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DIGITAL TWIN TECHNOLOGY IN HIGHER EDUCATION MANAGEMENT: THE CASE OF TURKEY

Research article

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Abstract

This study examines the application of digital twin technology as an efficiency model in higher education management in Turkey. Digital twin technology involves creating a virtual model of a physical object, system, or process. Digital twin technology, which models, monitors, and improves the behavior of an object using real-time data, is used in many sectors such as education, healthcare, banking, construction, and energy. In higher education, digital twin technology significantly improves the educational processes of students, faculty members, and administrators and increases their efficiency. In addition, more effective management can be achieved by creating and virtually modeling digital twin campuses. With digital twin technology in higher education management, administrators can benefit from improving education processes, analysis, and quality. On the other hand, digital twin technology helps students develop skills, model university-industry relations, analyze new skill needs in the digital world, and plan and implement education and training in connection with the labor market. Digital twin technology can be used in higher education to improve management processes, operate the system more efficiently, develop educational strategies and optimize resources, and develop decision-making processes based on realistic data. Therefore, digital twin technology offers significant opportunities to increase the efficiency of higher education institutions, improve education quality, and create a competitive higher education structure. The first part of the study examines digital twin technology and its place in higher education management. The second part includes the ITU digital twin project in Turkey.

Keywords: Digital Twin Technology, Higher Education Management, Digital Transformation, Industry 4.0

1. Introduction

Digital twin technology is a digital application that enables monitoring, testing, developing, and increasing the efficiency of a physical object, product, or service by modeling it in the virtual space using real-time data. Digital twins can be an office, a campus, a factory production facility, or a city and help make and implement decisions to monitor the operation, detect errors, improve performance, and maintain and strengthen its efficiency continuously and sustainably.

Digital twin technology can be used in many areas, such as education, health production, the efficiency of educational activities, business life, and job satisfaction. For example, modeling can be done with digital twin technology when the relationship between working conditions and job satisfaction is examined. Job satisfaction can affect both depression and self-esteem. Suppose the employee is delighted with their job performance. In that case, it will be more productive for the company (Sinal & Ergüneş, 2020: 11). With digital twin technology, working conditions, job satisfaction, and productivity can increase. Developing digital twin campuses in higher education can create a structure that will satisfy service providers and users.

It can be said that digital twin technology started with the creation of the digital twin software concept by Michael Grieves in 2002, and its functionality was developed with the Internet of Things technology. Digital twin technology is one of many technologies that demonstrate the evolution of digital technologies. With the development of digital technologies, new technologies such as Blockchain, big data, artificial intelligence, and the Internet of Things are rapidly developing. Interest in new concepts such as smart businesses, cryptocurrencies, autonomous vehicles, and sustainability has also increased (Deng et al., 2021: 126). Digital twin technology constitutes one of the essential parts of digital transformation in a digitalizing society.

The digital transformation process, which is accelerating with Industry 4.0, covers many areas such as education, production, planning, distribution, marketing, health, and so on, with many technologies such as blockchain technology, artificial intelligence technologies, cloud computing technologies, metaverse (virtual universe) and digital twin. Influenced. The digitalization process, which started in the 1950s, has led to the emergence of many new technologies, such as cloud computing technology, artificial intelligence, data mining, and the Internet of Things (Alptekin and Türkmen, 2023: 2). One of the most striking applications in the digital transformation process is the transformation of social media applications, one of the essential tools of digitalization, into important digital sharing platforms in all areas of life, from daily life to the corporate sphere. Social media offers many opportunities that provide access to information, where new information can be shared instantly, where new information can be learned, where communication and coordination activities can be carried out with the masses, and where people can be reached quickly in disasters, epidemics, and similar situations (Demir, 2023: 90). The use of social media has gained importance, especially in the field of education. The use of social media has become widespread in holding various courses and conferences, sharing course content, and teaching languages.

