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# Conceptual awareness levels of digital logistics among Turkish university students

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The logistics industry has witnessed the emergence of digital technology as a central topic of discourse, and terminology associated with digital logistics has gained extensive usage among professionals in the transportation, logistics, and international trade sectors. Digital logistics is highly dependent on the accumulation of data from the logistical activities conducted by organizations. The implementation of a digitalized process presents organizations with novel prospects, such as decreased operational expenses, increased efficiency, and reduced uncertainties associated with order fulfillment. Additionally, digital logistics facilitates the enhancement of distribution methods for businesses. The post-graduation knowledge levels of students become significant factors for potential employers. University education plays a crucial role in imparting academic and technical expertize in the domain of logistics; therefore, it is critical that logistics programs integrate a greater number of digital courses. Academic institutions play a pivotal role in enabling students to gain consciousness and comprehension of emerging patterns and concepts. In light of this, the purpose of this research was to determine "the extent of digital logistics and digitalization conceptual awareness" among university students. The results of the study will be used as a guide for educational institutions like colleges to follow when it comes to incorporating digital courses into their curriculum. It was decided to use questionnaires for the purpose of data collecting. A statistical analysis was conducted on the information gathered from the university students. While most students had a good grasp of the concepts of AI, VR, digital supply chain, and transportation management systems, female students showed less familiarity with these phrases than their male counterparts. It is possible for universities to provide students with the opportunity to acquire knowledge of digital logistics concepts through the implementation of training courses, workshops, programs, and term projects. It is advisable to promote students' acquisition of knowledge regarding digital technologies through the implementation of additional courses. The educational experience and students' overall level of awareness can be greatly enhanced through partnerships between IT firms and institutions.

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## Introduction

Initially, digitalization appears to prioritize data, as seen by the growing emphasis on Big Data. This entails the availability of vast quantities of data on the Internet, which can be analyzed in cloud-based systems. This type of digital data is a representation of a model of the world that it describes. The vast majority of the data that has been gathered, frequently in an unstructured and raw form, describes artifacts that exist in the real world. However, if the goal is to generate information and knowledge from these datasets beyond simply observation, one must aggregate relevant traits and abstract from numerous irrelevant details to address broader problems. These combined concepts are also representations that can explain the common and therefore applicable occurrences of objects, processes, and circumstances, as well as their distinct qualities that enable scientists and the public to comprehend specific aspects of the world (Gray and Rumpe, 2015).

The Fourth Industrial Revolution (Industry 4.0) and the Internet of Things (IoT) serve as the catalysts for digitalization, which is a fundamentally disruptive force that is altering our approaches to and perceptions of corporate activities and processes. Within the current wave of digitalization, the interactions between organizations (such as enterprises and governmental agencies) and customers are undergoing significant changes, leading to the continuous emergence of new models of business. In the current business environment, organizations in all sectors need to be agile, fast, adaptable, and able to quickly change direction in order to chase new business opportunities and stay in tune with the continuously evolving global business landscape. The significance of integrating cutting-edge technology into all operations, goods, and services is emphasized by digitalization. However, a significant amount of the expected benefit of digitalization for businesses and society has yet to be realized. Parida (2018) argues that the development of necessary knowledge and skills at individual, organizational, and social levels will be greatly aided by academic institutions (Parida, 2018).

Digitalization holds a great potential to improve the efficiency of the companies, particularly in product and service development. It facilitates more integrated value chains, enhancing the efficiency of various company functions, reducing the lead times, and enabling better control over the operations. Sharing information among systems and functions, including production resources planning, coordination improvement, visualization and planning of crucial processes are significant as well. Moreover, digitalization also affords companies equal or better opportunities to boost their revenue and lower their costs (Björkdahl, 2020).

Departments at relevant universities have begun to place a premium on up-to-date course materials and curriculum due to the increased need for human resources in the dynamic logistics industry. It is essential to examine the educational requirements at the university level, which are customized to align with the sector's demands and increasingly based on improved collaboration between the involved parties. As the sector experiences increased digitalization and investments in technology, the corresponding evolution of human resources needs is observed. When updating educational content in universities, it is crucial to accurately identify these specific needs. In order to keep up with the rapid pace of technological innovation, any educational content that is generated with the intention of catching up should be prepared both conceptually and practically. Furthermore, institutions should be ready to allocate additional resources to make new initiatives in this particular field. It is crucial to initiate the required initiatives promptly, despite the fact that such investments generally demand time to materialize, even though they may encompass everything from laboratories to faculty instructors. Over time, as universities develop a greater interest in logistics technologies, it will inevitably follow that investments in this sector will be sought after to fund the creation of new projects that address the sector's requirements.

Digitalization has profoundly altered the business models and processes. For businesses, this means rapid digitalization of internal company processes, product/service components, communication channels and other key elements in the supply chain (Geisberger and Broy, 2012). The use of digital technologies in business processes can yield benefits such as optimization of resource use, lower costs, increased employee productivity, improved work efficiency, optimization of supply chains, elevated customer satisfaction and dependency (Rachinger et al., 2019). The best examples of digitalization are seen in businesses operating in the retail sector where companies such as Amazon and Alibaba generate billion-dollar sales through both conventional stores and online platforms.

Digital business is anticipated to become the prevalent trend and have a substantial impact over the next five years, according to a forecast by DHL that starts in 2018 (DHL Trend Research, 2018). The prediction has been verified by the most recent time period. It is a well-known fact that digital business has substantially supplanted traditional forms of e-mail communications. In the future, the logistics industry will undergo significant changes due to the aging population, the rise of the millennial workforce, and the automation of repetitious and physically demanding labor.

