The results also highlight the importance of integrating these diverse laws across different spatial and energetic scales. Emergent phenomena—such as entropy production, spacetime curvature, microscopic fluctuations, and strong-field quantum behavior—cannot be explained by any single theory alone. Instead, they require hybrid modeling approaches that combine conceptual and mathematical elements from multiple frameworks. This integrative perspective positions modern physics as a layered structure of explanatory tools that become most powerful when applied jointly.

Ultimately, the study underscores that the future of physics depends not on the replacement of existing theories but on their synthesis. Progress in understanding dark matter, quantum gravity, extreme astrophysical processes, and complex thermodynamic systems will require interdisciplinary theoretical models capable of bridging micro-, meso-, and macro-scale phenomena. As experimental capabilities continue to expand, the need for unified, cross-scale approaches will grow even more urgent. Thus, the fundamental laws of physics should be understood not as competing narratives but as complementary components of a coherent and evolving scientific framework that offers increasingly accurate and comprehensive explanations of the natural world.

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THE IMPACT OF GLOBAL FINANCIAL COMMUNICATION ON ECONOMIC PUBLIC OPINION: THE ROLE OF NEW MEDIA USE

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ABSTRACT
The aim of this research is to examine the impact of global financial communication on economic public perception and to determine the role of new media credibility in this relationship. The research is carried out with a relational survey model in line with the quantitative research approach. The sample of the research consists of 391 participants living in the Turkish Republic of Northern Cyprus. The data are collected through a questionnaire consisting of a personal information form, the Global Financial Communication Scale, the New Media Credibility Scale and the Economic Public Perception Scale. The data obtained are analyzed using the SPSS package program. Normality test, KMO and Bartlett test, reliability analysis, descriptive statistics, t-test, ANOVA, correlation and regression analyzes are used in data analysis. According to the results of the research, there are positive and significant relationships between global financial communication, new media credibility and economic public perception. Global financial communication positively and meaningfully affects economic public perception. New media credibility is also determined as one of the important variables explaining economic public perception. Global financial communication and new media credibility together explain 51.4% of the total variance in economic public perception. Daily internet usage time, frequency of following financial news, financial literacy level and investment experience make a significant difference on the research variables. In general, it is seen that participants with high access to financial information, regular follow-up of financial news and investment experience have higher levels of global financial communication, new media credibility and economic public perception.
Key Words: Global financial communication, economic public opinion, new media credibility, financial information.

Introduction

Problem Situation

Globalization and digitalization are significantly changing the ways financial information is produced, distributed, and consumed. Exchange rates, interest rate decisions, international market movements, economic crises and developments in investment instruments now reach large audiences in a short time through digital media channels. The increasing interaction between financial markets leads to local economic perceptions being more influenced by global developments. In this process, financial communication is not limited to the transfer of economic information; It also affects the way individuals interpret economic events, develop risk perceptions and form expectations about the future (Castells, 2010; Alami, Dixon & Mawdsley, 2024).

New media environments allow financial information to circulate quickly, accessively and interactively. Social media platforms, digital news sites, mobile finance applications, online investment communities, and video-sharing platforms are becoming important sources of information for individuals to follow economic developments. Users' production and sharing of financial content transforms financial communication from a one-way transfer process to a multi-actor interaction area (Kaplan & Haenlein, 2010; Van Dijck, Poell & De Waal, 2018).

Economic public opinion consists of individuals' common perceptions and evaluations of economic developments, financial markets, economic policies and the future. Economic news, market commentary, and financial analysis in the media can impact individuals' economic prospects. The channels through which financial information is obtained, to what extent it is reliable and how it is interpreted by individuals are decisive in the formation of economic public opinion (Soroka, Stecula & Wlezien, 2015; Shiller, 2019).

The rapid spread of financial content in digital media environments also raises the issue of reliability. Unverified information, speculative interpretations, and manipulative content can influence individuals' economic assessments during times of economic uncertainty. New media credibility stands out as an important variable in terms of the level at which individuals accept the financial content they encounter on digital platforms and use it in their economic decision-making processes (Kohring & Matthes, 2007; Fletcher & Park, 2017; Newman et al., 2024).

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Although financial communication, economic public opinion and new media reliability are examined in separate areas in the literature, studies that deal with the impact of global financial communication on economic public perception together with new media reliability are limited. Especially in economies such as the TRNC, which are open to the outside world and directly affected by global financial developments, how individuals perceive the flow of financial information and the role of new media reliability in economic public perception need further examination. The study examines the relationships between global financial communication, new media credibility, and economic public perception through correlation and regression analyses.

Purpose of the Research

The aim of the research is to examine the impact of global financial communication on economic public perception and to determine the role of new media credibility in this relationship. For this purpose, the participants' levels of global financial communication, new media credibility and economic public perception are evaluated; The relationships between the variables are examined by correlation analysis, and the effect levels are examined by regression analysis.

The study seeks answers to the following questions:

- What are the levels of global financial communication, new media credibility and economic public perception?
- Is there a significant relationship between global financial communication and economic public perception?
- Is there a significant relationship between global financial communication and new media credibility?
- Is there a significant relationship between new media credibility and economic public perception?
- Does global financial communication significantly affect economic public perception?
- Does global financial communication significantly affect new media credibility?
- Do global financial communication and new media credibility together explain economic public perception in a meaningful way?

Importance of Research

The rapid circulation of financial information in digital media environments is transforming the way individuals perceive economic developments. Economic news, market commentary, investment advice, and financial analysis are now disseminated not only through traditional media but also through new media platforms. This makes the impact of financial communication on economic public opinion more visible.

The research is important in terms of considering the relationship between global financial communication and economic public perception together with the new media reliability variable. The study examines not only the relationship between variables, but also the extent to which global financial communication explains economic public perception. The findings obtained through regression analyses reveal the effect of financial information flow on economic perceptions in a more concrete way.