Since the early ages when agriculture gained prominence, the first industrial revolution in which steam energy was used, the second industrial revolution in which electrical energy was used, the third industrial revolution in which IT-supported production and the fourth industrial revolution or digital age in which cyber-physical systems were used have affected all forms of production with the influence of developing technology and have affected all forms of production. It has reshaped their lifestyles. Industry 5.0 or Society 5.0 refers to an intelligent society integrated with technology. Thus, with this process, integrating technology and society with a human-oriented approach is moving towards a process expressed as a 'smart society,' 'super-smart society,' or 'super-smart society.' Considering this process, it is put forward that with the use of robots in production, unemployment will gradually increase, the role of unions in social life will decrease, and new regulations in the field of labor legislation will be inevitable (Yankın, 2019: 1). Social life, which started with hunting, turned into agriculture, industry and information society, and Society 5.0, put forward by the Japanese, began to be described as a super smart society (Saracel and Aksoy, 2020: 26). Society 5.0 appears formally as the sum of the distance traveled by human history from the first human to the present day (Er et al., 2021: 27). The concept of Society 5.0 aims to increase the welfare level of the society by taking advantage of the opportunities offered by technology and to produce technology-based solutions to social problems (Sağlam and Çetintaş, 2022: 81). However, we should not forget the adverse effects such as the development of robotic technologies and the displacement of human resources from production areas, creating unemployment and social chaos.

Utilizing digital twin technology in higher education, scientific research activities, university-industry cooperation, and community service activities can make higher education more efficient, understandable, comparable, and constantly improved. Digital twin technology can provide advantages, especially in developing university-industry cooperation. Universities can offer scientific knowledge and research activities that the industry can use with digital twin technologies. Universities' research infrastructure and human resources can be better analyzed, designed, and made available to the industry.

2. Digital Twin Technology in Higher Education Management

Digital twin technology is a virtual model of a physical object, product or service. In simpler terms, digital twin technology creates an exact copy of a device, object, product or service that does not yet physically exist in a virtual environment. Making a digital twin copy is carried out by transferring full-time data taken from the physical environment as input to the digital twin with the help of the Internet of Things (IoT) or smart sensors.

Many advantages of digital twin technology can be mentioned. Thanks to digital twin technology, it is possible to detect problems that may occur within the scope of any device, device or service in advance, to see various innovations in advance, to carry out feasibility in a sense, to prepare virtual copies of different scenarios in advance and to carry out many analyses.

Digital twin technology is one of the essential advantages of the digital world. Many devices, services, products, management, planning, control, and similar tasks intended to be carried out in the physical world can be created in advance, at a lower cost, and created and tested in the virtual world through digital twin technology. When viewed in this form, digital twin technology contributes to the continuous improvement of the product, service or device, and cost savings also emerge. The digital twin also minimizes the wear and tear of objects, products, and services in the physical world, increasing error rates and improvement problems. This way, institutions using digital twin technology can become efficient and profitable. On the other hand, digital twin technology provides many advantages with its design, product development, and testing opportunities.

Digital twin technology also adds value to the product, service, device, working, service-producing, and service-receiving environments. Optimization of a previously virtual copy of the working environment increases efficiency. For example, thanks to the digital twin of a university campus, there are many advantages for both management activities and those who receive or benefit from that area.

Higher education management has gained a new dimension as digital technologies and digital transformation processes gain importance in every field, and human input, financial input, and technology take their place in all processes in education and training activities. All inputs traditionally used in the management process (incredibly human and matter and all others) require re-evaluation with technology. On the other hand, the success of the digital transformation process requires considering the system's internal and external inputs and stakeholders together with the realities of the digital age in management processes. Success in higher education management is affected by the digital transformation process we are in and affected by every aspect. This process includes not only the use of digital technologies but also the interaction and integration of the internal and external structure of the site. Because it would be unfair to think of industrial revolutions as only the production and use of specific technologies, these revolutions are a world and human revolution (Özdoğan, 2017: 30). Industrial revolutions change not only technology but also labor relations, education, social life, and many practices. Therefore, working styles and management styles in higher education administration also change.