By the year of 2025, digitalization is expected to bring an additional benefit of 1.5 trillion dollars for logistics operators and 2.4 trillion dollars for companies undertaking the digital transformation of the industry. According to the World Economic Forum, the digital transformation of the logistics industry will revolve around five key issues over the next decade: Big Data usage; creation of digital platforms allowing daily deliveries worldwide; new delivery capabilities such as digitized self-driving trucks and drones; adopting circular economic methods that reduce consumption and emissions; and the sharing of logistics infrastructures (Morning Future, 2019).

Mark McArthur from Alpega Group asserts that the digitization of logistics and supply chain is a matter of today, not a matter of the future. Technology and automation entailed by digitalization has the potential to minimize inefficiencies and the use of shared datasets can enable improved decision making. It is also stated that digitization can facilitate end-to-end connectivity between trading partners and their supply chains and offer visibility throughout the execution of all supply chain functions. Cloud-based collaborative platforms are essential components in building a circular economy and digital supply chain ecosystem, as they offer visibility, promote information sharing, and ensure transparency among shippers, carriers, customers, suppliers, and partners. Realizing the value of digitization applications requires strong capabilities in areas such as the Internet of Things (IoT), advanced analytics, artificial intelligence (AI), blockchain and other emerging technologies (Supply Chain 24/7, 2023).

Within the logistics industry, the process of digital transformation can yield substantial social and environmental advantages by enhancing productivity, minimizing energy usage, and mitigating emissions. The widespread adoption of digital technologies within the logistics industry is crucial in this regard.

In order to gain an edge over competitors, digitalized logistics activities offer several benefits. These include complete and real-time visibility into the supply chain, streamlined operations at the logistics center and in the transport chain, increased optimization with big data analytics, unlimited access to data through the cloud, better automation with decentralized and autonomous decision-making, fewer mistakes in complicated processes, higher customer satisfaction, and more adaptability in the supply chain.

In essence, the logistics sector is profoundly influenced by digitalization. In light of the critical nature of digitalization and the post-graduation knowledge levels of students in logistics affecting their opportunities for employment, academic and technical universities are actively aiming to integrate supplementary digital courses into their logistics curricula. In response to the efforts that educational institutions have been making in this area, the purpose of this research was to evaluate the degrees of conceptual awareness levels that university students have regarding digitalization and digital logistics. When it comes to the adoption of digital courses into their curriculum, the conclusions of the investigation will serve as suggestions for institutions to follow. This research helps academic institutions identify areas needed to create technology-friendly logistics curriculum infrastructure.

**Table 1 Distribution of students in the sample by demographic characteristics.**

| Demographic Feature | Variables | N | % |
|---|---|---|---|
| Gender | Male | 69 | 6160 |
| | Female | 43 | 3840 |
| Level of Education | Associate Degree | 25 | 2230 |
| | Bachelor's Degree | 87 | 7770 |
| Year of School | 1. Year | 4 | 360 |
| | 2. Year | 50 | 4460 |
| | 3. Year | 34 | 3040 |
| | 4. Year | 24 | 2140 |
| Department | LM | 60 | 5360 |
| | ITLM | 29 | 2590 |
| | Other | 23 | 2050 |
| CGPA | 1.8 Lower | 16 | 1430 |
| | 1.8–2.5 | 34 | 3040 |
| | 2.51–3.00 | 34 | 3040 |
| | 3.01–3.5 | 19 | 1700 |
| | 3.51–4.00 | 9 | 800 |
| Total | | 112 | 100 |

**Table 2 KMO and Bartlett's test analysis results.**

| Kaiser-Meyer-Olkin | | 0.905 |
|---|---|---|
| Bartlett's Test | Chi-Square | 2015,600 |
| | df | 276 |
| | Sig. | <0.001 |

## Literature review

Recent studies conducted by ICD and Statista report that the total volume of data circulating worldwide amounted to 64.2 zettabytes in 2020. It is estimated that this data whether is copied, stored in cloud systems, or recreated will reach 180 zettabytes by 2025. Undoubtedly, the COVID-19 pandemic crisis had a substantial impact on this situation due to the greater need for data used particularly via electronic systems at the time. Furthermore, the volume of this data has surged even more due to the increasing need for digital data in the logistics world (Reinsel et al., 2020; Statista, 2020). While it is rather challenging to determine the precise number of departments worldwide that offer logistics education, a study by EduRank.org reveals that there are 71,100 academic articles on Logistics and Supply Chain Management published worldwide by 923 universities. On the other hand, these studies have garnered a substantial number of citations, reaching 2,090,000.

While the use of logistics concept is relatively new in commercial context, it has a long-standing history within the military literature. The first steps towards the digitalization, on the other hand, were taken in 1800s with the introduction of the telegraph and telephone into our lives. The 20th century witnessed the emergence of computers and acceleration of the digitalization process. Finally, with the introduction of the Internet, digital transformation has reached its highest level (Fazlollahtabar et al., 2011).

'Digitization' and 'digitalization' have essentially different meanings. Before delving into the literature on digitalization, it is important to distinguish between these two concepts. According to Westerman, "digitization" is the process of converting analog information into digital data, while digitalization refers to any change experienced with the use of digital technologies in a business process (Westerman et al., 2011). "Digital transformation", on the other hand, is defined as the system-level restructuring of the economic world with digital expansion (Kiron et al., 2017; Kiron and Unruh, 2017).

The databases utilized for this research were "Emerald," "Ebsco Business Collection," and "National Thesis Center of the Turkish Council of Higher Education." The literature has been thoroughly reviewed using the specific term "digital logistics".

