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# Digital twin technology — awareness, implementation problems and benefits

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ABSTRACT
Aiming to ensure current market needs, manufacturing companies search for tools and methodologies that would help them deliver their products efficiently and cost-effectively and enable them to become a part of Industry 4.0. Digital twins are a technology created based on the idea of the Fourth Industrial Revolution. The solution helps recreate physical devices in virtual space based on gathered data. It supports performance tests, configuration changes, and predictive maintenance without engaging existing machines. The paper aims to gain knowledge about the awareness level of the digital twin technology among industry representatives and identify the most important problems that stand in the way of implementing the technology in enterprises. The research focused on market awareness of the described technology. It also examined how companies use employee suggestions to improve their organisations and the factors that influence process efficiency. The methods used for the research were a literature review and cross-sectional survey conducted with 50 employees of manufacturing and IT companies. The research showed the need to implement digital twins in enterprises. Half of the survey respondents replied that the technology would help improve the efficiency of the company's processes. The main benefit of the conducted research is identified awareness of the technology among industry representatives. In the future, the research will be extended to include the analysis of specific cases affecting the implementation of digital twins in enterprises.

KEY WORDS
**Industry 4.0, digital twin, cyber-physical system, Internet of Things**

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## Introduction

In 2010, the German government introduced the concept of Industry 4.0. (German: Industrie 4.0.), which was very quickly adopted by foreign economies. "The concept of 'Industry 4.0' is, in general, to use the automation and digitisation processes of the industry that have been taking place in German industry for years to transform existing factories into self-steering and self-adaptive socio-technical systems (Smart Factories), allowing for the creation of intelligent value

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chains (...)" (Bendkowski, 2017). The Fourth Industrial Revolution is built based on the widespread Internet access and the collection of large amounts of data that "must be processed and managed" (Gajdzik, 2018). This concept integrates people, machines, and processes. The collected information allows the effective management of production processes and the adaptation of these processes to the current market needs. "Determinants of the development of industry at the 4.0 level are shorter product lifecycle, shorter manufacturing cycle, short production series, increased product range, personalisation of products, integration of information technology (IT) with operational technology (OT), increase in the development of devices such as automats, robots, chatbots, change of manufacturing processes to processes with parameters of high productivity and precision of product execution" (Gajdzik, 2018). The challenges faced by the economy are overcome by implementing new ICT (information and communication technologies) solutions and methodologies, which allow adapting enterprise processes to the Industry 4.0 requirements (Szum & Magruk, 2019; Bialobrodzki et al., 2020; Siderska, 2021).

The digital twin technology is a solution related to Industry 4.0 that has been gaining popularity in the manufacturing sector.

The first definition was created in 2002 by Michael Grieves in reference to product management issues. "A digital twin in its original form is described as a digital-information construct about a physical system, created as an entity in its own right and connected to a given physical system. The digital representation should optimally contain all the information about the system's resources that could be obtained by analysis in the real world." (Kritzinger et al., 2018). Another definition indicates that "A digital twin is a mathematical representation (mathematical model) of physical objects in a virtual layer within cyber-physical systems.

The mathematical model of the object processes data from sensors installed on a specific object and data associated with the object, with both physical and virtual sensors present at the sensor level (Maintenance, 2016)" (Gajdzik, 2018). This solution allows a digital reproduction of any physical object and entire groups of objects and processes. The resulting virtual copies can support a range of activities, such as configuration changes, performance tests, and simulations, saving time and resources as this is done without stopping production lines or involving physical devices.

The digital twin technology is also useful for changes in management methodologies of manufacturing companies. Companies are looking for new ways to adapt their organisation's operations to changing market conditions, increasing their competitiveness while reducing waste of resources and reducing costs. These changes concern processes within the organisation and the entire supply chain.

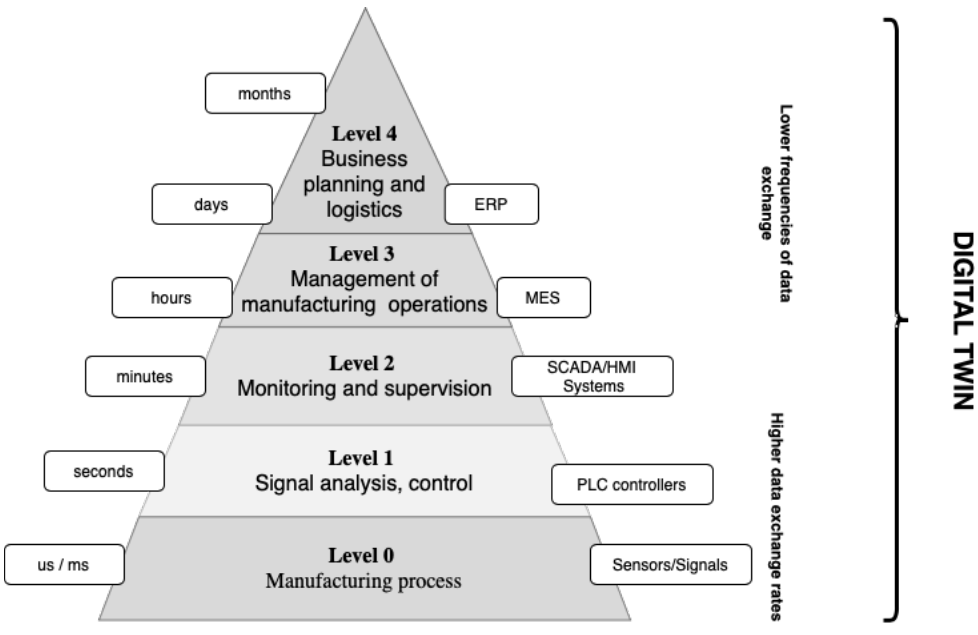


Fig. 1. Levels of management and automation of processes in a company
Source: Elaborated by the author based on (Akerman, 2018, p. 2).