It is also important that the study was carried out in the TRNC sample. In the TRNC, which has a small and open economic structure, currency movements, global market fluctuations and international economic developments can directly affect the economic evaluations of individuals. Therefore, examining the relationship between global financial communication, new media credibility and economic public perception in the context of the TRNC can contribute to both communication sciences and finance literature.

Conceptual Framework

Financial Communication in the Digitalization Process

Digitalization refers to the transfer of economic, social and institutional processes to digital environments depending on the developments in information and communication technologies. The finance sector stands out as one of the areas most heavily affected by digital transformation. Banking services, investment transactions, payment systems, financial reporting, investor relations and market information processes are increasingly carried out through digital channels. Traditional financial communication tools such as printed reports, newspaper advertisements, television broadcasts and face-to-face information applications are being replaced by faster, interactive and accessible digital communication forms. The production, sharing and consumption of financial information gain a more dynamic structure with this transformation (Castells, 2010; Arner, Barberis & Buckley, 2016).

Before digitalization, financial information was mostly available to investors through periodic reports, traditional media publications and corporate statements. With the widespread use of internet technologies, the time to access financial information has been shortened, and investors have become able to follow the developments in global markets in real-time. Corporate websites, investor relations pages, financial news portals, and mobile applications are among the essential tools in financial communication. Companies publish their financial reports

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in digital environments, which enables investors to access information directly and increases transparency in financial communication processes (Marston & Straker, 2001; Arrese, 2015).

One of the key impacts of digitalization in financial communication is the reduction of information asymmetry. Information asymmetry refers to differences in the level of access to information among market actors. Corporate disclosures, financial reports, digital investor relations applications, and online information systems contribute to investors making more informed decisions. Presenting information in a timely, accurate and understandable manner is important for building trust in financial markets (Healy & Palepu, 2001; Marston & Straker, 2001).

Social media platforms are also among the important components of financial communication in the digitalization process. Platforms like Facebook, X, LinkedIn, Instagram, and YouTube provide direct communication spaces for financial institutions, banks, investment companies, and individual investors. Financial institutions reach investors through social media, provide information about market developments and carry out corporate reputation management processes. These platforms transform financial communication into an interactive and participatory structure rather than one-way information transfer (Kaplan & Haenlein, 2010; Van Dijck, Poell & De Waal, 2018).

The speed factor has a central place in digital financial communication. Central bank decisions, inflation data, interest rates, corporate balance sheets, currency movements, and global market developments can reach large audiences within seconds through digital platforms. The circulation of financial information at this speed can influence investor behavior and market expectations. The way economic news is presented, financial narratives, and media frameworks can be decisive in individuals' economic evaluations (Shiller, 2019; Soroka, Stecula & Wlezien, 2015).

The development of financial technologies expands the scope of digital financial communication. Mobile banking applications, digital wallets, online investment platforms, robo-advisory systems and financial tracking applications facilitate individuals' access to financial services. Financial communication is no longer limited to information sharing; the delivery of financial services is evolving into a broader structure with user experience and personalized financial recommendations (Arner et al., 2016; Gomber, Koch & Siering, 2017).

Big data and artificial intelligence technologies are also reshaping financial communication processes. Financial institutions utilize data analytics to analyze customer behavior, track investor trends, and deliver personalized financial content. AI-powered systems can quickly process market data, provide automated content generation, and provide real-time assessments of financial developments. Data-driven communication structure contributes to the faster and more targeted transfer of financial information (Brennen & Kreiss, 2016; Arner et al., 2016).

In addition to the opportunities offered by digitalization, there are also significant risks. Misinformation, speculative comments, manipulative content, and unverified financial news spread on social media and online platforms can negatively affect investors' decision-making processes. While the ease of information production increases the diversity of financial content, it makes it more important to distinguish reliable sources. Trust in new media is considered one of the key factors determining the impact of digital financial communication (Newman et al., 2024; Fletcher & Park, 2017).

Crypto assets and blockchain technologies constitute a different dimension in the field of digital financial communication. In cryptocurrency markets, investors' information acquisition processes largely proceed through digital platforms, social media groups, and online communities. The decentralized structure expands the traditional institutional framework of financial communication, but it also increases the risks of information manipulation and speculative content. This area makes visible the need for new regulation and trust mechanisms in digital financial communication (Werner et al., 2021; OECD, 2022).

Central banks and international financial institutions are also adapting to the digitalization process, transforming their communication strategies. Interest rate decisions, monetary policy statements, economic reports, and financial indicators are presented to the public through digital platforms. Online reports of the IMF, World Bank and similar organizations are among the important sources of information in the formation of global economic expectations. Digital channels enable faster and more transparent sharing of economic information (IMF, 2025; Blinder et al., 2022).

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The Concept of New Media

Developments in communication technologies bring about radical changes in the processes of information production, distribution and consumption. With the spread of internet technologies, digital-based communication environments have emerged in addition to traditional media tools and these environments have started to be explained with the concept of new media. New media; It covers the digital communication areas shaped on the basis of computer, internet and mobile technologies, where users can take part as content producers as well as content consumers. Interaction, participation, speed, versatile communication and accessibility are among the basic features of new media (Binark & Bayraktutan, 2013; Lister, Dovey, Giddings, Grant & Kelly, 2009).

While traditional media is mostly based on a one-way communication model, new media offers a communication structure where users can instantly react, create and share content. While content production in tools such as newspapers, radio and television is under the control of media organizations, users also actively participate in the communication process in new media environments. This feature is considered to be one of the main differences that distinguishes new media from traditional media (Manovich, 2001; Yengin, 2014).

The basis of new media technologies is the internet. The internet accelerates access to information, reduces the impact of geographical boundaries, and enables individuals to communicate on a global scale. Social media platforms, blogs, forums, podcasts, online news sites, video sharing platforms and mobile applications are among the main examples of new media environments. These platforms offer individuals the opportunity to access information and share content without time and place limitations (Castells, 2010; Van Dijk, 2020).