Alfred Maurstad deserves credit for being the first to publish the term "digital logistics" in scholarly literature. Maurstad, who developed a model for his doctoral dissertation titled "Navy Supply System," asserts that the communication network connects the different phases of a real-time requisitioning system as an essential link. However, a Navy real-time requisitioning system requires more than just this. It also requires an "automated digit network" to effectively communicate all digital logistics information (Maurstad, 1964).

According to Koroliova (2019), digital logistics is defined as digitization of freight transport. This includes intelligent management systems and tracking of cargo at all stages of transport, unmanned technologies, full automation of document flow (electronic goods and transport documents), fast customs clearance in cross-border traffic. Development of artificial intelligence in the logistics industry and supply chains has brought about many changes, and the rise of powerful technology is creating innovations such as predictive analytics, autonomous vehicles, and smart roads (Kuprenko, 2019).

In fact, references to digital logistics have also been made within the military literature. For example, in 1984, the US Department of Defense introduced the "Computer Aided Logistics System Program" and advocated for the adoption of "digital logistics" instead of paper-based logistics (Calogero and DeTolla, 1987). For this very reason, in his 1998 article for Harvard Business Review, Peter Drucker argued that the logistics information systems employed by organizations carrying out logistics activities are instrumental in ensuring the effective use of organizational processes and enhancing the flexibility of organizations (Drucker, 1988). As a result, in 2000, the US Department of Defense released a report titled "Digital Logistics", stating that they anticipate a complete digital transition by 2030 and since this transition is expected to have dramatic impacts on military logistics, it is necessary to revise the logistics processes to leverage the advantages presented by this digital future (Devito, 2000).

According to Douaioui et al., logistics plays an important role in the digitalization of socio-economic ties. According to the authors, logistics systems that can support the digital world should display a same level of flexibility and agility as production systems. Digital logistics shows a transformation towards "intelligent logistics" where material flows are monitored in real time, fostering improved transport management and reducing the risks of precision management. The integration of cyber-physical systems and the Internet of Things into logistics systems are other

**Table 3 Results of initial factor analysis.**

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 12,184 | 50,767 | 50,767 | 12,184 | 50,767 | 50,767 |
| 2 | 1513 | 6304 | 57,071 | 1513 | 6304 | 57,071 |
| 3 | 1200 | 4999 | 62,069 | 1200 | 4999 | 62,069 |
| 4 | 1147 | 4781 | 66,850 | 1147 | 4781 | 66,850 |

**Table 4 First item factor loads of the digital logistics conceptual awareness scale.**

| Article No | Component Matrix | Article No | Component Matrix |
|---|---|---|---|
| Article 1 | 0.463 | Article 13 | 0.717 |
| Article 2 | 0.709 | Article 14 | 0.718 |
| Article 3 | 0.610 | Article 15 | 0.723 |
| Article 4 | 0.635 | Article 16 | 0.782 |
| Article 5 | 0.791 | Article 17 | 0.705 |
| Article 6 | 0.731 | Article 18 | 0.753 |
| Article 7 | 0.793 | Article 19 | 0.774 |
| Article 8 | 0.742 | Article 20 | 0.699 |
| Article 9 | 0.781 | Article 21 | 0.658 |
| Article 10 | 0.731 | Article 22 | 0.680 |
| Article 11 | 0.714 | Article 23 | 0.755 |
| Article 12 | 0.644 | Article 24 | 0.708 |

crucial factors in the evolution of logistics (Douaioui et al., 2018). This evolution has found a great level of acceptance over the last decade, both in research and in practice. Underscoring this, an article published in Forbes included the following statement: “Every five days, a digital logistics startup is born somewhere around the world.” (D’Incà and Borreck, 2017).

A study conducted by Teng et al. observes the relationship between “Internet” + and logistics. The study classifies the Internet+ contributions, added value and challenges in the digitizing logistics industry (Teng et al., 2018). A series of studies led by Sanders, Wang, and Chen explored the use of Big Data and strategies in logistics and supply chain management and categorized them (Sanders, 2014; Wang et al., 2016).

Krajcovic et al. examined the concept of “digital twins” for smart manufacturing and logistics systems. In the study, concepts such as Cyber Physical Systems (CPS) and Internet of Things (IoT) were utilized and concepts such as digital trends in the logistics sector, whilst smart logistics, and “Logistics 4.0” were explored (Krajcovic et al., 2018). The research by Neradilova et al. delved into the examination of autonomous robots and driverless systems (Neradilova and Fedorko, 2017). Da Silva et al., on the other hand, conducted a literature study involving technology transfer in the supply chain, a topic that is closely associated with logistics (Da Silva et al., 2019). Schlüter et al. researched “which digital technology is the best” in order to solve the problems experienced in both logistics and supply chain and conducted a survey to support their research (Schlüter and Hetterscheid, 2017). Furthermore, the World Economic Forum (WEF) provided insights on the future of the digitalized logistics sector in a White Paper in 2016, examining the digital trends in the logistics sector. The white paper, prepared in collaboration with Accenture, highlighted the importance of fields such as artificial intelligence, advanced automation, cloud computing technology, simulation technologies and data-driven service (World Economic Forum, 2016).

From an educational standpoint, educational institutions, particularly those offer higher education, should incorporate digital technologies into teaching and learning processes, ensuring students to acquire necessary digital skills encouraging innovation and increasing employability (Fleaca and Stanciu, 2019). Korepin et al. assessed the need for common online courses and IT-based applications within the context of digital economy and digital logistics education. The authors conducted a survey focusing on “self-education” and “use of Internet” among the economics students in Russia. Considering the needs of new labor market for educating professionals in digital logistics field and improving relevant skills, the study underscores “the need to transform e-learning approaches” (Korepin et al., 2020). In another study, Miranda et. al. sought to describe the level of “digital literacy” among higher education students through self-assessments (Miranda et al., 2018). Finally, Doğan and Baloğlu developed a scale with a view to defining the level of Industry 4.0 conceptual awareness of undergraduates. The scale was applied among a group of 300 undergraduates studying at the engineering and economics departments of a public university in Turkey (Doğan and Baloğlu, 2020).