Fig. 1 presents the individual levels of management and automation of processes in an enterprise, indicating the systems currently supporting their implementation and the frequency of data exchange. In the author's opinion, the digital twin technology occurs at all levels of automation and allows to monitor the work of individual devices horizontally and vertically to maintain and optimise them predictively. It enables a synergic combination of MES (Manufacturing Execution System) features and SCADA (Supervisory Control and Data Acquisition) class solutions. From a micro perspective, it consists of descending to the level of data collected from individual sensors, their observation, and analysis for further use and optimisation. It allows for internal detection of deviations from the norm, bottlenecks, performance problems, and their improvement through monitoring of parameters and work indicators. On a macro scale, it enables the management of specific sub-processes and processes involving more than one machine and, thus, impacts the entire company's operation and, consequently, the possibility of its self-improvement (Barni et al., 2020).

This article is divided into four parts. The following part of the article describes the literature review related to the topic of "Digital Twins" over the past years. The next part addresses the research method. Then, the article presents the results of a survey conducted by the author and a discussion of the conducted analyses and findings. The last part presents conclusions, limitations and defines further research directions.

The paper aims to gain knowledge about the awareness level of the digital twin technology among industry representatives and identify the most important benefits and problems that stand in the way of implementing the technology in enterprises.

## 1. Literature review

Initially, a review of literature trends in the SCOPUS and Web of Science databases was performed, which showed that the term "digital twins" is becoming more popular every year. Based on the analysed literature, the author identified the research gap as a lack of information on the awareness level of the digital twin technology and the identification of problems that may prevent the implementation of the technology in Polish enterprises.

A query was performed in the SCOPUS database using the phrase "digital twin" (Fig. 2). Before 2016, the number of new publications did not exceed ten per year. Since 2016, the interest has shown noticeable growth with 24 new publications. In the following years, the number of articles was as follows: 114 in

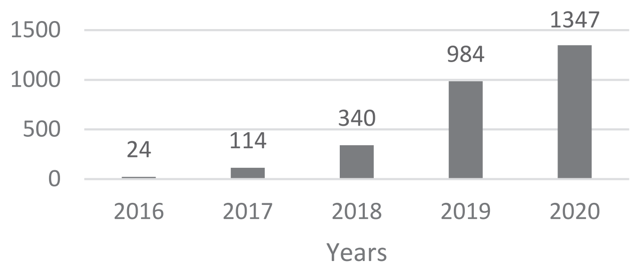


Fig. 2. Number of publications in the Scopus database per year


Fig. 3. Number of publications in Web of Science per year

2017, 340 in 2018, 984 in 2019, and 1347 in 2020. After 2020, the total number of all articles in the database relating to digital twins was 2920.

An analysis of the Web of Science database revealed 540 entries containing the phrase "digital twin". The first publication dates back to 2013 and concerns the development of an ICME-based digital twin model of a single-composite aircraft fuselage (McWilliams et al., 2013). A significant increase only occurred in 2017. Fig. 3 shows the number of publications in the Web of Science database by year.

The author verified the relationship between the analysed technology and other disciplines based on network building methods and cluster creation used in the paper by Gudanowska (2017). The overall analysis showed that the concept of digital twins mainly occurs in two areas: "Engineering" and "Computer Science". The other areas are: "Mathematics", "Decision Sciences", "Energy, Material Science", "Physics and Astronomy", "Business", "Management and Accounting", "Earth and Planetary Sciences", and "Social Sciences".

Fig. 4 and 5 show the scheme created based on a graph generated in VOSviewer (Halicka, 2017; Winkowska et al., 2019; Siderska & Jadaan, 2018; Szpilko, 2017; Szum, 2021) regarding the co-occurrence of the term "digital twin" with other terms. After optimisation, six clusters were obtained.