One of the most distinctive features of new media is interactivity. Users can comment, share content, participate in discussions, and produce their own content on digital platforms. This structure makes the communication process more participatory; individuals cease to be passive recipients of information and become a part of the processes of knowledge production and circulation (Jenkins, 2006; Binark & Bayraktutan, 2013).

New media increases content diversity with its user-oriented structure. While content production is carried out by a limited number of media outlets in traditional media systems, individuals, communities, and institutions can create their own content in digital environments. The visibility of different opinions increases, and more actors take part in the formation of public opinion. This structure, which is expressed as participatory culture, strengthens the effect of new media on social communication (Manovich, 2001; Jenkins, 2006).

Digitalization plays a decisive role in the development of new media. The convergence of different types of content, such as text, audio, images, and video, on a single platform is explained by the concept of convergence. Thanks to convergence, media content becomes accessible on different devices and digital platforms; Media consumption habits are also changing. Users can now read news, watch videos, comment and share content on the same platform (Jenkins, 2006; Lister et al., 2009).

New media differs from traditional media in terms of speed and accessibility. Content spread on digital platforms can reach very large audiences in a short time. Social media platforms, in particular, are effective in the formation of the agenda, the dissemination of news and the shaping of public opinion. The transfer of news consumption styles to digital environments changes the habits of individuals to follow the agenda (Castells, 2010; Newman et al., 2024).

Social media is one of the most widely used components of new media. Platforms like Facebook, Instagram, X, TikTok, LinkedIn, and YouTube are important areas for information sharing, agenda tracking, interaction, and social discussions. Social media is becoming more and more prominent in the processes of young generations' access to news and information. Social media platforms are also effective in the formation of public opinion on economic, political and social issues (Kaplan & Haenlein, 2010; Newman et al., 2024).

New media environments have problematic areas as well as advantages. The rapid spread of unverified information, disinformation, information pollution and manipulation are among the common problems encountered in digital media environments. While the ability of each user to produce content increases the diversity of information, it also deepens the reliability problem. Digital media literacy is becoming an important requirement for individuals to critically evaluate online content (Wardle & Derakhshan, 2017; UNESCO, 2023).

New media also affects economic life. Digital marketing, electronic commerce, online banking, financial technologies and digital investment platforms constitute the economic dimension of the new media ecosystem. New media tools in financial markets are changing the way investors access information and reshaping financial

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communication processes. Today, new media is considered as one of the basic elements of economic and social transformation beyond being a means of communication (Arner, Barberis & Buckley, 2016; Castells, 2010).

New Media and Financial Communication

The relationship between new media and financial communication constitutes one of the important research areas of digitalized economic life. New media built on internet-based technologies; It is changing the way financial information is disseminated thanks to speed, accessibility, interactivity, user participation and the ability to produce content. Economic news, market commentary, investment advice, company statements, and financial analyses now reach large audiences instantly through digital platforms (Binark & Bayraktutan, 2013; Castells, 2010).

Financial communication refers to the process of sharing financial information and economic data between investors, businesses, financial institutions and the public. While financial communication was carried out through newspapers, television, radio and corporate reports in the traditional period, new media technologies make this process more dynamic and interactive. Corporate websites, social media accounts, financial news portals, mobile applications and digital investment platforms are among the basic tools of financial communication (Arrese, 2015; Cornelissen, 2020).

New media expands the scope of financial communication by facilitating access to financial information. In the past, access to financial data was mostly limited to institutional investors and professional market actors, but digital platforms also enable individual investors to access financial information. Financial news websites, economic analysis platforms, and investment applications contribute to individuals' more active participation in financial markets. Thus, financial communication is no longer a limited process carried out between corporate actors and reaches a wider user base (Castells, 2010; Gomber, Koch & Siering, 2017).

Social media platforms exert a pronounced influence on financial communication. Platforms like X, LinkedIn, Facebook, Instagram, and YouTube are evolving into spaces where investors track economic developments, monitor financial commentary, and shape investment decisions. Companies, banks and financial institutions also communicate directly with their target audiences through these platforms and share financial information quickly. This structure carries financial communication to a bidirectional, visible and interactive ground (Kaplan & Haenlein, 2010; Fletcher & Park, 2017).

New media environments play a decisive role in accelerating the flow of financial information. Economic indicators, central bank decisions, corporate balance sheets, currency movements, and global market developments reach millions of users in a short time through digital news platforms and social media. The speed of information flow can affect investors' decision-making processes and lead to faster price movements in financial markets. Instant access to financial information makes new media one of the main information channels of today's financial system (Shiller, 2019; Newman et al., 2024).

The relationship between new media and financial communication is not limited to information sharing; investor perceptions and economic expectations are also shaped within this relationship. Media coverage of economic news, expert commentary, market analysis, and social media discussions can influence individuals' assessments of economic developments. In times of economic crisis, uncertainty and periods of intensified market fluctuations, new media content can have more visible effects on investor behavior (Soroka, Stecula & Wlezien, 2015; Shiller, 2019).

One of the significant contributions that new media offers in terms of financial communication is accessibility. Individuals with an internet connection can follow financial developments in different regions of the world, examine economic data, and obtain information about investment vehicles. The increase in access to information for small investors facilitates participation in financial markets. Financial education content disseminated on digital platforms also contributes to the development of financial literacy (Binark & Bayraktutan, 2013; Gomber et al., 2017).

The strengthening of financial communication in new media environments also raises the problem of reliability. Unverified information, speculative content, and manipulative comments disseminated on social media platforms can negatively impact investors' decision-making processes. The source, accuracy and impartiality of financial information become critical to the effectiveness of digital financial communication. Trust in new media is considered as one of the main factors affecting the level of acceptance, interpretation and use of financial content in economic decision-making processes (Fletcher & Park, 2017; Newman et al., 2024).

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Method

Research Model

This research is designed in line with a quantitative research approach to examine the impact of global financial communication on economic public perception and the role of new media credibility in this relationship. Relational survey model is used in the research. A relational survey model is defined as a research model that aims to determine the existence, level, and direction of a relationship between two or more variables (Karasar, 2023). The independent variable of the research is global financial communication, the dependent variable is economic public perception, and the mediator/explanatory variable is new media reliability.

