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Tangible Social Concerns in a Digitalized World: An RRI Case Study on Digital Transformation Technologies at TEKNOPAR

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1. Introduction

Responsible innovation and research allow democratic societies to mold newly evolving technologies and inscribe values on the technology in question. Responsible Research and Innovation (RRI) methodologies can examine digital transformation processes in this context. Digital transformation employs digital technology to build new or modify existing business processes, culture, and customer experiences, to satisfy changing business and market requirements. Within the framework of TEKNOPAR Industrial Automation in Ankara, Turkey, this paper analyzes digital transformation and examines the current existing or nonexistent RRI aspects. This study aims to provide information and evaluate concerns about social, cultural, technical, and environmental aspects of this company's digital transformation activities and provide solutions in the context of RRI for the company, stakeholders, and other parts of digital transformation. The technical aspects of digital transformation, stakeholder design, and values emphasizing safety, privacy, and sustainability, were investigated in this study. This work analyzes the ability of the company to incorporate these critical values into its designs, communicate with people during their production and design processes, and involve users and stakeholders using the RRI framework. According to our background research and findings, the organization can broaden its present assessments by including product life-cycle management into their current assessments and go even further into incorporating values like sustainability into their ideas and solutions by considering the life-cycle assessment approach.

2. Theory

This project will utilize Responsible Research and Innovation (RRI) to examine digital transformation activities. According to the RRI approach, companies have six crucial lessons to improve their responsible innovation activities: Strategizing for stakeholder engagement, broadening current assessments, placing values center stage, experimenting for responsiveness, monitoring RRI progress, and aiming for shared values [1]. The first lesson, integrating stakeholders in the design process, is about listening. It is vital because it enhances transparency and democracy to serve the demands and interests of stakeholders. The second lesson, extending current assessments, is also an essential aspect of RRI. Companies often already consider values, issues, and judgments to some level; RI helps them widen their perspectives. The third lesson, putting values first, allows firms to think about multiple values at once. RRI suggests that values

should be at the core of the design process, and multiple values should be considered in an innovation context. The fourth lesson, experimenting for responsiveness, is an essential aspect of RI and involves building spaces for testing to anticipate probable stakeholder reactions and legal and social implications. The fifth lesson, monitoring RRI progress, involves building an internal and external RRI supervision structure. According to the sixth lesson, the corporation merely "focuses on its actions" and leaves it up to society to judge if the company can give mutual trust. Some of these six lessons, namely strategizing for stakeholder engagement, placing values center stage, and broadening current assessments, are thoroughly studied in the context of digital transformation processes in this project. This approach is the most suitable for TEKNOPAR since they are a research-oriented company focusing on designing specific technologies for different applications, and the social implications of innovations can be disregarded. Our approach fits well for understanding how the company applies different approaches to produce responsible technologies.

3. Background Research

3.1. Technical Aspects of Digital Transformation

Previous studies define digital transformation as "a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies" [2]. In recent years, firms across practically all industries have undertaken various projects to investigate new digital technologies and capitalize on their benefits. These processes usually entail changes to essential corporate operations, products and processes, organizational structures, and management principles. Businesses must adopt management practices to manage these complicated shifts [3].

Even though digital technologies (DT) are a prominent topic of conversation at the moment [4], the concepts of digital products, services, and media were already widely understood in the 1990s and early 2000s. For example, in the retail business in the 1990s and 2000s, mass media advertising campaigns were considered key digital channels via which to contact customers. However, most sales were still made in brick-and-mortar locations, sometimes in cash. From 2000 to the present, the proliferation of smart devices and social media platforms has resulted in a significant shift in the methods customers use to contact businesses and their expectations of response times and multi-channel availability. In today's world, there is much emphasis placed on mobile devices and

on providing value for customers by taking advantage of the types of individualized customer data that mobile technologies can provide on a vast scale [5].

Digital transformation has become a significant trend in strategic information systems research [6] and practices [7] in recent years. Digital transformation technology, at its most basic level, refers to the significant changes occurring in society and industry due to digital technologies [8]. At the organizational level, ongoing research has suggested that businesses must devise "plans that embrace the implications of digital transformation and generate greater operational performance" to innovate with these technologies [9].

On the other hand, although this current digitalization gives an enormous opportunity for industries to alter themselves digitally, it also has the potential to have a significant impact on all aspects of human society. Thanks to digitization, information and services may flow freely, and increasing access for a wide range of users can help break down socioeconomic and cultural barriers. For example, the rise of "digital twins," which are precise representations of business and human entities based on activity data, can improve efficiency, functionality, and quality of life. As computers become more widespread, artificial intelligence becomes more prevalent, and digital transformation becomes more standardized, society will increasingly rely on technology [10].