Cluster 1, "Data management", created in VOSviewer, contains concepts related to learning, forecasting, decision-making, and prediction. It includes issues related to artificial intelligence and predictive maintenance, the operation of which is largely based on the previously mentioned concepts. Cluster 2, "Modeling and design", is a group of concepts related to data visualisation and modelling, product, and lifecycle management. The strongest cluster group is the term "lifecycle management" mentioned 166 times, and its strength of connection with the term "digital twin" is 580, which is the second strongest connection. Terms in Cluster 3, "Industry", relate to manufacturing and industry. In this group, it is worth noting the term "manufacturing", mentioned 195 times, whose strength of connection with the

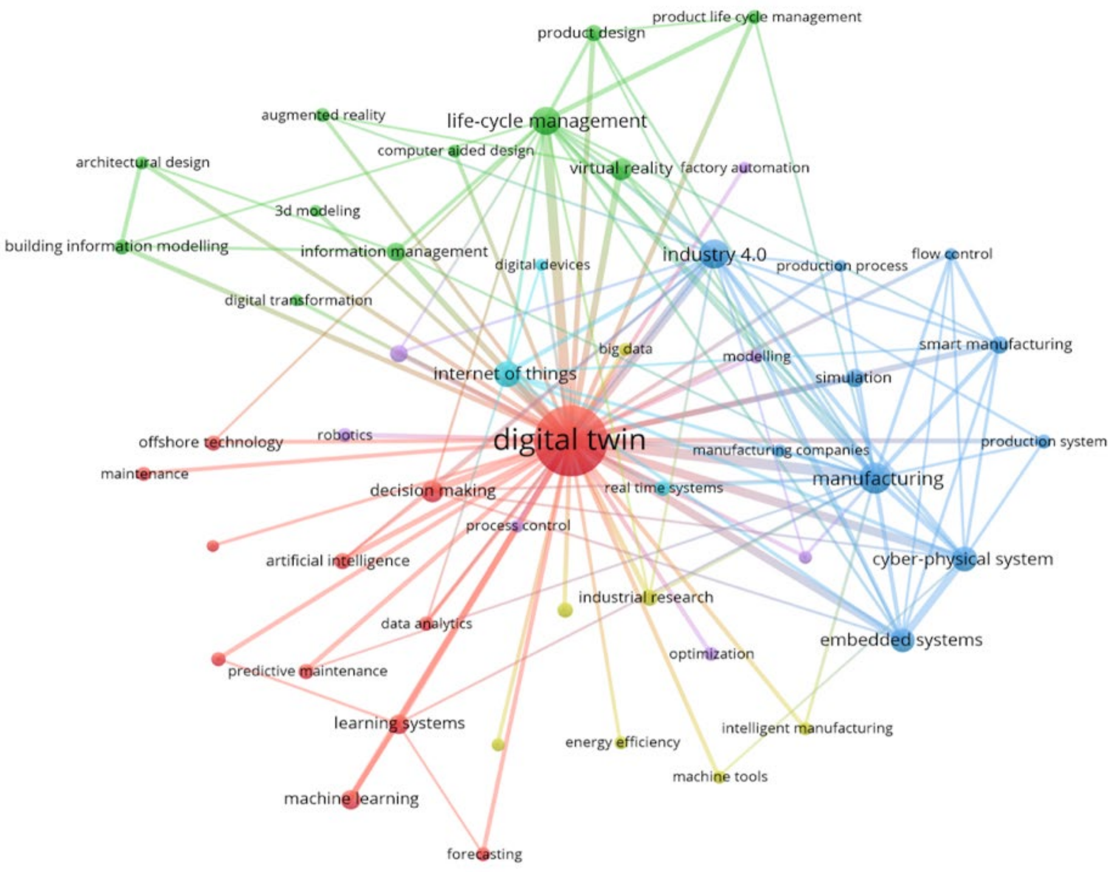


Fig. 4. Association graph obtained in VOSviewer


Fig. 5. Clusters obtained in VOSviewer

term "digital twin" is 683. Cluster 4, "Architecture and data storage", contains concepts related to the management and storage of data and industrial research. Cluster 5, "Processes and automation", brings together concepts relating to the modelling, control, and management of processes and their optimisation. Cluster 6, "Systems and devices", has three concepts: "digital devices", "Internet of Things", and "real-time systems".

The study showed a strong correlation of terms "digital twins" and "manufacturing", "Industry 4.0", "Internet of Things", "lifecycle management", "embedded systems", and "cyber-physical system". A noteworthy aspect is the increasing occurrence of phrases "information management" and "decision making" concerning the digital twin technology, which suggests that this technology is considered not only in the context of technical aspects and benefits but also as a tool for managing processes and products in companies.

Articles on digital twins tend to address specific use scenarios, specific cases. This indicates a lack of generic technology applications to cover broader areas.

The literature survey showed a frequent occurrence of the digital twins' topic with the terms "industry 4.0", "predictive maintenance", "manufacture", and "lifecycle management". This correlation may indicate areas where the digital twin technology is currently developing the strongest and most frequently find its applications. Based on the review presented above, to confirm the thesis on the use of the described technology in the manufacturing sector, an analysis of representative examples of the use of digital twins in manufacturing sector companies was performed, and the nature of benefits was determined in individual cases.

Europe is the largest supplier of production equipment. Nevertheless, in recent years, more and more suppliers from Asian countries have appeared in the market (Armendia et al., 2019). Increasing competitiveness of suppliers from Europe is closely related to the implementation of Industry 4.0 postulates in enterprises. The development of ICT, such as CPS (Cyber-Physical Systems), IoT (Internet of Things), or cloud systems and the increase of process knowledge through data monitoring has a significant impact on the perception of machine design and use processes in companies.

They enable significant improvements to be made at the design stage and throughout the product lifecycle, as well as increasing Overall Equipment Effectiveness (OEE). OEE is an indicator used to determine the performance of machine fleets and is a combination of availability, productivity, and quality (Shanghua et al., 2020).