Universe and Sample

The universe of the research consists of individuals aged 18 and over living in the Turkish Republic of Northern Cyprus. Sampling is used because it is difficult to reach the entire universe in terms of time and accessibility. Convenience sampling method is used in the research. Convenience sampling is explained as a sampling method that is accessible to the researcher and based on collecting data from individuals who are willing to participate in the research (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz & Demirel, 2023). The sample of the study consists of 391 individuals living in the TRNC and voluntarily participating in the research.

Data Collection Tools

A questionnaire form is used as a data collection tool in the research. The questionnaire form consists of four parts. In the first part, there is a personal information form to determine the demographic characteristics of the participants and their habits of accessing financial information. In other sections, there are the Global Financial Communication Scale, the New Media Credibility Scale and the Economic Public Perception Scale. Scale items are structured with a 5-point Likert type rating. Participants are asked to rate their level of agreement with the statements between "1=Strongly Disagree" and "5=Strongly Agree".

Global Financial Communication Scale

The Global Financial Communication Scale is used to measure individuals' level of following global economic and financial developments, the way they use financial information resources, and the impact of financial information on their economic evaluations. The scale is based on the work of Arrese (2015), Castells (2010), Shiller (2019), Held and McGrew (2023), and Alami, Dixon, and Mawdsley (2024).

New Media Reliability Scale

The New Media Reliability Scale is used to measure individuals' perceptions of the accuracy, reliability, impartiality, and descriptiveness of the financial content they encounter in new media environments. The preparation of the scale is based on Kohring and Matthes' (2007) approach to trust in the media. The scale is organized by taking into account new media environments and financial content.

Economic Public Perception Scale

The Economic Public Perception Scale is used to measure individuals' perceptions of economic developments, financial markets, economic policies, and future economic expectations. In the preparation of the scale, studies in the field of economic expectations, media effects and economic public opinion are used. In this direction, the studies of Soroka, Stecula and Wlezien (2015) and Shiller (2019) are taken into consideration.

Data Collection

Data is collected through an online questionnaire. The survey link is delivered to the participants through digital communication channels. The purpose of the research is explained to the participants, it is stated that the participation is voluntary, and it is stated that the data obtained will be used for scientific purposes. No personal information that can directly identify you is requested.

Data Analysis

The data obtained in the research are analyzed using the SPSS package program. Before proceeding with the analysis process, incomplete data, incorrect entry and outlier checks are made. Skewness and kurtosis values are examined to determine whether the data are normally distributed. The suitability of the scales for factor analysis is evaluated by KMO and Bartlett Sphericality Test. Cronbach's Alpha coefficients are calculated to determine reliability levels. Pearson correlation analysis is applied to determine the relationships between variables, and regression analysis is applied to examine the effect of global financial communication and new media credibility on economic public perception.

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Findings

Table 1. Distribution of Demographic Characteristics of Participants

Variable	Category	n	%
Gender	Women	210	53.7
	Male	181	46.3
Age	18–25 years	74	18.9
	26–35 years	139	35.5
	36–45 years	92	23.5
	46–55 years old	61	15.6
	56 years and older	25	6.4
Education Level	High school and below	56	14.3
	Associate Degree	68	17.4
	Undergraduate	178	45.5
	Master's Degree	72	18.4
	Doctorate	17	4.3
Monthly income level	20,000 TL and down	48	12.3
	20,001–35,000 TL	97	24.8
	35,001–50,000 TL	116	29.7
	50,001–65,000 TL	78	19.9
	65,001 TL and over	39	10.0
	I don't want to specify	13	3.3
District of residence	Nicosia	136	34.8
	Famagusta	82	21.0
	Kyrenia	76	19.4
	Iskele	43	11.0
	Güzelyurt	34	8.7
	Lefke	20	5.1
	Total	391	100.0

Table 1 shows the distribution of the demographic characteristics of the participants. According to gender distribution, 53.7% of the participants were female and 46.3% were male. The highest rate in age distribution is in the 26-35 age group with 35.5%. At the education level, undergraduate graduates rank first with 45.5%.
The highest rate in monthly income is seen in the range of 35,001-50,000 TL with 29.7%. This ratio is followed by the income range of 20,001–35,000 TL with 24.8% and 50,001–65,000 TL with 19.9%. Nicosia has the highest rate with 34.8% in the distribution of districts of residence. Famagusta is the other prominent district with 21.0% and Kyrenia with 19.4%.

Table 2. Distribution of Participants on Internet, Financial Information and New Media Usage Characteristics

Variable	Category	n	%
Daily internet usage time	Less than 1 hour	18	4.6
	1–3 hours	83	21.2
	4–6 hours	146	37.3
	7 hours and up	144	36.8
Frequency of following financial news	Never	23	5.9
	Rarely	72	18.4
	Occasionally	121	30.9
	Often	105	26.9
	Every day	70	17.9
The source where financial information is tracked	Television	55	14.1
	Newspaper / Magazine	19	4.9

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Variable	Category	n	%
	News websites	91	23.3
	Social Media	113	28.9
	YouTube	48	12.3
	Podcasts	10	2.6
	Financial mobile apps	45	11.5
	Other	10	2.6
New media platform for financial content	Instagram	90	23.0
	Facebook	38	9.7
	X	78	19.9
	LinkedIn	36	9.2
	TikTok	32	8.2
	YouTube	79	20.2
	Podcasts	15	3.8
	No specific platform	15	3.8
	I don't follow	8	2.0
Financial literacy level	Very low	18	4.6
	Low	61	15.6
	Medium	194	49.6
	High	93	23.8
	Very high	25	6.4
Previous investment status	Yes	214	54.7
	No	177	45.3
	Total	391	100.0

Table 2 shows the distribution of participants' internet usage, sources of access to financial information, new media platform preferences, financial literacy levels, and investment experiences. In daily internet usage time, the range of 4-6 hours ranks first with 37.3%. 36.8% of the participants stated that they use the internet for 7 hours or more per day.