On the other hand, giving face-to-face or digital courses in higher education administration is also among the issues that must be addressed. In other words, although face-to-face education is active, every higher education institution should develop the infrastructure to carry out educational activities in the digital environment. In the digital transformation process, all elements of education, face-to-face, distance, online, and offline, must be used together (Özen, 2019: 7).

Transferring management work and transactions to the virtual environment is necessary for the system's efficiency and the interaction and access to the system of all other internal and external components with which higher education is in relationship. For example, with blockchain technology, transcripts of all students can be transferred to the virtual environment, and all other relevant institutions can access the system in the virtual environment, wherever they are in the world. For example, with NFT technology, virtual copies of many assets, especially works of art, can be transferred to the digital space, and it is impossible to change or copy them. In this state, it is possible to preserve its existence. On the other hand, a virtual environment is created with metaverse technology, and it is possible to give various courses in a virtual environment.

In higher education administration, digital twin technology refers to creating, testing, bundling, and improving virtual models of physical objects, devices, and services. Many examples can be given for digital twin technology, such as creating a virtual campus, creating a virtual classroom environment, and performing virtual classroom management. Digital twin technology can also be used in open and distance learning applications. Higher education management is a whole that includes not only itself but also its internal and external stakeholders, relevant institutions and organizations on a global scale, human resources, and technological developments. Educational processes in higher education, the production of scientific knowledge, the implementation of new technologies, and the economy, which is becoming more digital every day, are also gaining importance. Higher education will be more efficient with the human resources trained to find a place in the digital economy and contribute to the economy, especially with the production of technology that the economy needs. Using digital technologies in management processes provides advantages in increasing efficiency and quality in management. Digital twin technology can be considered a tool that will be very useful in creating a virtual model in management, testing it, and improving the process.

Digital twin technology can provide advantages in higher education. Digital twin technology is one of the prominent technological tools in developing, testing and implementing more efficient management processes and education-training experiences. Digital twin technology can be used especially in science, art, and STEAM (Science, Technology, Engineering and Mathematics) education.

Creating digital twin campuses can contribute to the current situation, capacity utilization, more significant benefit, and development of stakeholders by recreating physical campuses in the virtual space. In this way, all internal and external stakeholders can benefit from campus opportunities in the digital field and participate in activities. They can get involved in better education and training practices and experience simulations on various subjects. Digital twin technology provides significant benefits in improving the quality of education, strengthening accessibility, saving on resource use, reducing carbon footprint, and developing an environmentally friendly system.

3. ITU Digital Twin Project in the Case of Turkey

Istanbul Technical University (ITU) joined the Digital Twin Project within the scope of the Digital Europe Program on November 14, 2022. This program, developed within the scope of university-industry cooperation, aims to train a well-equipped workforce in robotics, IoT, and cyber security. The Council of Higher Education (YÖK, 2021) also supports evaluating education, training, and grading in universities for knowledge production and graduate qualifications within the framework of university-industry cooperation processes and implementing recommendations accordingly. With this approach, universities will produce scientific knowledge and new technologies the industry needs and use human resources efficiently.

ITU Digital Twin Project can be considered an exemplary application for developing digital transformation-oriented investments, application experiences, and digital technologies in Turkish higher education. The project's scope includes the nature of the project, the application of digital twin technology on a global scale, and the development of university-industry cooperation. The nature of the project and its collaboration structure are listed below.

ITU has developed a joint master's program within the scope of digital twin technology with the Digital Europe Program and the EELISA European University program.

The European Union develops the Digital Europe Program within the scope of digital transformation-oriented goals and covers 2021-2027. The digital transformation focus of the program is on building digital capacity across Europe and disseminating the production and use of digital technologies. Priority areas include artificial intelligence, cyber security, the development of advanced digital skills, the creation and use of digital capacity, and the development of cooperation.

The EELISA European University program is a joint initiative developed by nine higher education institutions in engineering. The universities included in the EELISA European University program are Istanbul Technical University (ITU), Budapesti Műszaki és Gazdaságtudományi Egyetem (BME), Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), École des Ponts ParisTech (ENPC), Institut Mines-Télécom (IMT), Scuola Superiore Sant'Anna (SSSA), Universitatea Politehnica din Bucureşti (UPB), Universidad Politécnica de Madrid (UPM), Universität Stuttgart (USTUTT). This program aims to develop a general European Engineering model. On the other hand, producing intelligent and sustainable solutions using digital technologies also stands out among the main objectives.