Additionally, to reduce maintenance costs and ensure a high level of equipment operability, companies tend to move away from reactive to predictive maintenance (Sasiadek & Basil, 2018). Predictive maintenance is "a strategy assuming optimal use of machinery and equipment by eliminating the occurrence of failures and optimal planning of maintenance works based on technical condition survey" (Gunia, 2019). The main objective of predictive maintenance in the manufacturing sector is to avoid downtime of production lines and to determine when equipment service will be necessary. The basis of predictive maintenance is to have prior information about possible failures that may happen in a specific period (Wisniewski, 2010). Such knowledge allows to order earlier inspections, service parts of the line and thus prevent downtime in the factory (Plinta & Banach, 2015). As an example of the implementation of predictive maintenance with the help of a digital twin, it is possible to point to making calculations of the Remaining Useful Life (RUL) of equipment (Aivaliotis et al., 2019).

Manufacturing companies frequently face problems with physical equipment tests due to downtime and high repair costs. Obtaining failure data from the physical device seems to be the best solution, but it is not a common practice. A digital twin allows determining the parameters of equipment operation during a failure to generate specific data to learn algorithms (e.g., predictive ones). Repair of specialised equipment is expensive, so many companies use the predictive model as a way to reduce potential costs. The implementation of this maintenance model is enabled by pre-collected data from sensed equipment that can be used to create algorithms to predict failure (Tomkowiak & Kolinski, 2010).

Table 3 presents the most important areas for the use of digital twins and possible benefits to the enterprise. This study showed groups of organisational and technological benefits, analogous to Kaizen methodology areas implemented in enterprises (Mauer, 2017; Piotrowska, 2011; Piasecka-Gluszak, 2011).

The organisational benefits relate mainly to human resources, financial, and management processes in the company, while the technological benefits cover the area of production process management and production efficiency, with a particular emphasis on infrastructural and technological aspects (Yuik et al., 2020).

Both cases concern the organisational sphere supporting financial and employee processes and processes related to knowledge collection and sharing, and the technological sphere covering infrastructure, production processes and their optimisation (Philbin & Kennedy, 2020; Lyp-Wronska, 2016).

Based on the literature study and the analysis of the benefits from implementing digital twin technologies in a company, a survey was conducted to assess the familiarity of industry representatives with digital

Tab. 1. Examples of the use of the digital twin technology

| Example of use | Method of use | Benefits |
|---|---|---|
| Predictive maintenance | Gathering information about possible failures that may occur within a specific period | Reduce maintenance costs and downtime [O];<br>Ensure a high level of operability of the equipment [T];<br>Carry out simulations to determine when failure may occur (e.g., in the case of an increase in the temperature of the equipment), including performance tests of the infrastructure [O]; Possibility to check different failure scenarios [O];<br>Generating sensor data to learn predictive algorithms [T];<br>Determination of specific characteristics understandable for algorithms; characteristics are determined based on collected data, often not feasible to process in an automated way; a digital twin is an aggregation of data, a reflection of operation of a specific device [T];<br>As a result, a possibility to order earlier maintenance, servicing of line components and thus preventing work downtimes in the factory [O] |
| Identification of bottlenecks | Perform tests and configuration changes on virtual copies of devices and processes | Ensure the adequate performance of production lines [T];<br>Implementation of innovations, configuration changes [T];<br>Improve the performance of production lines [O] |
| Tracking of equipment wear to increase OEE | Simulating the wear and tear of equipment under specific conditions | Optimising the equipment design process — reducing the number of prototypes and test iterations produced (Armendia et al., 2019) [O];<br>Reduction of equipment manufacturing costs [O];<br>Reduction of device delivery time by 20 % (Armendia et al., 2019) [O];<br>Carrying out identical actions on a physical device and a virtual model; the former provides data for a faithful representation of the device in virtual space, the latter allows to carry out the same actions to detect anomalies — check for differences in data [O] |

O — organisational, T — technical

twin technology. The survey and its results are described below.

## 2. Research method

These studies used literature review and questionnaire survey as research methods. The survey was conducted at the end of 2020 on a sample of 50 employees of the industrial and supporting sectors (including IT). Some survey questions used a 5-point Likert scale. The part related to technology assessment used a modified 7-degree scale. This was done to diversify the respondent answers and minimise the phenomenon of extreme answers (Tarka, 2015).

In this article, a diagnostic survey was chosen as the research method; the technique was surveying, while the research tool used was a questionnaire built in the form of an online survey prepared on the Google Forms platform. Data collection was based on the technique of CAWI (Computer Assisted Web Interview). The link to the survey was provided to respondents in emails via social media (mainly Facebook platform).

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The prepared questionnaire consisted of three parts:

Part A. Scope of the potential use of technology

Part B. Actions affecting the improvement of process efficiency in the enterprise

Part C. Factors affecting the implementation of digital twins technology in the enterprise

Part D. Evaluation of the Digital Twins technology

Part E. Respondent Profile.