The occasional option stands out in the frequency of following financial news with 30.9%. The rate of those who follow frequently is 26.9%, and the rate of those who follow every day is 17.9%. Social media ranks first with 28.9% among the sources where financial information is followed. News sites are in second place with a rate of 23.3%.

Among the new media platforms used for financial content, Instagram stands out with 23.0%, YouTube with 20.2% and X with 19.9%. At the level of financial literacy, 49.6% of the participants rated themselves at a moderate level. When we look at the previous investment status, it is seen that 54.7% of the participants have investment experience, while 45.3% have not invested before.

Table 3. Descriptive Statistics on Scales

Scale / Sub-Dimension	N	Min.	Max.	Mean	SD	Level
Global Financial Communication Scale	391	1.80	5.00	3.72	.684	High
New Media Reliability Scale	391	1.60	5.00	3.58	.731	High
Economic Public Perception Scale	391	1.70	5.00	3.81	.652	High

Table 3 contains descriptive statistics for the scales. The average score of the Global Financial Communication Scale was 3.72, the average score of the New Media Reliability Scale was 3.58, and the average score of the Economic Public Perception Scale was 3.81.

When the average values are examined, it is seen that the global financial communication, new media reliability and economic public perception levels of the participants are in the high range. The highest average is in the Economic Public Perception Scale, and the lowest average is in the New Media Reliability Scale. SD values ranged from .652 to .731, indicating that the scale scores were distributed around the means at an acceptable level.

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Pearson correlation analysis was applied to determine the relationships between the variables in the research. The total scores of the Global Financial Communication Scale, New Media Reliability Scale and Economic Public Perception Scale were used in the analysis.

Table 4. Correlation Analysis Results Between Scales

Variables	1	2	3
1. Global Financial Communication	1		
2. New Media Credibility	.612**	1	
3. Economic Public Perception	.684**	.589**	1

p < .01

Table 4 shows the results of the Pearson correlation analysis between the scales. There is a positive, moderate and significant relationship between Global Financial Communication and New Media Reliability (r=.612; p<.01). There is a positive, moderate, and significant relationship between Global Financial Communication and Economic Public Perception (r=.684; p<.01).

There is also a positive, moderate and significant relationship between New Media Credibility and Economic Public Perception (r=.589; p<.01). When the correlation coefficients between the variables are examined, it is understood that the strongest relationship is between Global Financial Communication and Economic Public Perception. The positive correlations between the scales show that as the perception of global financial communication and the level of new media credibility increase, the perception of economic public opinion also increases.

In the research, regression analysis was performed to determine the effect of global financial communication on economic public perception. In the analysis, the Global Financial Communication Scale was considered as the independent variable and the Economic Public Perception Scale was considered as the dependent variable. The New Media Reliability Scale was evaluated as an explanatory variable in the model.

Table 5. Regression Analysis Results on the Impact of Global Financial Communication on Economic Public Perception

Model	B	SE	β	t	p
Constant	1.384	.132		10.485	<.001
Global Financial Communication	.652	.035	.684	18.501	<.001

R	R²	Adjusted R²	F	p
.684	.468	.467	342.287	<.001

Table 5 shows the results of the regression analysis on the impact of global financial communication on economic public perception. The model was significant (F=342.287; p<.05). Global financial communication accounts for 46.8% of the total variance in economic public perception.

The Global Financial Communication Scale had a positive and significant effect on the Economic Public Perception Scale (β=.684; t=18.501; p<.05). The increase in the global financial communication score increases the economic public perception score.

Table 6. Regression Analysis Results on the Impact of Global Financial Communication on New Media Credibility

Model	B	SE	β	t	p
Constant	1.147	.159		7.214	<.001
Global Financial Communication	.654	.043	.612	15.278	<.001

R	R²	Adjusted R²	F	p
.612	.375	.373	233.417	<.001

Table 6 shows the results of the regression analysis on the impact of global financial communication on new media credibility. The model was significant (F=233.417; p<.05). Global financial communication accounts for 37.5% of the total variance in new media credibility.

The Global Financial Communication Scale had a positive and significant effect on the New Media Reliability Scale (β=.612; t=15,278; p<.05). As the perception of global financial communication increases, the perception of new media reliability also increases.

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Table 7. Multiple Regression Analysis Results on the Impact of Global Financial Communication and New Media Credibility on Economic Public Perception

Model	B	SE	β	t	p	Tolerance	VIF
Constant	1.106	.175		6.320	<.001		
Global Financial Communication	.493	.043	.517	11.552	<.001	.625	1.599
New Media Credibility	.243	.040	.273	6.089	<.001	.625	1.599

R	R²	Adjusted R²	F	p	Durbin-Watson
.717	.514	.512	205.224	<.001	1.981

Table 7 shows the results of multiple regression analysis on the impact of global financial communication and new media credibility on economic public perception. The model was significant (F=205.224; p<.05). Global financial communication and new media credibility together explain 51.4% of the total variance in economic public perception.

The Global Financial Communication Scale had a positive and significant effect on the Economic Public Perception Scale (β=.517; t=11.552; p<.05). The New Media Credibility Scale also had a positive and significant effect on the Economic Public Perception Scale (β=.273; t=6.089; p<.05). When standardized beta coefficients are examined, it is seen that the strongest effect on economic public perception belongs to the global financial communication variable.

VIF values below 10 and tolerance values above .10 indicate that there is no multi-linkage problem between the variables. The Durbin-Watson value of 1.981 indicates that there is no autocorrelation problem between the error terms.

Conclusion and Discussion

The aim of the study is to examine the impact of global financial communication on economic public perception and to determine the role of new media credibility in this relationship. When the descriptive statistics of the scales are examined, it is seen that the mean of the Global Financial Communication Scale is 3.72, the average of the New Media Reliability Scale is 3.58 and the average of the Economic Public Perception Scale is 3.81. The mean values show that the participants' levels of global financial communication, new media credibility and economic public perception are in the high range. The fact that the highest average is in the perception of the economic public reveals that the perceptions and evaluations of the participants regarding economic developments are strong.