3.2. Public Values and Concerns

Digital transformation shapes industry and public life in different ways, and while doing so, new concerns and related applications arise. One of them is safety and safety management. As Industry 4.0 dominates the industry with automation, it brings new applications that will change the management of occupational health and safety [11]. The second one is privacy, as it has become one of the most critical concerns in the digital world with the evolution of data sharing and theft.

3.2.1. Safety

In industry, one of the major concerns is worker safety. Every system has safety requirements, and they must be met. A 20th-century movement, the so-called "Safety First," is the pioneer of this concept. They aimed to improve working conditions and develop workplace safety requirements to reduce workplace hazards [12]. Until then, "Safety First" became a slogan in industry, and companies were obliged to bring safety regulations controlled by governmental institutions [13]. These regulations were primarily used for worker safety for the last decade, called passive safety measures. With the introduction of autonomous systems, active safety measures were introduced.

These active safety measures are usually built up from sensors, which can be remotely accessed through an interface/software. In this era, new safety equipment is anything that can be digitally controlled. For instance, personal protective equipment (PPE) equipped with any sensor is widely used in IoT. The data collected can be transmitted and saved in a Cloud, in which safety managers can immediately access workers' safety status remotely [14].

Another aspect of the active safety measures is active predictive safety measures. These are so-called machine learning algorithms implemented on a system fed with workplace data of all kinds. Critical factors in the workplace, which may be accident-related, are determined and given to the algorithm as parameters. Then, the algorithm determines which factors are primarily responsible for the past accidents and what are their possible role in these accidents. In this way, users can better understand the root cause of many unknown and sudden accidents, and necessary precautions can be taken [15], [16].

Furthermore, with the development of high accuracy wearable inertial sensors, the health status of the workers can be monitored and analyzed. To prevent work accidents, machine learning algorithms are used in motion analysis to detect fatigue or any malfunction. The software creates a digital model of the work done and the worker's regular movements, which tries to match the sensitive data fed through the inertial sensors. The motion analysis comparison of the model and the worker on the field reveals the worker's health status and thus serves as a preventive safety measure [17]. However, as the matter is worker health, these autonomous measures should undergo a series of tests for reliability. They can only be used in the industry if their test reveals a 100% reliability score, and their maintenance should be followed accordingly to keep this reliability level.

3.2.2. Privacy

Privacy can be considered a concern and an outcome of digital transformation. First, it is believed that with the digital transformation and twinning, sensitive data of companies of their systems are transferred to the digital environment. Before digital twinning, all systems were designed independently, and documentation was not held in one place. Furthermore, some were not digitized and on hard copy for security concerns. As the digital twin contains all of the system's information in one, the system must be well preserved to prevent theft [18]. This concern applies to data processing and Big Data applications as well. Big Data companies process a large amount of data, including personal data, which should be well preserved. For instance, hospitals preserve patient

records on digital platforms. When needed, they can be shared with insurance companies and pharmacies. Most people do not want their health data to be accessed by third parties other than authorities [19], [20]. For this reason, advanced cyber security measures must be taken on these digital platforms.

On the other hand, digital transformation and twinning can be used for privacy enhancement in the industry. This time, the digital twin is used as a tool for designing and implementing privacy enhancement mechanisms and is used to detect privacy concerns in the system [21]. The existing privacy technologies can be implemented in the digital twin and further improved. However, one needs to be sure the model's outcome can be applied to the actual system. The digital twin model operates in a digital environment, and there are so many parameters to consider; it is a complex, interactive environment. The configurations learned from the model must be carefully inspected before being applied to the actual system [22].

3.3. Stakeholders and Users

Stakeholder engagement is an essential part of the RRI. Therefore, it must also be applied to the digital transformation. It is required to broaden current assessments and shape how the data is digitized based on stakeholder experience and expectations. The digitization must be done only after the stakeholder engagement to understand expectations fully [1]. For example, the following groups are the main stakeholders included in digital twinning [23]:

- **System:** Government agencies, authorities
- **Planners:** People creating/implementing digital transformation
- **Enterprises:** Companies/organizations that manufacture products
- **Users:** End-product recipients
- **Operators:** Personnel in charge of handling operations and production
- **Maintenance:** Personnel in charge of maintaining the system

Companies creating the digital twin must primarily engage with authorities, planners, and users. According to the rules and regulations set by authorities, a digital transformation standard must be determined. These regulations must be set according to the rights and needs of users, planners, enterprises, and workers. There are sets of regulations that are not specific to one case, and therefore the user must agree on one of these beforehand.