The author examined the level of familiarity with the digital twin technology among representatives of industrial enterprises. The study involved 50 respondents, mainly from Podlaskie Voivodeship (94 %). Among the respondents, 76 % were residents of cities with a population above 250 thousand, and 66 % were male. The age groups were below 25 y/o (10%), 25–35 y/o (40 %) and 36–45 y/o (26 %), 46-55 y/o (10%), 56-65 y/o (2%) and above 66 y/o (2%). The vast majority (88 %) of respondents had higher education.

An analysis of the respondents in terms of their position (Fig. 6) showed that a vast majority (88 %) declared openness to new technological solutions and were convinced that the development of technologies guaranteed the competitiveness of their companies (78 %). In addition, 79 % of the respondents believed that using the digital twin technology would confirm their openness to novelty. Subsequent questions focused on familiarity with the technology and factors favouring and hindering its implementation in enterprises.

# 3. Results

Half of the respondents declared having heard of the digital twin technology before. A significant percentage (64 %) believed there was a need to develop this technology, 34 % believed it should be developed, 2 % had no opinion. Half of the respondents believed that the technology would help to increase the efficiency of the company's processes, 46 % thought it would allow their optimisation, 4 % had no opinion. On the other hand, 32 % of respondents were willing to use this technology in their enterprise, 46 % would rather use it, and 16 % did not know. This shows awareness among industry representatives of the digital twin technology and related opportunities and benefits.

When asked in what time frame the digital twin technology would be used globally, 30 % believed that it was already in use, 6 % — it would be used within the next year, 50 % — within the next five years, 14 % — within the next ten years. Concerning Poland, 52 % of respondents believed the technology would be widely used within the next five years, 28 % — within the next ten years, 18 % — within the next 20 years, and 2 % believed it would never be implemented. The results indicate that respondents consider the implementation of the digital twin technology in Poland being at an earlier stage compared to the rest of the world. The survey also identified problems related to the uptake of the digital twin technology (Fig. 7).

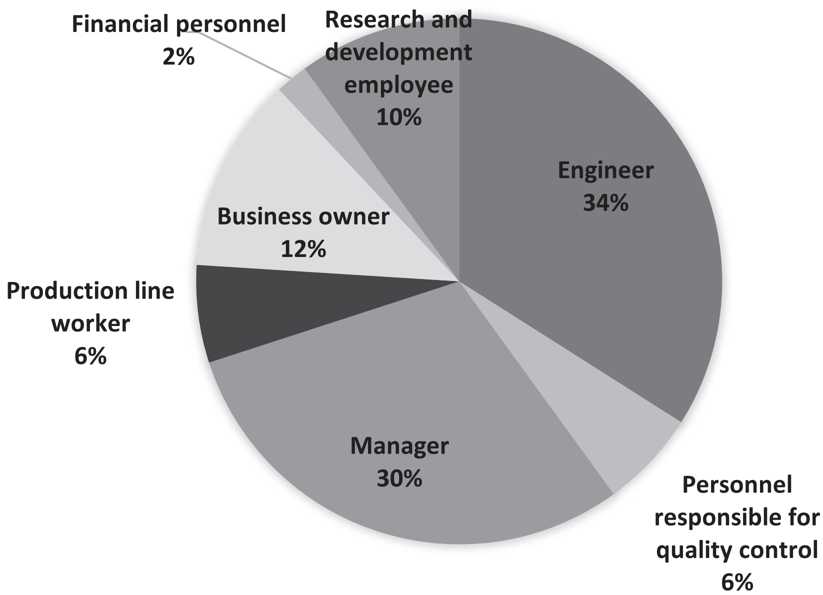


Fig. 6. Distribution of responses regarding positions held by respondents

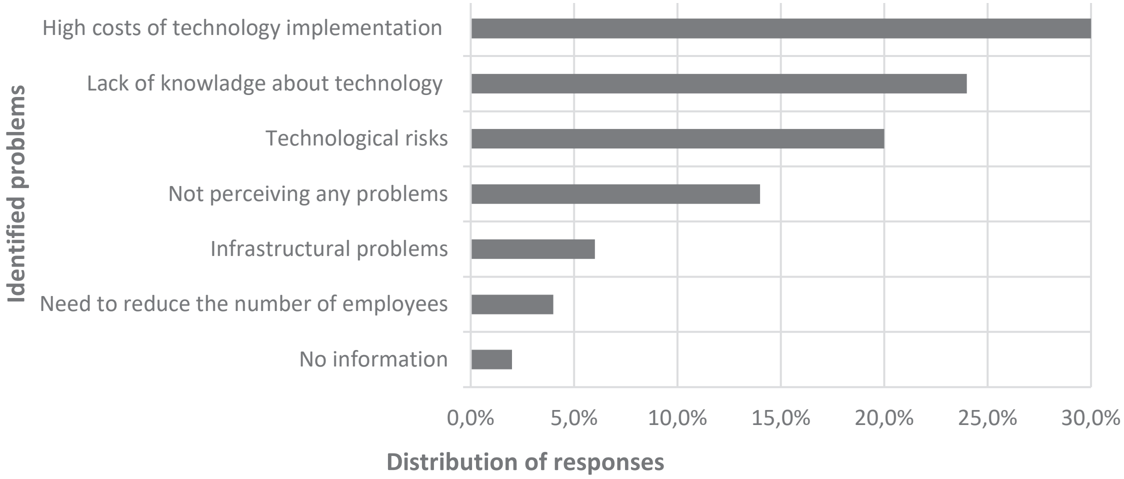


Fig. 7. Distribution of responses regarding problems in the uptake of the digital twin technology

The most common problem (indicated by 30 % of respondents) was high costs of the technology implementation, i.e., the technology itself (adding new devices, preparation of appropriate mathematical models, the complexity of the process of modelling the real object), the adaptation of the infrastructure, personnel costs (hiring new employees), and subsequent costs of repairing errors resulting from the inaccurate operation of the solution.