The master's program, developed within the scope of the digital twin project developed jointly with ITU's Digital Europe Program and EELISA European University program, aims to improve university-industry cooperation, improve human resources in areas such as data engineering, robotics, IoT (Internet of Things) and cyber security. Aims to cultivate. The master's program developed within the project's scope supports the creation of an ecosystem that will support digital twins for the built environment and urban infrastructures.

3.1. Data Engineering Program

The Data Engineering Program is an educational program focused on data analytics and big data management. Topics such as data modeling, data analysis, database management, machine learning, and artificial intelligence are among the main trainings within the program's scope. The program aims to train engineers with in-depth knowledge of data-related issues. Data engineers are expected to be competent in data-related issues, solve data-related problems, and develop creative data-based solutions. Within the scope of the data engineering program, students are expected to gain programming skills in programming languages such as Scala, Python, Java, Hadoop, GCP, AWS, and Docker.

3.2. Robotics Program

The Robotics program is an engineering field. Design, production, testing, control, and development of robots come to the fore within the program's scope. Developing a control scheme is another issue that comes to the fore within the program's scope. Working features of robots, interaction patterns with the robot and its environment, how the received data are processed and transformed, movement of robots and detection of sensors, and image processing issues are evaluated within the scope of the control scheme. On the other hand, disciplines such as bioengineering, mechatronics, computers, electronics and nanotechnology have features that can work in parallel with the robotics discipline. With an interdisciplinary approach, these fields do not conflict with each other. Robotic coding can be used in almost every field. Aviation, medicine, education, production, and defense industry are among the first things that come to mind. Various programming languages can be used in robotic coding. Programming languages such as Pascal, LISP, Java, and Scratch can be used in robotic coding. Robotic technology is effective for the benefit of humanity, providing cost savings, saving time and labor, and increasing user satisfaction in the efficient use of resources and minimizing errors. On the other hand, developing robotic technologies, reconsidering human resources, and investing in teaching the culture and habits of living and working with robots appear as essential issues. On the other hand, unemployment and new professions and the development of skills suitable for these new professions will be among the most critical issues of the future. Although problems such as training human resources with a new understanding and unemployment are mentioned, robotics programs and technology will undoubtedly be at the top in all future fields.

3.3. Internet of Things (IoT) Program

The Internet of Things (IoT) program can be defined as an application field that performs digital functions such as developing software applications for smart devices, connecting devices to the Internet, interacting with technologies such as artificial intelligence and cloud computing, and collecting and processing data. Just like robotic technologies, IoT can be used in many different sectors. Internet of Things technology can be used in many areas, such as smart agriculture or digital agriculture, factories, buildings, cities, health, transportation, wireless home appliances, lighting, and defense technologies. IoT programs can be developed with the help of various sensors, devices, and programming languages. IoT applications can be developed with the help of applications such as Blynk and Raspberry Pi. IoT technology can be considered one of the essential digital powers of the Industrial Revolution with its structure that connects to the internet and allows devices to share data. When viewed in this form, it helps to move physical devices to the digital space and to increase the speed and quality of work and transactions in daily life, as well as in education, production, defense industry, medicine and countless other fields, by allowing the devices to work interactively with each other. The IoT program can be considered an essential training and production area, both in terms of the program's content and considering that its use will increase employment and productivity by training human resources in this field.

3.4. Cyber Security Program

The basis of the cyber security program is developing knowledge, skills, and application examples that eliminate security vulnerabilities in the cyber field, protecting and encrypting data, and protecting it against attacks. Especially in the digitalization process and Society 5.0, which accelerated with the fourth industrial revolution, the most critical security need in all areas has moved to the cyber field. The scope of the cyber security program includes developing and improving the cyber security design and management system, network security, cryptography, computer forensics, cyber security law, and malware audits. Cybersecurity is coming to the fore as a developing field among educational programs, and the need for human resources trained in the field of cybersecurity is increasing in the labor market. Considering the professions of the future, cyber security programs also offer essential career opportunities.