The most apparent benefit of digital twinning is on the production and maintenance line. As models of machines or tools are created in a digital platform, there is no need for labor work and resources.

The digital platform has all kinds of parameters specific to the case, and any real-life scenario can be generated. This way, without heating a screw up to 500˚C for heat test, it can be simulated virtually by coding the properties of the screw. Furthermore, based on the stakeholder engagement with the workers, safety measures or the utility of real-life tools can be tested via digital twinning. Without implementing an additional utility on the machine, its feasibility can be tested without spending any resources. User design is also feasible as the user can be easily included in the process. Unlike the workshop environments, simulations take little time such that users can interfere with the process simultaneously, not waiting for heating the screws to some degree thousands of times. Furthermore, after design, interference by the user is also feasible with digital twinning. The models can be accessed and modified virtually according to user experience; new simulations can be created easily. After reflecting on the feedback, the system will be dynamic and easily redesigned.

Digital twinning is a significant element in digital transformation. Although it has shared values and stakeholders, twinning does not contain all its properties. In digital transformation, the public is another stakeholder. They might not be users of the platform, but everyone is affected by the transformation in this era. Governments and transformers must consider public consultation.

3.4. Sustainability

Like Industry 4.0, one of the aims of digital transformation is enhancing resource use efficiency. When the two phrases digital and sustainability come together, the first thing that comes to mind is paper use. With digitalization, less paperwork exists [24]. Today, almost every government-related operation can be done online, and not even a paper is wasted, whereas 20 years ago, government building archives were full of paper [25]. It is not only a matter of paper resources, but the wood undergoes many operations that leave a carbon footprint. With digitalization, resources are not wasted, and almost no carbon footprint is left on nature [26].

Secondly, there have been significant changes with the digital transformation of the production and maintenance line. On the worker’s side, machines and tools are being modeled digitally and simulated in various conditions, which would require both labor work and resources. This way company’s carbon activity is also reduced. As resource usage is reduced with the introduction of simulations, there will be less production by any means, and as a result, pollution caused by the production line and waste will significantly drop. Produced tools will be tested in various environments, which cannot be achieved in real life. As a result of multi-level simulations,

products will be more reliable and robust. This way, the carbon activity per product will remain the same, but fewer products will be produced for test purposes and market usage, which is around a 50% decrease.

Another aspect of digitalization on sustainable production is its effect on life cycle costs. Life cycle cost includes any cost from the pre-concept phase to the retirement and disposal phase. At the end of the design stage, life cycle assessments show that 80% of the budget is already determined and cannot be further improved (Figure 1) [27]. User design is crucial at this stage, as some costs cannot be improved after the design phase. As digital twinning provides various parameters for the simulation, best-performing designs can be implemented, improving the life cycle cost. Typically, we expect the support/sustainment costs to be below for a sustainable product. However, life cycle cost contains design and manufacturing costs, inversely related to support costs. For a sustainable product, these three parameters must be considered at once. As digital twinning introduces various parameters, design and manufacturing costs can also be included in the life cycle cost calculations [28]. This way, life cycle cost (LCC) can be optimized for different conditions, as shown in Figure 2 below [27]. Digital twinning maintains sustainable production by improving life cycle costs and resource management.

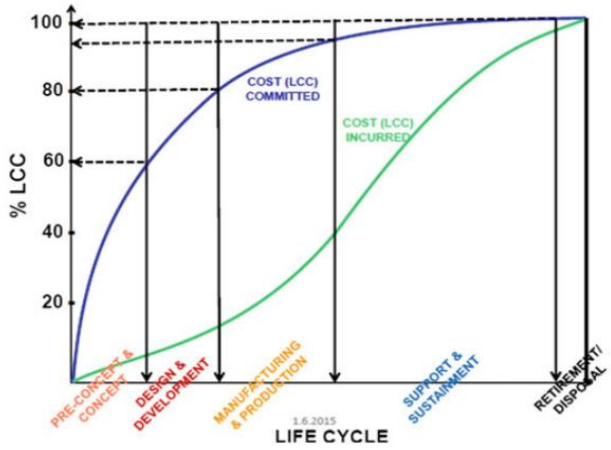

Figure 1: %LCC vs Life Cycle [27]