Based on the findings of the literature review, it is important to acknowledge that although research has been conducted on the concepts of digital logistics, there is a lack of studies investigating the conceptual awareness of such concepts. Consequently, this research possesses an original characteristic in that it fills this specific gap.

## Research methodology

The primary objective of this study was to assess the level of conceptual awareness about digital logistics among university students. The participants in the study consisted of students enrolled in either a bachelor’s or associate degree program in the departments of logistics management and international trade and logistics at the time of the research. This study used a quantitative method and relied on a survey model to gather data. The purpose of a survey model is to provide an accurate description of a current or past situation and to generate predictions and generalizations about the entire universe via sampling. To rephrase, it is a research strategy that uses a subset of the universe or the population at large to draw conclusions about the whole. (Karasar, 2016). Survey studies also investigate the participants’ skills, abilities, and attitudes with respect to a specific subject or event, as well as their opinions or interests. These studies generally involve larger samples in comparison to other research methods (Büyüköztürk et al., 2016).

The study’s population comprises students enrolled in departments such as “international trade and logistics,” “logistics management,” and similar programs at varying Turkish universities that located in different regions during the academic year 2022–2023.

Providing an explanation for the two aforementioned academic degree credentials is beneficial. An associate degree is a two-year post-secondary education program that provides training for intermediate professionals and serves as the initial phase of undergraduate studies. In contrast, a bachelor’s degree is a minimum four-year undergraduate program that follows

**Table 5 Digital logistics conceptual awareness scale item loads and common variances.**

| Component Matrix | | | |
|---|---|---|---|
| 7. Cyber-Physical Systems | 0.795 | | |
| 5. Advanced Automation | 0.792 | 11. Augmented Reality | 0.715 |
| 16. Simulation Technologies | 0.784 | 13. Digital Supply Chain | 0.714 |
| 9. Big Data and Data Analytics | 0.779 | 24. IT Based Applications | 0.713 |
| 19. Blockchain Technologies | 0.772 | 17. Data Driven Service | 0.711 |
| 18. Autonomous Vehicle | 0.754 | 2. Artificial Intelligence | 0.706 |
| 23. Drone Technologies | 0.753 | 20. Cloud Robotic Applications | 0.705 |
| 8. Cloud Computing Technology | 0.741 | 22. Transportation Management System | 0.678 |
| 6. Cyber Security | 0.737 | 21. Lights-Out Manufacturing | 0.653 |
| 10. Virtual Reality | 0.734 | 12. Mixed Reality | 0.641 |
| 15. Smart Storage and Sensor Technologies | 0.725 | 4. 3D Printers | 0.638 |
| 14. Neural Networks | 0.718 | 3. Machine Learning | 0.606 |
| Explained Variance | | | 50,767 |
| Kaiser-Meyer-Olkin | | | 0.906 |
| Bartlett's Test | Chi-Square | | 1961,258 |
| | df | | 253 |
| | Sig. | | <0.001 |

**Table 6 Reliability statistics.**

| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | *N* |
|---|---|---|
| 0.957 | 0.957 | 24 |

**Table 7 Tests of normality.**

| | Kolmogorov-Smirnova | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Digital Logistics Conceptual Awareness | 0.077 | 112 | 0.100 | 0.981 | 112 | 0.120 |
| | | | Statistic | | Std. Error | |
| Digital Logistics Conceptual Awareness | Mean | | 3,2318 | | 0.08207 | |
| | Skewness | | −0.285 | | 0.228 | |
| | Kurtosis | | 0.137 | | 0.453 | |

**Table 8 The averages of students' digital logistics conceptual awareness scores for each concept.**

| Awareness Concept | Mean | Awareness Concept | Mean |
|---|---|---|---|
| 1. Internet of Things (IoT) | 3.36 | 13. Digital Supply Chain | 3.62 |
| 2. Artificial Intelligence | 3.60 | 14. Neural Networks | 2.61 |
| 3. Machine Learning | 3.28 | 15. Smart Storage and Sensor Technologies | 3.40 |
| 4. 3D Printers | 3.34 | 16. Simulation Technologies | 3.43 |
| 5. Advanced Automation | 3.03 | 17. Data Driven Service | 3.24 |
| 6. Cyber Security | 3.26 | 18. Autonomous Vehicle | 3.29 |
| 7. Cyber-Physical Systems | 2.71 | 19. Blockchain Technologies | 3.19 |
| 8. Cloud Computing Technology | 3.40 | 20. Cloud Robotic Applications | 2.79 |
| 9. Big Data and Data Analytics | 2.93 | 21. Lights-Out Manufacturing | 3.05 |
| 10. Virtual Reality | 3.61 | 22. Transportation Management System | 3.68 |
| 11. Augmented Reality | 3.31 | 23. Drone Technologies | 3.45 |
| 12. Mixed Reality | 2.72 | 24. IT Based Applications | 3.27 |