As the main obstacle, 24 % of respondents indicated a lack of knowledge about the technology and the general awareness of its use. The lack of knowledge was suggested both by business managers and rank-and-file employees.

One-fifth of respondents pointed to technological risks as the main obstacle to implementing the technology. They underlined such problems as creating a universal tool to digitally represent objects, the uncertainty about the reliability of the digital copy, failure to consider all environmental variables, the accuracy of the mathematical model, the emergence of substitutes of lower quality, and data security. The percentage of respondents not perceiving any problems with the introduction of this technology in enterprises amounted to 14 %. Some respondents (6 %) pointed to infrastructural aspects, such as the lack of a standardised platform for creating digital twins, the need to collect large amounts of data, and the lack of infrastructure in the form of sensor devices, while 4 % indicated other obstacles, such as the need to reduce the number of employees in enterprises to implement ICT systems.

In the context of the declared technology implementation obstacles, it was important to verify factors determining the increased effectiveness of processes in enterprises and their possibility to implement the digital twin technology. Among them were:

- investments in machinery and modern tools,
- employee training,
- the implementation of IT systems,
- the implementation of Lean/Kaizen tools.

Fig. 8 provides the distribution of answers to the question "Please indicate which of the listed actions will have a significant impact on increasing the efficiency of processes in your company — from 1 to 7, assuming that 1 — 'has no impact', 7 — 'has a significant impact'".

Respondents (38 %) indicated that employee training would have a significant impact on increasing the effectiveness of processes in an enterprise. This is in line with current trends arising from studies into the development of, primarily, micro, small and medium-sized enterprises, which indicate the accumulation of knowledge and improvement of employee competence having a definite impact on the survival of the organisation and improvement of competitiveness (Pauli, 2012). It also causes greater openness and increased awareness of the need for innovation in an enterprise.

The implementation of IT solutions is also important as 32 % of respondents indicated that their implementation would have a significant impact on improving the work of their organisation. Numerous studies have confirmed the positive influence of IT tools, among others, in the areas of supply chain management and related business processes (e.g., planning, execution, extended cooperation) (Cywka, 2007).

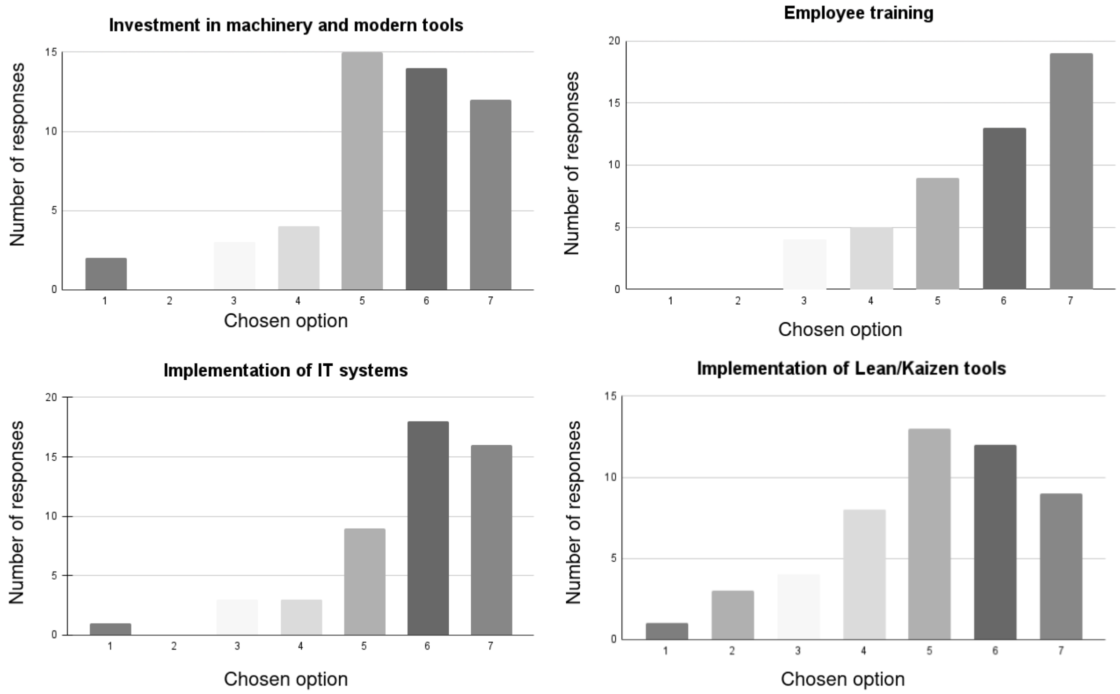


Fig. 8. Distribution of responses to the question on factors having a significant influence on increasing the efficiency of the company's processes