3.5. Development of Built Environment and Urban Infrastructures

Built environment and urban infrastructures refer to the spaces that constitute people's living spaces and the systems that include essential services such as water, electricity, communication, waste management, and transportation provided in urban life. Creating a copy of cities' physical, social, economic and environmental characteristics in the virtual space is possible with digital twin technology. Virtual digital twin modeling includes real-time data and the condition and performance of the relevant area or physical spaces. For this reason, digital twins can be considered practical tools in the design, construction, operation, maintenance, and sustainability of environmental and urban infrastructures, ensuring efficiency, energy use, and zero footprints. Digital twins include improving existing areas and using new energy sources, addressing the characteristics of relevant areas such as disasters, floods, and earthquakes, and making them more efficient. With the ITU Digital Twin Project, the development of built environment and urban infrastructures, three-dimensional visualization of the environment and buildings, in terms of many inputs such as ventilation, lighting, transportation, water, electricity, traffic, disaster, flood and earthquake characteristics of the region, both before and after any time. It will provide benefits in controlling in case of a disaster or malfunction. ITU Digital Twin Project is efficient with the programs and projects it currently focuses on and provides an example of a digital twin technology application for many practitioners.

4.Conclusions

Digital twin technology is a functional technology that can be used in many areas, including analysis, improvement, effective use of resources and increased efficiency. The use of digital twin in higher education management is an effective technology that can be used to increase institutional performance, minimize errors, use resources effectively and achieve more successful results in management. A digital twin is a virtual model of a physical object, product, process, city, campus or any application. There are many advantages to be gained from using digital twin technology. Among these advantages, quality in production and production, testing and improvement, productivity increase and cost reduction are at the top of these advantages.

Digital twin technology is used in higher education management in many areas, from education and training activities to the production of scientific knowledge and university-industry cooperation. The basis of digital twin technology is efficiency. Digital twin technology can be considered a practical application in planning, testing, improving, and implementing educational processes in higher education. Digital twin technology can also be used as an effective tool in research studies and, in a sense, research design and feasibility can be carried out.

Digital twin technology can also be used functionally in university-industry relations. The industry and the university can analyze and monitor the internal and external inputs and resources of the field in which they cooperate. It can be used as an effective tool for determining the human resource needs of the industry and for the competencies and development of human resources. In short, digital twin technology offers significant advantages in improving the quality of education in higher education, making continuous improvement, monitoring, and increasing competitiveness.

Digital twin technology can help educational institutions, faculty, and students plan and improve educational processes. Skills, interests, and learning styles can be determined according to their characteristics. Such an analysis can also guide the teaching staff of educational activities. Contributes to the development of educational materials and effective learning and teaching strategies. Digital twin technology is also functional in performance evaluation. Digital twin technology can also track students' success, progress, and performance.

Considering all these processes, improving quality also allows students, faculty members, and educational institutions to make effective decisions, control weak points, and benefit from opportunities. General situation assessment for educational institutions supports efficient resource use and decision-making mechanisms.

This study examined the ITU digital twin project, one of the best examples of digital twin technology applications in higher education. The ITU digital twin project can be considered an excellent example for many higher education and industry institutions. It can contribute to developing new ideas and application models for the project scope and new digital twin applications. First, the project improves university-industry cooperation by covering the primary areas in the digital transformation process. ITU digital twin project is the development of postgraduate programs in data engineering, robotics, the internet of things, and cyber security, and these are carried out both with partners in Europe and within the scope of university-industry cooperation. Within the project's scope, it supports Turkey's digital transformation and digitalization processes on an urban scale to create an ecosystem that will support digital twins for the built environment and urban infrastructures.

Digital twin technology in higher education serves the digital transformation capacity and human resources training in data engineering, robotics, and cyber security. Modeling and implementing the ITU digital twin project in higher education and different sectors and benefiting from its experiences will help the digital transformation of many sectors.

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