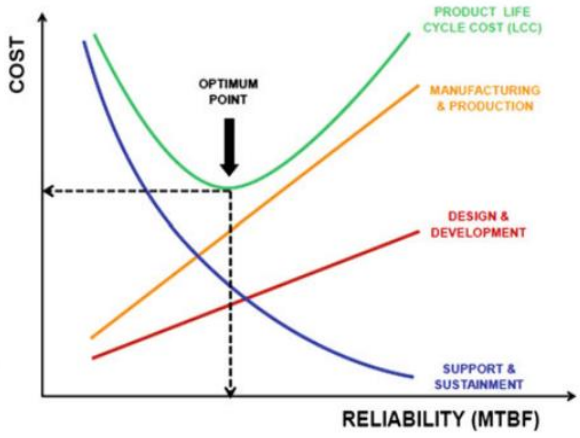

Figure 2: Cost vs Mean Time Between Failure (MTBF) [27]

4. Methods

The project's data was obtained from interviews as well as written sources. All the written sources were found using the internet. The Google search engine and the Google Scholar platform were used to discover trustworthy news websites and scholarly articles.

Employees of a company that works on various digital transformation projects were interviewed to understand the social values of digital transformation and industry 4.0. The interviewees shed some light on the values inscribed to the technology during the development phase and the developers' thoughts and integrations of responsible research and innovation. The company chosen for this purpose is TEKNOPAR. TEKNOPAR was chosen because of the number of projects it is doing in digital transformation. As a company, they have been in the business of industry 4.0 from the start. Also, our group members Fırat and Şahan have worked in this company before and personally know higher-ups from the company; we can arrange meetings with the company. We interviewed a manager, a software engineer, and a machine learning engineer.

The same set of interview questions was used in all three interviews for consistency. The questions revolved around the digital transformation, industry 4.0 applications, and their impact. Specifically, questions about stakeholders, potential risks, sustainability, and technology features were asked.

The interviews were only transcribed as the interviews were made in English; we did not need to translate. The QDA Miner Lite program was used for the coding of the interviews. In the coding, the responses from the interviews were organized into categories like risks and values. This method made the writing of the project report more efficient.

5. Findings

TEKNOPAR was established in Ankara in 1996 to design and implement modern automation systems for developing industrial sectors and facilities. TEKNOPAR delivers automation systems and solutions for the energy, mobile applications, defense industries, and industrial facilities, thanks to its outstanding R&D experience. TEKNOPAR integrates mechanical, electrical-electronic, hydraulic, automation, and information technology applications and offers complete integrated turnkey solutions as a single contractor for design, application, and assembly to provide a wide range of services to its customers offer end-to-end solutions [29].

One of TEKNOPAR's main application fields is digital transformation processes. To this end, the company closely monitors information technologies through contact and collaboration with leading relevant research institutions and R&D companies worldwide, particularly in Europe, and incorporates the most recent developments into industrial applications. To promote the digital transformation of various enterprises, TEKNOPAR provides solutions for Information Systems, M2M/IoT, Big Data and AI, Digital Twin technologies, and related products and services suitable for its fields of activity [30]. The company has a dedicated research and development center to promote research and innovation activities in the mentioned areas.

The findings from the interview were categorized into four subsections: stakeholders, technological applications, technical, and values. The findings' data are from the interview described in the previous section.

5.1. Technology

This section is about the technical concerns and risks the new developments carry. TEKNOPAR is primarily a company with customers, and they develop products that are sold to those customers. It is natural for them to have technical concerns as their customers also have the same concerns. The code words under which the interviews are analyzed are Economy, Efficiency, Privacy Risk, and Industrial Needs.

Category	Code	Text
Technology	Economics	"... digitalization decreases the cost and increases the profit" [manager]
	Efficiency	"... The digital twin technology, on the other hand, allows these parts to be used nearly until their failure. As a result, maximum efficiency from the parts is attained" [software engineer]
	Privacy Risk	"Although it may appear at first that digital transformation is entirely virtual and without hazards, this is not the reality. There may be some issues about the users' privacy. …" [machine learning engineer]

Category	Code	Text
Technology	Privacy Risk	"Before, when all the documents were in paper, protection of private information was very easy as stealing physical documents was hard…" [manager]
	Industrial needs	"Here in TEKNOPAR, we keep up with the newest digital transformation technologies and develop solutions to meet industrial needs." [machine learning engineer]

5.1.1. Economics

In Interview 1, the manager says, "... digitalization decreases the cost and increases the profit.", highlighting the importance of looking desirable to the investors. They mention increasing profits as a technical value to be more desirable. As explained, TEKNOPAR is a company, and if they do not get investors or customers, it will be bankrupt. The companies that undergo a digital transformation do so with the hopes of increasing their profits. The developed technology being as profitable as possible becomes a significant concern to attract these customers.