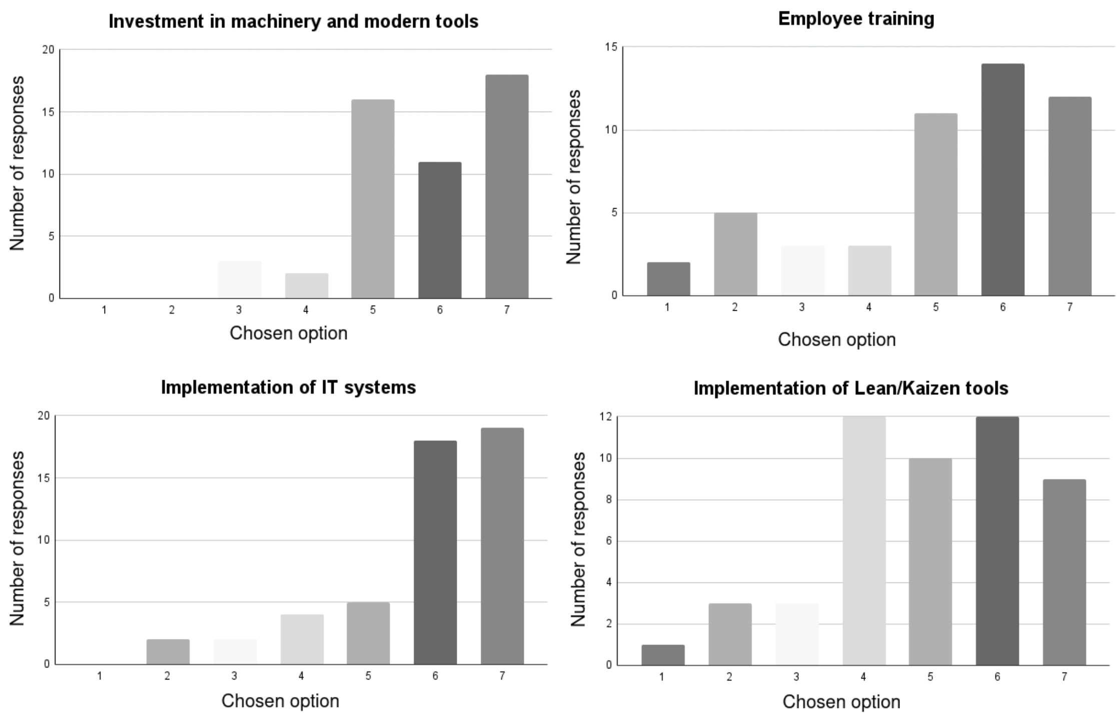


Fig. 9. Distribution of responses to the question on factors having a significant impact on the implementation of the digital twin technology in the company

Fig. 9 presents the distribution of answers to the question "Please indicate which of the listed factors, in your opinion, may determine the implementation of digital twin technologies in the enterprise, assuming that 1 — 'has no impact', 7 — 'has a significant impact'".

In terms of factors that may influence the implementation of the digital twin technology, the

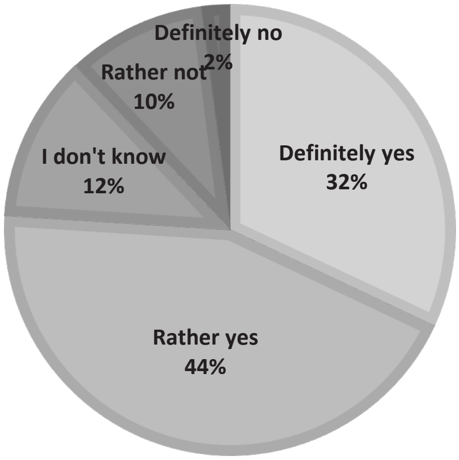


Fig. 10. Distribution of responses to the question regarding the treatment of employee suggestions in their company

respondents indicated investments in machinery and modern tools (15 respondents or 36 %) and the implementation of IT systems (18 respondents or 38 %) as having a significant impact. Respondents believed that modern infrastructure would determine the introduction of the technology in enterprises. Consequently, enterprises should first modernise their infrastructure by either purchasing new equipment or modernising (retrofitting) the existing one to fully benefit from the opportunities offered by the digital twin technology.

Additionally, the research verified whether companies were open to employee suggestions for improving company operations, implementing optimisation, and process improvement (Fig. 10).

Almost half of the respondents (44 %) indicated that their organisations tend to consider employee suggestions for the process performance improvement. 32 % indicated that they rather consider the suggestions. In the author's opinion, this is a good result, not far from the average of Polish enterprises, which is 80.7 % (the average for manufacturing enterprises is 83.9 %) (Dekier & Grycuk, 2014). It is worth pointing out that systems for considering employee suggestions are used by Polish companies often and are usually connected with the introduction of lean management tools (Dekier & Grycuk, 2014). In the author's opinion, building appropriate organisational culture, increasing the involvement of employees and their responsibility for the effects of the company's activity, is an inseparable element of improving its operation, streamlining processes, and, consequently, implementing innovations (Wisniewski & Dobrowolska, 2019; Tomaszuk, 2018).