According to the results of the correlation analysis, there are positive and significant relationships between global financial communication, new media credibility and economic public perception. The relationship between global financial communication and economic public perception is r=.684. A significant positive correlation was found between global financial communication and new media credibility at the level of r=.612, and a positive significant correlation was found between new media credibility and economic public perception at the level of r=.589. The fact that the strongest relationship between the variables is between global financial communication and economic public perception shows that the flow of financial information has a prominent place in the economic evaluation processes of individuals.

The results of the regression analysis reveal that global financial communication has a positive and significant impact on economic public perception. Global financial communication accounts for 46.8% of the total variance in economic public perception. The standardized beta coefficient of β=.684 shows that as the level of global financial communication increases, the perception of economic public opinion also strengthens. The impact of global financial communication on new media credibility is also positive and significant. The variance rate explained in this model is calculated as 37.5% and the standardized beta coefficient is calculated as β=.612.

In multiple regression analysis, global financial communication and new media reliability together explain economic public perception in a meaningful way. The fact that the two variables together explain 51.4% of the total variance in economic public perception shows that the model has a strong explanatory effect. In the model, the beta coefficient of global financial communication is calculated as β=.517, and the beta coefficient of new media reliability is calculated as β=.273. It is seen that the strongest effect on economic public perception belongs to the global financial communication variable, while new media reliability makes a significant contribution to the model.

The results obtained from the research show that the circulation of financial information on a global scale affects the economic perceptions of individuals. Financial news, market commentary, economic indicators, and financial

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content disseminated on digital platforms play a significant role in the way individuals evaluate economic developments. Shiller's (2019) approach that economic narratives have an impact on individuals' expectations and decision processes and Soroka, Stecula, and Wlezien's (2015) evaluations that economic news can shape public perception coincide with the results of the research.

The significant effect of new media reliability on economic public perception shows that finding financial content encountered on digital platforms reliable is effective in economic evaluation processes. Kohring and Matthes' (2007) approach, which considers trust in the media as a multidimensional structure, reveals the importance of evaluating financial content in terms of accuracy, impartiality and reliability in new media environments. Fletcher and Park's (2017) findings on the relationship between digital media trust and news consumption also support the role of new media credibility on economic perception.

The positive impact of global financial communication on new media credibility shows that the way financial content is presented is related to the perception of trust in digital media environments. Conveying financial information in a clear, understandable, up-to-date, and accessible manner enables individuals to have more confidence in the economic content on new media platforms. Castells' (2010) approach to network society and Van Dijck, Poell, and De Waal's (2018) evaluations of the central role of digital platforms in information circulation show that financial communication processes take place more quickly and interactively in new media environments.

In general, the research reveals that global financial communication is a powerful variable in explaining economic public perception. New media credibility stands out as an important variable that directly affects economic public perception and increases the explanatory nature of the model together with global financial communication. The dissemination of financial information on a global scale, its visibility in new media environments, and its reliability by individuals are effective in shaping economic public perception. This situation increases the importance of accurate, transparent, understandable and reliable information transfer in financial communication processes.

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THE ROLE OF DIGITAL RESOURCES IN RAISING ENVIRONMENTAL AWARENESS AMONG PRIMARY SCHOOL STUDENTS

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ABSTRACT
This study systematically examines the role of digital resources in fostering environmental awareness among primary school students and provides a pedagogical justification for their integration into the Life Science curriculum. As global environmental challenges such as climate change, biodiversity loss, and resource depletion intensify, developing environmental literacy at an early age becomes increasingly important. Digital technologies offer innovative and effective learning environments that enhance students' understanding of ecological concepts.

Research indicates that interactive videos, mobile environmental applications, augmented and virtual reality tools, and online learning platforms significantly enrich students' ecological knowledge and strengthen inquiry-based learning. Virtual ecosystem models, digital maps, and field-observation apps simplify complex environmental processes and make them accessible to young learners. Observations conducted in Azerbaijani schools and teacher feedback reveal that the use of digital tools increases student motivation, attention, and engagement. Furthermore, digital environmental activities have a measurable impact on students' real-life behaviors, including waste sorting, water conservation, and environmentally responsible decision-making.

The findings highlight the need for a systematic integration of digital resources into the Life Science curriculum, the enhancement of teachers' digital-pedagogical competencies, and the development of Azerbaijani-language ecological learning platforms. This approach serves as an innovative and sustainable model for strengthening environmental culture and supporting responsible ecological behavior among primary school students.
Key Words: environmental education, primary school, digital resources, ecological literacy, ICT in education, Life Science.

Introduction

The global ecological crisis—manifested through climate change, depletion of water resources, deforestation, and escalating air pollution—renders the development of environmental awareness a critical imperative globally, as well as in Azerbaijan. The formation of ecological knowledge and behavior must initiate during the primary education phase rather than being deferred to secondary or higher education levels. This is primarily because children's attitudes toward the environment, observation skills, environmental responsibilities, and core values are substantially shaped during their primary school years (Əlizadə, 2004).

Educational reforms and next-generation curricula in the Republic of Azerbaijan designate environmental education as a priority domain (UNESCO, 2021). Accordingly, the content standards of the "Life Science" curriculum allocate significant emphasis to components such as nature conservation, ecological balance, and the sustainable utilization of water, air, and soil resources (Azərbaycan Respublikasının Ümumi təhsil fənləri üzrə kurikulumları, 2012). However, the instruction of this content cannot achieve optimal efficiency without the integration of modern pedagogical technologies and student-centered interactive methodologies (Mehrabov, 2010; Veyisov, 2007). Concurrently, enhancing the digital pedagogical competencies of pre-service primary school teachers within regional higher education institutions carries strategic importance for the accurate execution of this process in schools (Azərbaycan Respublikasında təhsilin inkişafı üzrə Dövlət Strategiyası, 2013).