**Table 9 Averages of digital logistics conceptual awareness scores by gender.**

| Awareness Concept | Male | Female | Mean |
|---|---|---|---|
| 1. Internet of Things (IoT) | 3.52 | 3.09 | 3.31 |
| 2. Artificial Intelligence | 3.68 | 3.47 | 3.58 |
| 3. Machine Learning | 3.26 | 3.30 | 3.28 |
| 4. 3D Printers | 3.25 | 3.49 | 3.37 |
| 5. Advanced Automation | 3.07 | 2.95 | 3.01 |
| 6. Cyber Security | 3.17 | 3.40 | 3.29 |
| 7. Cyber-Physical Systems | 2.74 | 2.67 | 2.71 |
| 8. Cloud Computing Technology | 3.64 | 3.02 | 3.33 |
| 9. Big Data and Data Analytics | 2.94 | 2.91 | 2.93 |
| 10. Virtual Reality | 3.65 | 3.53 | 3.59 |
| 11. Augmented Reality | 3.46 | 3.07 | 3.27 |
| 12. Mixed Reality | 2.80 | 2.60 | 2.70 |
| 13. Digital Supply Chain | 3.52 | 3.77 | 3.65 |
| 14. Neural Networks | 2.57 | 2.67 | 2.62 |
| 15. Smart Storage and Sensor Technologies | 3.33 | 3.51 | 3.42 |
| 16. Simulation Technologies | 3.55 | 3.23 | 3.39 |
| 17. Data Driven Service | 3.19 | 3.33 | 3.26 |
| 18. Autonomous Vehicle | 3.36 | 3.19 | 3.28 |
| 19. Blockchain Technologies | 3.20 | 3.16 | 3.18 |
| 20. Cloud Robotic Applications | 2.77 | 2.84 | 2.81 |
| 21. Lights-Out Manufacturing | 3.20 | 2.81 | 3.01 |
| 22. Transportation Management System | 3.65 | 3.72 | 3.69 |
| 23. Drone Technologies | 3.48 | 3.40 | 3.44 |
| 24. IT Based Applications | 3.22 | 3.35 | 3.29 |

secondary education (Türkiye Cumhuriyeti Ölçme, Seçme ve Yerleştirme Merkezi Başkanlığı, 2023). University students in Turkey can choose from 31 bachelor's and 54 associate's degree programs in the field of logistics management, international trade and logistics, or similar fields. (Yükseköğretim Program Atlası, 2023). The survey questionnaire utilized in the research was distributed to students enrolled in 12 universities[1] that offer both undergraduate and associate degree programs. Two of these twelve universities are the leading institutes in Turkey with regard to the subject matter under study, in addition to having the greatest capacity to accommodate students. For the purpose of demonstrating the scheme, universities from seven additional regions of Turkey were chosen. The gathering of replies from the questionnaire took place between the 4th of August and the 2nd of September in the year 2022.

Table 1 demonstrates the demographic features of the students who were chosen as part of the sample. The survey showed that

**Table 10 Independent samples T-Test results (gender).**

| | Gender | *N* | Mean | Std. Deviation | Levene's Test | | *t* test | | |
|---|---|---|---|---|---|---|---|---|---|
| Digital Logistics Conceptual Awareness | Male | 69 | 3,2597 | 0.86189 | F | Sig. | t | df | Sig. |
| | Female | 43 | 3,1870 | 0.88754 | 0.293 | 0.589 | 0.429 | 110 | 0.671 |

**Table 11 Averages of digital logistics conceptual awareness scores by education.**

| Awareness Concept | Associate Degree | Bachelor's Degree | Mean |
|---|---|---|---|
| 1. Internet of Things (IoT) | 3.44 | 3.08 | 3.26 |
| 2. Artificial Intelligence | 3.71 | 3.20 | 3.46 |
| 3. Machine Learning | 3.26 | 3.32 | 3.29 |
| 4. 3D Printers | 3.33 | 3.36 | 3.35 |
| 5. Advanced Automation | 3.09 | 2.80 | 2.95 |
| 6. Cyber Security | 3.38 | 2.84 | 3.11 |
| 7. Cyber-Physical Systems | 2.70 | 2.76 | 2.73 |
| 8. Cloud Computing Technology | 3.57 | 2.80 | 3.19 |
| 9. Big Data and Data Analytics | 2.91 | 3.00 | 2.96 |
| 10. Virtual Reality | 3.70 | 3.28 | 3.49 |
| 11. Augmented Reality | 3.34 | 3.20 | 3.27 |
| 12. Mixed Reality | 2.66 | 2.96 | 2.81 |
| 13. Digital Supply Chain | 3.68 | 3.40 | 3.54 |
| 14. Neural Networks | 2.49 | 3.00 | 2.75 |
| 15. Smart Storage and Sensor Technologies | 3.46 | 3.20 | 3.33 |
| 16. Simulation Technologies | 3.51 | 3.16 | 3.34 |
| 17. Data Driven Service | 3.25 | 3.20 | 3.23 |
| 18. Autonomous Vehicle | 3.40 | 2.92 | 3.16 |
| 19. Blockchain Technologies | 3.29 | 2.84 | 3.07 |
| 20. Cloud Robotic Applications | 2.76 | 2.92 | 2.84 |
| 21. Lights-Out Manufacturing | 3.03 | 3.12 | 3.08 |
| 22. Transportation Management System | 3.77 | 3.36 | 3.57 |
| 23. Drone Technologies | 3.54 | 3.12 | 3.33 |
| 24. IT Based Applications | 3.31 | 3.12 | 3.22 |

**Table 12 Mann-Whitney test results (Education).**

| | Education | N | Mean Rank | Mann-Whitney U | Sig. |
|---|---|---|---|---|---|
| Digital Logistics Conceptual Awareness | Associate Degree | 25 | 4944 | 911,000 | 0.217 |
| | Bachelor's Degree | 87 | 5853 | | |

61% of the participants were male students, whereas about 39% were female students. Among the research participants, 22% were pursuing an associate degree while 88% were pursuing a bachelor's degree. Out of these students, 45% had a cumulative GPA (grade point average) of 2.50 or lower, while 65% had a GPA above 2.50.