## 4. Discussion of the results

The research conducted within the framework of this article has shown an increasing interest in the subject of digital twins over the recent years. This was confirmed by the literature review, indicating an increase in the number of publications in the subject area and interviews conducted with representatives of the industry and supporting sectors. The bibliometric analysis showed that the term "digital twin" mainly occurs in two areas: "Engineering" and "Computer Science". It is a very interesting trend showing sectors where the technology is developing. The literature studies showed a low percentage of publications in Polish. Moreover, existing studies refer to very narrow cases of technology use (case studies), only a few being general. The author's thesis is that the interest in the technology will soon (less than in five years) translate into concrete investments in increasing the level of innovativeness of Polish enterprises and their competitiveness through digital transformation. This is also confirmed by the survey, where more than half of the respondents believed that the implementation of digital twins would take place in Poland within the next five years.

The literature indicates that the concept of digital twins is still very general and inconclusive (Liu et al., 2020). Despite this, both academia and industry are making attempts to define it. For example, such an attempt is the definition coming from CIRP Encyclopaedia of Production Engineering, indicating that, "A digital twin is a digital representation of a unique active product (real device, object, machine, service, or intangible asset) or unique product-service system (a system consisting of a product and a related service) that comprises its selected characteristics, properties, conditions, and behaviours by means of models, information, and data within a single or even across multiple life cycle phases." (Jones et al., 2020). Foreign literature indicates that it is not possible to build a single definition due to the wide implementation of the solution, generalisations or attempts to create extremely highly specialised digital twins dedicated to specific applications. For example, the German literature distinguished five archetypes of digital twins with varying degrees of complexity, considering, e.g., the possibility of autonomous control of a system, data acquisition options, data processing and the possibility of controlling physical assets (Van der Valk et al., 2021).

Furthermore, digital twins can be created for completely different fields of science and technology. Among examples are digital twins (DT) of autonomous robots used in agriculture (Lumer-Klabbers et al., 2021), which allow for parallel motion of DT and an actual robot. Next is DT of autonomous vehicles (Almeaibed et al., 2021) used for research on safety and security. The simulation platform for Unmanned Aerial Vehicles used as a digital twin was described by Yang et al. (2020). In the field of smart factories, examples of digital twins are shown in the paper by Martins et al. (2020).

Even though the technology of digital twins is emerging, industry representatives are aware of its existence and the necessity of its further development (98% of respondents indicated the need for expansion of this technology). According to the conducted research, the implementation of the solution in production companies is still hindered by high costs, insufficient awareness of implemented solution benefits (Maurek, 2015), and technological risks related to inadequate adaptation of mathematical models and algorithms, which may result in an inappropriate representation of physical devices in virtual space. The conclusion from the conducted research is the need to create the product in such a way as to make the managers and decision-makers aware of the benefits of implementation, to show not only technical indicators but, above all, financial indicators and savings resulting from the implementation (Gorustowicz, 2019).

From the point of view of production companies' employees, the most important influence on increasing the process efficiency is employee training and the implementation of IT systems. The greatest influence on the implementation of the digital twin technology will be exerted by investments in machinery and modern tools and the implementation of IT systems (Cywka, 2007).

The limitations of the research were a small sample of respondents, their small geographical diversity (most lived in the Podlaskie region of Poland), and the lack of previous research allowing a comparison of trends and the level of familiarity with technology over time. Considering that the technology is still developing, the author decided to use general questions about the level of familiarity with digital twin technology.

The results may be a prelude to further research, which could include research in enterprises where digital twins are being used, identifying the factors (organisational, financial) that favour the implementation and verifying them in detail (investment in machinery, employee training, IT systems, Lean/Kaizen tools) influencing implementation. In addition, it is possible to verify the use of employee suggestions by Polish enterprises, the correlation of this phenomenon with the level of innovativeness of enterprises, and the possibility of its classification as a factor determining the implementation and development of the digital twin technology.

## Conclusions

The implementation of new technologies and innovative solutions determines the competitiveness of enterprises and has a significant impact on their long-term development and the achievement of short-term goals.

This study aimed to gain empirical knowledge about the level of familiarity with the digital twin technology among industry representatives and to identify the most important problems that stand in the way of implementing the technology in enterprises. Within the framework of the study, the author performed a bibliographic analysis and classification of benefits resulting from the implementation of the solution, distinguishing organisational and technological benefits.

The conducted research showed that new technologies such as digital twins are becoming increasingly popular and are an integral part of the development of manufacturing companies, among others. Many of the respondents perceive limitations in the form of insufficient readiness to implement them by enterprises and high costs of their implementation; however, they see modern IT systems as an inseparable element of the industrial revolution.

As part of further research, the author intends to verify the level of knowledge of the technology and the factors determining its implementation and development (Halicka, 2016). A survey is planned on a larger sample of respondents with increased participation of managers to thoroughly examine the impact of knowledge and the level of technology knowledge on the possibility to introduce it in the company's operations. Additionally, it is planned to verify the influence of the cost factor on the possibility to implement solutions in organisations and on the development of technology itself (Nazarko, 2016; Magruk, 2017).

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