The educational landscape of the 21st century is undergoing rapid digitalization, and this transformation introduces novel opportunities for teaching environmental topics in primary schools (Atan & Kocasaraç, 2022). Virtual field trips, interactive maps, augmented reality (AR) models, mobile applications, and animations enable students to conceptualize environmental phenomena in a more lucid, engaging, and practical manner (Karaca & Aktaş, 2019). Aligned with the developmental and age-specific characteristics of primary school learners, digital resources effectively reinforce visual learning, interactivity, and hands-on practices (Odabaşı, 2018).

The objective of this paper is to investigate the role of digital resources in cultivating environmental awareness and sensitivity among primary school students, delineate the scientific-pedagogical foundations of the subject, and propose an effective methodological model for educators.

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The Role of Environmental Education at the Primary School Level

The primary school period constitutes one of the most sensitive developmental phases for shaping environmental consciousness in children. This age cohort is characterized by active interaction with the environment, where learning driven by observation and empirical experience is predominant. The objective of environmental education extends beyond the mere transmission of factual knowledge regarding nature; it aims to foster responsible behaviors, ecological mindsets, and a sustainable, long-term value system in children. In this context, environmental education represents a comprehensive pedagogical process encompassing cognitive (knowledge), affective (values), and behavioral components.

The Phase of Forming Environmental Knowledge

This phase concerns primary school students' comprehension of natural phenomena, their interrelationships, and the anthropogenic impacts on nature (Boeve-de Pauw et al., 2015). The transmission of environmental knowledge is executed through various didactic approaches, visual and digital resources, and experiential activities. At the primary level, students fundamentally acquire the following ecological concepts:

- **Differentiation between living and non-living entities:** The ecological roles of plants, animals, water, air, and soil as natural components.
- **Basic ecosystem awareness:** Elementary concepts regarding forest, aquatic, and meadow ecosystems, along with their fundamental constituents.
- **Natural processes:** Simplified conceptualizations of the water cycle, photosynthesis, and the causes and consequences of air and soil pollution.
- **Human-nature interactions:** Concrete examples illustrating how human activities positively or negatively influence the ecological equilibrium.

In organizing this cognitive content, the age-specific characteristics of primary school students are strictly considered. Since logical deduction skills are still emerging at this stage, topics are presented in a simplified, concrete, and observation-based format.

Cultivating Environmental Values

The internalizations of environmental values fosters emotional and social responsibility toward nature. This stage lies at the core of environmental education, given that sustainable environmental behaviors necessitate the prior formation of value-based attitudes. The primary values targeted for acquisition include:

- **Love and preservation of nature:** Children recognize the significance of exhibiting care toward plants, animals, water, and soil.
- **Sense of responsibility:** Students begin to understand that environmental protection is a collective, universal duty.
- **Formation of aesthetic values:** Perceiving the intrinsic beauty of nature, observing colors, sounds, and seasonal transitions.

According to Piaget’s (1964) theory of cognitive development, primary school-aged children operate within the concrete operational stage, meaning they may experience difficulty grasping abstract ecological concepts. Consequently, to transform these values into daily practices, natural phenomena should be delivered predominantly via visual materials, authentic experiences, observational activities, animations, and interactive games (Alkan, 1998).

Environmental Behaviors

Environmental behaviors denote the concrete, practical actions taken by children to protect nature. The ultimate goal of cultivating these behaviors is to ensure that students develop into responsible, ecocentric individuals in their future lives (Zimmerman & Land, 2014). Exemplary pro-environmental behaviors that can be developed at the primary school level include:

- **Waste segregation:** Children acquire the habit and understand the importance of sorting plastic, paper, and other waste materials.
- **Energy and water conservation:** Developing practical skills such as turning off lights in classrooms and households, preventing water wastage, and utilizing domestic appliances efficiently.
- **Plant and animal care:** Cultivating small plants within the classroom or participating in tree-planting activities in the school yard enhances children's sense of accountability.

Experiential learning, project-based learning, digital simulations, and ecological gaming represent the most viable approaches to instilling these behaviors. Consequently, students transform from passive recipients of information into active participants in environmental conservation.

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Pedagogical and Psychological Foundations of Digital Resources

Within the primary education environment, digital technologies exhibit a high degree of adaptability to students' age characteristics and psychological development stages. The appropriate integration of technology into instructional processes strengthens students' information processing networks, thereby facilitating retentive learning (Mishra & Koehler, 2006; Siemens, 2005). The pedagogical and psychological affordances of digital resources can be categorized under the following dimensions:

Enhancing Motivation and Attention Span

By nature, primary school students exhibit shorter attention spans and are highly responsive to visual stimuli. Rich animations, dynamic graphics, and interactive designs substantially elevate students' engagement in the lesson. The motivational mechanisms of digital resources are linked to:

- **Gamification elements:** Features such as points accumulation, leveling up, and reward mechanisms stimulate students through intrinsic motivation (Prensky, 2001).
- **Emotional impact of multimedia delivery:** The integration of music, sound effects, and animations establishes a positive affective foundation in the classroom, rendering learning more appealing (Günüç, 2021).

According to Bandura's (1977) Social Learning Theory, visual modeling accelerates the formation of behavioral patterns in children. Demonstrating pro-environmental actions through digital videos (e.g., proper waste recycling) reinforces the student's inclination to replicate these behaviors in their personal lives.

Simplifying Complex Ecological Processes and Fostering Inquiry

Numerous environmental themes, such as the water cycle, photosynthesis, biodiversity, and ecosystem dynamics, can appear overly abstract and intricate to primary school learners. Digital models and interactive simulations mitigate this challenge by making concepts more accessible. Rather than merely transmitting information, digital tools prompt students to investigate, observe, and deduce, thereby fostering critical inquiry skills (Jonassen, 2000). Utilizing these tools, students can construct brief research presentations on environmental issues and engage in peer-to-peer knowledge exchange (Selwyn, 2016).