## Results and discussion

The data obtained will be used in this section of the research to determine the conceptual awareness levels of university students in relation to digital logistics. In addition, this part contains analysis and findings that will provide answers to the topics that are addressed within the scope of the sub-objectives of the research.

In this research, an Exploratory Factor Analysis (EFA) was utilized to determine the construct validity of the scale. Factor analysis uses correlated variables to quantify a structure with numerous variables and explain them with statistics in well-designed research. Therefore, this method decreases the variability and allows for the identification of the factor structure inside the observed structure (Büyüköztürk, 2002). Before factor analysis, Kaiser-Meyer-Olkin (KMO) and Bartlett tests were done to assess data suitability. The outcomes of "KMO and Bartlett's" tests are given in Table 2.

As seen in Table 2, the KMO value of the scale was found to be "0.905", indicating an excellent degree of sample adequacy. In addition, the Chi-Square test result being significant at the 0.001 level (2015,600- $p < 0.01$) in Bartlett's test indicates that the data follow a multivariate normal distribution. These results suggest that the data are suitable for factor analysis.

The factor analysis conducted thus far to ascertain the number of factors comprising the scale has identified four factors, each with an explained variance level of 66,850 and an eigenvalue of 1 or greater. Table 3 displays the eigenvalues and the corresponding percentages of explained variance for the initial analysis. In light of the fact that the initial factor accounted for 50,767 of the total variance, it was also determined that a one-dimensional factor should be constructed.

It is evident from the data presented in Table 4 that none of the twenty-four items in the scale fall below the specified minimum factor loading value of "<0.45" as mentioned in the appropriate literature.

Table 5 displays the amount of variation explained by the structure acquired in the second analysis phase of the 24-item scale (which was designed as a single factor), as well as the scale's item loadings and KMO and Bartlett test findings.

As seen in Table 5, the 24-item scale exhibited a KMO value of "0.906" and "Bartlett's" test value of Chi-Square = 1961,258; sd = 253 ($p < 0.01$). The explained variance of the scale was found to be 50,767%. Tavşancıl (2014) stated that it would be appropriate for the variance explained in single-factor scales to be 30% or more. It was determined that the factor load values of the items in the scale ranged between "0.606" and "0.795".

To assess scale reliability, the Cronbach's Alpha reliability coefficient was examined. According to Table 6, the scale's Cronbach's Alpha value has been determined as "0.957". This score indicates a significantly high level of reliability for the 24-item scale.

The findings of the Kolmogorov-Smirnov normality test, which was performed for determining the distribution properties of the data gathered in the study, are presented in Table 7.

Based on the analysis of data received from 112 students, it was found that the distributions seen in the significance calculations were normal, as shown in Table 7. This conclusion is based on the observation that the sig. value obtained from the Kolmogorov-Smirnov normality test, which was done to assess the distribution of the 24-item scale data, above the minimum value of 0.05. Kurtosis and Skewness scores between −1.5 and +1.5 also indicates a normal distribution in the data.

**Table 13 Averages of digital logistics conceptual awareness scores by years.**

| Awareness Concept | 1. Year | 2. Year | 3. Year | 4. Year | Mean |
|---|---|---|---|---|---|
| 1. Internet of Things (IoT) | 3.50 | 3.30 | 3.26 | 3.58 | 3.41 |
| 2. Artificial Intelligence | 3.75 | 3.54 | 3.62 | 3.67 | 3.65 |
| 3. Machine Learning | 3.75 | 3.16 | 3.29 | 3.42 | 3.41 |
| 4. 3D Printers | 3.50 | 3.28 | 3.29 | 3.50 | 3.39 |
| 5. Advanced Automation | 2.25 | 2.82 | 3.29 | 3.21 | 2.89 |
| 6. Cyber Security | 4.00 | 3.06 | 3.24 | 3.58 | 3.47 |
| 7. Cyber-Physical Systems | 2.75 | 2.60 | 2.88 | 2.71 | 2.74 |
| 8. Cloud Computing Technology | 3.00 | 3.24 | 3.38 | 3.83 | 3.36 |
| 9. Big Data and Data Analytics | 3.50 | 2.82 | 3.06 | 2.88 | 3.07 |
| 10. Virtual Reality | 3.75 | 3.76 | 3.47 | 3.46 | 3.61 |
| 11. Augmented Reality | 3.25 | 3.44 | 3.26 | 3.13 | 3.27 |
| 12. Mixed Reality | 2.00 | 2.74 | 2.79 | 2.71 | 2.56 |
| 13. Digital Supply Chain | 4.25 | 3.50 | 3.71 | 3.63 | 3.77 |
| 14. Neural Networks | 2.00 | 2.60 | 2.65 | 2.67 | 2.48 |
| 15. Smart Storage and Sensor Technologies | 3.25 | 3.16 | 3.91 | 3.21 | 3.38 |
| 16. Simulation Technologies | 3.50 | 3.30 | 3.65 | 3.38 | 3.46 |
| 17. Data Driven Service | 3.50 | 3.10 | 3.56 | 3.04 | 3.30 |
| 18. Autonomous Vehicle | 3.50 | 3.18 | 3.53 | 3.17 | 3.35 |
| 19. Blockchain Technologies | 3.00 | 3.12 | 3.53 | 2.88 | 3.13 |
| 20. Cloud Robotic Applications | 2.00 | 2.80 | 2.94 | 2.71 | 2.61 |
| 21. Lights-Out Manufacturing | 2.75 | 3.18 | 3.09 | 2.79 | 2.95 |
| 22. Transportation Management System | 3.75 | 3.52 | 3.71 | 3.96 | 3.74 |
| 23. Drone Technologies | 2.75 | 3.54 | 3.32 | 3.54 | 3.29 |
| 24. IT Based Applications | 3.75 | 3.26 | 3.26 | 3.21 | 3.37 |