5.1.2. Efficiency

In the second interview, efficiency is mentioned as a goal of digital transformation by the software engineer. As an example, digital twin technology is used. They say, "... The digital twin technology, on the other hand, allows these parts to be used nearly until their failure. As a result, maximum efficiency from the parts is attained". This allows the machine parts to be used with almost maximum efficiency and ties into companies' environmental values and concerns about sustainability.

5.1.3. Privacy Risk

The machine learning engineer talks about how digital transformation and industry 4.0 inherently carry a risk to the worker and user privacy. With increasing digitalization, it has also become possible to store immense amounts of data, and it is also possible to steal information which was impossible to do before. The manager shows this change in the industry by giving an example

using banks “Before when all the documents were in the paper, protection of private information was very easy as stealing physical documents was hard…”.

5.1.4. Industrial Needs

Since technology has proliferated, most technological artifacts are too complex and large to be developed by a single company. For example, even Apple bought iPhone X’s screens from Samsung [31]. Because of this, the technologies developed by some companies are usually just parts of other technological artifacts or company structures. Most companies’ products need to satisfy the industry’s needs and standards to stay competitive. TEKNOPAR is no exception to this. In their interview, the machine learning engineer mentions this aspect of their development by saying, “Here in TEKNOPAR, we keep up with the newest digital transformation technologies and develop solutions to meet industrial needs.”. As such, the technological artifact needs to satisfy the needs of the larger whole they will fit into.

5.2. User Experience and Design

This section is about the technological applications of digitalization in which the company takes part and their design philosophy which incorporates the user’s desires and needs in the final technological artifact. The Industry 4.0 vision, which prioritizes automation and digitalization, relates to TEKNOPAR’s products.

5.2.1. Technological Applications

Category	Code	Text
User Experience and Design	Technological Application	“In terms of IT, we work on information systems, M2M (machine-to-machine) & IoT (Internet of things), digital twins, big data, and other applications of artificial intelligence.” [manager]
		“... we are now undertaking research is digital transformation. We work in a variety of sectors in this area, including artificial intelligence…” [machine learning engineer]

As said in the interviews, TEKNOPAR works in a variety of fields. These are information systems, M2M (machine-to-machine) & IoT (Internet of things), digital twins, big data, and artificial intelligence. A deeper analysis of the most prominent of these areas is given in the following paragraphs.

The Internet of Things (IoT) refers to physical items equipped with sensors, computing power, software, and other technologies that connect to and exchange data with other devices and systems over the Internet or other communication channels. The communication between different objects allows users to integrate different automated machines and make them work together on a task.

Artificial intelligence (AI) is a term that describes the simulation of human intelligence in programmable objects such as robots, computers, and embedded systems to "think" and act like humans. Any machine that demonstrates features associated with a human mind might be considered intelligent. Digitalization also refers to the digitalization of routines attributed solely to humans, such as learning from experience and problem-solving.

Big Data is a term used to cover a large field of technical areas. However, big data is more extensive, more complex datasets, especially from new data sources. These datasets are so bulky that traditional data processing software cannot manage them. Nevertheless, this large volume of data can be used to solve business problems that could not be handled before, so it is essential to analyze them as such big data could be seen as the field of analyzing massive data, which is traditionally hard to analyze.

5.2.2. Stakeholders

The digital transformation affects people from diverse backgrounds. Therefore, the background research and interviews highlight many different stakeholders. The main stakeholders are companies, workers, the public, and the government.

Category	Code	Text
User Experience and Design	Stakeholder	"... practically every company is investing in digital transformation …" [manager]

Category	Code	Text
User Experience and Design	Stakeholder	"Digital transformation is also very important for workers." [manager]
		"... digital transformation will become an increasingly important element of our lives." [software engineer]
		"... municipalities could use digital twins for scheduling bus, road maintenance …" [machine learning engineer]

Digital transformation helps companies in many ways to increase their efficiency and profit without ignoring environmental values. Therefore, most of the high technology companies value digital transformation and have action plans to ensure their transformation is effective. Workers of these companies are another group that will be affected by digital transformation. Some old professions will be automatized, and there will be no need. On the other hand, some new jobs will emerge in the future with digital transformation. Another potential aspect of digital transformation is the privacy of workers. Since all company data will be digitized, it is open to attacks or misuse by the company owners. Hence, workers are indicated as stakeholders, as the manager says in his interview. Like companies, governments and municipalities should also complete their digitalization. Their transformation needs security due to the higher volume of data and the need for more privacy. According to the machine learning engineer, governments and municipalities are other stakeholders, and they store the general public's data. Therefore, the digital transformation includes every person in society.