Individualized Learning and Artificial Intelligence

Digital platforms offer profound advantages in tailoring the learning trajectory to individual learner profiles. This is particularly crucial in primary education, where children's prior knowledge, learning paces, and interests vary significantly. Crucially, the implementation of Artificial Intelligence (AI) in education allows students to progress at their own pace, enabling them to reinforce weak ecological concepts through adaptive assessments and personalized pathways (Luckin et al., 2016). This approach aligns with Vygotsky's (1978) "Zone of Proximal Development" (ZPD) theory, wherein digital tools serve as instructional scaffolding that bridges the gap between a student's current capacity and their prospective learning goals.

Core Digital Resources Utilized in Environmental Education

Digital resources ensure that environmental education in primary schools is conducted in a more comprehensive, practical, and highly motivating manner. These tools provide students with opportunities to observe nature in both real and virtual environments, learn via interactive tasks, and formulate sustainable behavioral habits.

Mobile Applications and Digital Field Trips

Mobile applications occupy a distinct position in environmental education as they facilitate interaction between students and the physical environment (Zimmerman & Land, 2014). Leveraging digital mapping tools like Google Earth, children can analyze diverse conservation areas, rivers, and global ecosystems in a 3D format without leaving the classroom. Simultaneously, mobile applications designed to identify plant and animal species in nature stimulate children's innate investigative instincts.

Animation and "Digital Storytelling"

Digital storytelling represents one of the most potent instructional methodologies at the primary school level (Robin, 2008). Short animations and interactive narratives centered on environmental issues evoke emotional resonance and enhance cognitive retention. By explicating the causes and ramifications of environmental degradation through a simplified narrative arc, these tools cultivate empathy in young learners.

To provide a systematic evaluation of how these diverse technological components interface with educational outcomes, a conceptual framework is synthesized below:

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Table 1. Pedagogical Framework of Digital Resources in Primary Environmental Education

Digital Resource Type	Core Educational Features	Target Ecological Skill / Value	Pedagogical / Psychological Basis
Mobile Applications & 3D Mapping (e.g., Google Earth, Seek)	Real-world exploration, species identification, spatial awareness.	Scientific observation, Biodiversity recognition.	Experiential Learning Theory (Kolb, 1984)
Gamified Platforms & Simulations (e.g., Kahoot, Eco-games)	Reward mechanisms, points, adaptive level transitions.	Energy conservation habits, Waste segregation.	Gamification & Motivation (Prensky, 2001)
Digital Storytelling & Animations (e.g., Animated eco-narratives)	Emotional resonance, cause-and-effect visualization.	Nature preservation, Empathy towards living beings.	Social Learning Theory & Modeling (Bandura, 1977)
AI-Powered Adaptive Tools (e.g., Personalized ecological quizzes)	Customized learning pacing, instant automated feedback.	Conceptual understanding of complex ecosystems.	Zone of Proximal Development (Vygotsky, 1978)

Discussion

The findings of this study demonstrate that the utilization of digital resources plays a paramount role in enhancing the quality of environmental education in primary schools, exerting a significant impact on both children's knowledge levels and their daily ecological behaviors. The accumulated data reveal that digitally mediated lessons not only maximize student motivation but also enable learners to grasp the essence of ecological topics more profoundly, contextualize them within real-life scenarios, and build permanent behavioral habits.

Despite the profound benefits of digital integration documented in this study, the successful implementation of these resources in regional areas, such as Shamakhi and other districts of Azerbaijan, faces distinct pedagogical constraints. As noted by Əlizadə (2004) and Mehrabov (2010), infrastructural disparities and varying levels of digital literacy among primary school educators can impede the standardized delivery of ecological curricula. This socio-technological gap, often referred to as the digital divide, implies that the mere availability of mobile applications or animations does not guarantee ecological literacy unless accompanied by systematic teacher training. Therefore, transforming passive technology consumption into active ecological inquiry requires a blended approach where digital simulation complements, rather than replaces, physical contact with nature (Siemens, 2005; Zimmerman & Land, 2014).

These outcomes closely parallel the international literature. Zimmerman and Land (2014) affirm that mobile learning tools constitute a key determinant in raising environmental awareness among children. Their research underscores that students utilizing interactive applications approach environmental problems with higher sensitivity, and display rapid advancement in observation and decision-making skills. This pedagogical approach carries immense contemporary relevance for the primary school age cohort, a period marked by high cognitive flexibility where the acquisition of new behavioral models is more easily achieved.

Furthermore, UNESCO's (2021) strategic educational frameworks consistently reaffirm the pioneering role of digital technologies. UNESCO emphasizes that digital resources must not be limited to passive knowledge transmission; rather, they should serve as vital instructional instruments that drive students toward active engagement, problem-solving, critical reflection, and creative thinking. In this regard, the outcomes observed within Azerbaijani schools align seamlessly with global frameworks, indicating that digital resources in primary education concurrently serve the cultivation of broader 21st-century skills.

Conclusion and Recommendations

This study explicitly demonstrates that environmental education at the primary school level can be executed in a far more systematic and impactful manner through the integration of digital resources. Empirical observations indicate that digital tools do not merely facilitate the cognitive acquisition of data; they significantly contribute to students' internalization of environmental values and the development of an accountable, pro-environmental stance toward nature.

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Recommendations

Based on the research findings, the following recommendations are proposed:

- **Systematic Integration of Digital Environmental Resources:** Interactive applications, digital simulations, and software modeling environmental issues should be granted a more expansive role within primary school curricula.
- **Teacher Professional Development in Digital Pedagogy:** To ensure the effective utilization of digital resources, educators must be systematically integrated into professional development programs focusing on modern digital tools, methodologies, and platforms.
- **Expansion of Gamified Instructional Materials:** Given that digital games and interactive quests significantly amplify learner motivation, the volume, accessibility, and pedagogical quality of gamified environmental learning materials must be augmented.

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