**Table 14 Kruskal-Wallis test results (Years).**

| | Year | N | Mean Rank | Kruskal-Wallis H | | |
|---|---|---|---|---|---|---|
| Digital Logistics Conceptual Awareness | 1 | 4 | 6113 | X2 | df | Sig. |
| | 2 | 50 | 5260 | 1441 | 3 | 0.696 |
| | 3 | 34 | 6082 | | | |
| | 4 | 24 | 5773 | | | |

Table 8 presents the findings of the analysis performed on the 24 concepts related to digital logistics at the item level in the data collection tool.

Table 8 demonstrates that the awareness levels of concepts such as artificial intelligence, virtual reality, digital supply chain, and transportation management system, which are all related to digital logistics, notably surpass the medium level. Moreover, it is noteworthy that students show a general understanding of all 24 concepts, as non-awareness levels fall within the medium range.

One of the additional sub-objectives that the research examined was whether there were any differences in the levels of digital logistics conceptual awareness among university students based on gender, education, class, and student success.

According to the data shown in Table 9, the female students generally had lower average levels of awareness compared to their male counterparts.

Table 10 shows the results of the independent samples t-test conducted to determine whether the difference in total scores of the students based on gender variable is significant or not.

The assessment of differences in achievement, education level, and class was conducted using non-parametric tests due to the small number of groups (less than 30).

In Table 10, the independent sample t-test results for digital logistics awareness among university students by gender showed that the equality of variances assumption in the Levene test was not met at the "Sig. <0.05" level. Hence, the second line of the t-test result was considered. The statistical analysis reveals that the mean score for male participants is 3.25, whilst the mean score for female participants is 3.18. The mean scores of the two groups show no significant difference at the "sig<0.05" level. Alternatively stated, the conceptual awareness levels of male and female students are indistinguishable.

Table 11 demonstrates that the averages of the students at the associate degree level are higher than the averages of the undergraduate students investigated in the research. The Mann-Whitney U test findings for determining the presence of a statistically significant difference in the total scores of students based on their education level are presented in Table 12.

Since the department names differ in undergraduate-associate degree programs, the relevant index was added to the questionnaire. However, based on the analysis, no difference was observed between undergraduate and associate degree awareness levels. Since the sig. value is greater than 0.05 according to Mann-Whitney Test Results (Table 12), there is no significant difference in digital logistics conceptual awareness among students enrolled in associate or bachelor's programs. Therefore, the awareness levels of associate and bachelor's students are the same.

When comparing students in other years to those in the third and fourth grades, the averages of the conceptual awareness levels of university students, based on the years they are studying, are generally higher, as indicated by Table 13. When considering all years, "Artificial Neural Networks" is likewise less well-known than others. Table 14 displays the Kruskal-Wallis test findings, which reveal if there is a significant difference in the total scores of the students based on their academic levels.

When the results are examined, it is observed that the conceptual awareness levels of university students on the digital logistics do not differ according to their academic level ($x^2 = 1441, sig.>0.05$).

Upon a careful examination of the results presented in Table 15, it becomes apparent that the average awareness levels of the students with an overall average GPA between 2.51 and 3.00 surpass those in other GPA ranges. The Kruskal-Wallis test results conducted to determine whether there is a significant difference between the total scores of the students according to their grade point average ranges are shown in Table 16.

**Table 15 Averages of digital logistics conceptual awareness scores by CGPA.**

| Awareness Concept | 1.8 Lower | 1.8–2.5 | 2.51-3.00 | 3.01-3.5 | 3.51-4.00 | Mean |
|---|---|---|---|---|---|---|
| 1. Internet of Things (IoT) | 3.12 | 3.25 | 3.35 | 3.84 | 3.44 | 3.40 |
| 2. Artificial Intelligence | 3.44 | 3.19 | 3.68 | 4.05 | 3.67 | 3.61 |
| 3. Machine Learning | 3.38 | 3.25 | 3.32 | 3.42 | 2.44 | 3.16 |
| 4. 3D Printers | 3.18 | 3.44 | 3.44 | 3.37 | 3.33 | 3.35 |
| 5. Advanced Automation | 3.15 | 2.50 | 3.29 | 3.05 | 2.44 | 2.89 |
| 6. Cyber Security | 3.26 | 2.94 | 3.47 | 3.32 | 2.89 | 3.18 |
| 7. Cyber-Physical Systems | 2.79 | 2.56 | 2.97 | 2.68 | 1.78 | 2.56 |
| 8. Cloud Computing Technology | 3.41 | 2.69 | 3.68 | 3.84 | 2.67 | 3.26 |
| 9. Big Data and Data Analytics | 2.85 | 2.69 | 3.29 | 2.79 | 2.56 | 2.84 |
| 10. Virtual Reality | 3.29 | 3.63 | 4.00 | 3.63 | 3.22 | 3.55 |
| 11. Augmented Reality | 3.18 | 3.31 | 3.71 | 3.37 | 2.22 | 3.16 |
| 12. Mixed Reality | 2.88 | 2.50 | 2.97 | 2.63 | 1.78 | 2.55 |
| 13. Digital Supply Chain | 3.53 | 3.44 | 3.76 | 3.58 | 3.78 | 3.62 |
| 14. Neural Networks | 2.74 | 2.44 | 2.97 | 2.42 | 1.44 | 2.40 |
| 15. Smart Storage and Sensor Technologies | 3.26 | 3.13 | 3.85 | 3.21 | 3.11 | 3.31 |
| 16. Simulation Technologies | 3.38 | 3.13 | 3.71 | 3.58 | 2.78 | 3.32 |
| 17. Data Driven Service | 3.15 | 3.00 | 3.59 | 3.11 | 3.00 | 3.17 |
| 18. Autonomous Vehicle | 3.35 | 2.75 | 3.62 | 3.53 | 2.33 | 3.12 |
| 19. Blockchain Technologies | 3.09 | 2.75 | 3.62 | 3.42 | 2.22 | 3.02 |
| 20. Cloud Robotic Applications | 2.91 | 2.19 | 3.35 | 2.68 | 1.56 | 2.54 |
| 21. Lights-Out Manufacturing | 2.94 | 2.50 | 3.18 | 3.42 | 3.22 | 3.05 |
| 22. Transportation Management System | 3.62 | 3.50 | 3.79 | 3.95 | 3.22 | 3.62 |
| 23. Drone Technologies | 3.12 | 3.13 | 3.94 | 3.47 | 3.33 | 3.40 |
| 24. IT Based Applications | 3.12 | 2.88 | 3.65 | 3.16 | 3.33 | 3.23 |

**Table 16 Kruskal-Wallis Test Results (CGPA).**

| | CGPA | *N* | Mean Rank | Kruskal-Wallis H | | |
|---|---|---|---|---|---|---|
| Digital Logistics Conceptual Awareness | 1.8 Lower | 16 | 4466 | *X2* | df | Sig. |
| | 1.80–2.50 | 34 | 5688 | 9093 | 4 | 0.059 |
| | 2.51–3.00 | 34 | 6641 | | | |
| | 3.01–3.50 | 19 | 5797 | | | |
| | 3.51–4.00 | 9 | 3556 | | | |

It is seen that the digital logistics conceptual awareness levels of university students do not differ according to their CGPA ($x^2 = 9093$, sig. >0.05).

## Evaluation

In today's landscape, the importance of digitization and digital logistics for sustainable economic growth and competitiveness of countries and businesses is becoming more evident. The advent of new technologies and digital systems underscores the necessity for businesses to embrace digital logistics in order to gain a competitive advantage. Businesses are now compelled to integrate into digital systems not only to achieve the speed, transparency and quality demanded by the customer but also to reduce logistics costs. Besides ensuring a competitive edge, the utilization of digital technologies in logistics management is also imperative for being able to thrieve in today's global business environment. The escalating needs for knowledge in the education of students and experts in the logistics sector also emerge new requirements in this field.

Thanks to the cloud systems employed by the global logistics companies such as Fedex, UPS and DHL, businesses now can access to necessary information (availability, destination, etc.) through the system, carry out collaborative logistics activities with other companies and use the limited resources jointly. In this way, they can reduce their greenhouse gas emissions. In fact, digitalized logistics systems can transform into green logistics systems to address the global warming issues. The realization of these possibilities relies on the innovative business models that will be created by the digitalization of logistics activities. This underscores the need for human resources with a comprehensive understanding of operations and processes to develop technology in the field of logistics, alongside the support by engineers specializing in developing technologies.

According to the results obtained as a result of this study, the knowledge on digital logistics terminology can be enhanced by training courses, seminars, programs, and term projects at universities. Students should be encouraged to learn about the digital technologies through new courses. Universities are primary conduits through which students can develop awareness and acquire knowledge on emerging trends and terms, reach opportunities and gain the skills necessary for their future careers. Through the collaboration between universities and information technology companies, the quality of education level and students' awareness will enhance for certain.

Efforts have been made to create a roadmap for guiding universities in getting prepared for the new technologies in the field of logistics and building a educational foundation in this regard. Update of the course content can help analyzing the needs in the field in a better way. Universities can provide more support with projects by determining the needs of the sector and creating the necessary infrastructure.

## Data availability

Datasets are available in the supplementary files.

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## Note

1 İstanbul University, Recep Tayyip Erdoğan University, Beykent Üniversity, Akdeniz University, Niğde Ömer Halisdemir University, Bandırma Onyedi Eylül University, İstanbul Gelişim University, Sivas Cumhuriyet University, İstanbul Esenyurt University, Tokat Gaziosmanpaşa University, Nişantaşı University, Ondokuz Mayıs University.

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## Author contributions

These authors jointly supervised and contributed equally to this work. All the authors have read and approved the final manuscript and agree to be accountable for all aspects of the research.

## Competing interests

The authors declare no competing interests.

## Ethical approval

This article does not contain an application that requires ethical committee approval. Thanks to the information added to the beginning of the questionnaire, the participants shared their information on a voluntary basis (Dear students: This survey has been developed to source data for digital awareness studies in the field of logistics. The information planned to be obtained will not be used in any way other than for scientific purposes. Personal data such as your name, identity and contact information are in no way the subject of the survey. Your contribution to the survey is very crucial in terms of the validity and the success of the research). At the same time, no individual specific information was obtained in the study, gender class age information was taken for general evaluations. Therefore, the principle of voluntariness is taken as a basis for general studies in Turkey and there is no need for board approval. There is no experiment on humans.

## Informed consent

The authors obtained informed consent from all participants in the study before the survey. Transition to the survey was achieved with the approval of the voluntary basis information added to the beginning of the survey, so each student participating in the survey declared that they were voluntaries.

## Additional information

**Supplementary information** The online version contains supplementary material available at https://doi.org/10.1057/s41599-024-02907-8.

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