Our findings suggest that more and more people will be affected by digital transformation as the use of digital devices will increase due to developing technology. All the interviews imply that digital technologies will be widespread in the future. More actors will be obliged to invest in digitalization due to the global conjecture, which highly prioritizes effective solutions of digital technology for information processing.

5.2.3. User Involvement

The interviewees highlighted that it is vital to consider the concerns and needs of both current and future stakeholders.

Category	Code	Text
User Experience and Design	User Involvement	"... we try to constantly take feedback from workers during both the design and early usage phase." [manager]
		"The feedback we receive from consumers is fed into our system …" [software engineer]
		"... the feedback we receive from our customers is, of course, an extremely important factor… the technology is designed as transparently as possible, so it does not conflict with their privacy concerns." [machine learning engineer]

The engineer at TEKNOPAR gets feedback from current users on their software products. Furthermore, they organize public surveys to detect the needs and concerns of the society and use them as inspiration for their research and development projects. They constantly get feedback from the current primary users of their products. The manager expresses this by saying, "we try to constantly take feedback from workers during design and early usage." Secondly, the machine learning engineer argues that they use customer feedback mainly focused on privacy issues, and they maintain successful communication with customers to address their concerns. Therefore, for TEKNOPAR, the term feedback does not only include getting ideas from customers. TEKNOPAR also informs customers on how they solve the problems mentioned by the users. This way a, healthy communication is maintained between end-product users and the company.

5.2.4. Accidents due to System Failures

Category	Code	Text
User Experience and Design	Accidents due to system failures	"... unwanted machinery failures which lead to dangerous workplace accidents…" [manager]
		"... computer systems that manage heavy machines or robots can cause serious injuries." [software engineer]
		"There are numerous hazards linked with an algorithm's precision." [machine learning engineer]

As all technological artifacts, digitalization and practices related to industry 4.0 carry some dangers due to system failures. All the interviewees mention the possible dangers of the technology. So, while developing their technologies, TEKNOPAR is aware of the possibility of such dangers, and they try their best to avoid them. As an example of the dangers system failure could create, the manager talks about the case if a digital twin system is faulty. A component could be used until it breaks down, which in extreme cases could cause workplace accidents that could ultimately result in harming the workers or machinery. TEKNOPAR is careful of such danger in the development of the technological artifact.

5.3. Sustainability and Design

In the interviews, sustainability is mentioned in terms of economic and environmental values. The interviewees sometimes prioritize economic or operational benefits and name the ability of continuous efficient operation of systems as "sustainability." Environmental values are also referred to as sustainability by some interviewees. Therefore, the interviewees constantly referred to two dimensions of sustainability, namely environmental and economic. Some examples for both cases are given in the following table. In this work, these two meanings attributed to sustainability are separated. The code "efficiency for sustainability" refers to economic sustainability, and "environmental values" are used for the latter meaning attributed to sustainability. The difference can be seen in the following codes.

Category	Code	Text
Sustainability and Design	Efficiency for Sustainability	"TEKNOPAR's digital twin technology gives … the capacity to fix machinery before it becomes obsolete … so that it can be fixed proactively. We also supplied electrical and hydraulic systems to over a hundred Turkish hydroelectric power facilities…" [machine learning engineer]
		"We believe that sustainability comes from "repair" and "reuse" principles. One of our activity fields is digital twin technology that enables users to repair their machinery before failure and reuse them for much longer periods of time." [manager]
		"... The digital twin technology, on the other hand, allows these parts to be used nearly until their failure. As a result, maximum efficiency from the parts is attained…" [software engineer]
	Environmental Values	"Digital transformation and especially use of information systems heavily decrease the usage of papers. This is extremely important as deforestation is one of the most severe environmental issues." [manager]
		"... We conduct research on undersea cable defect detection using remotely operated vehicles and solar panel defect detection utilizing drones." [software engineer]

5.3.1. Environmental Values

One of the central notions of sustainability includes environmental conservation. The interviewees highlighted that digitalization's significant sustainability benefits prevent deforestation and

pollution by minimizing paper usage and gas emissions. Software developer exemplifies the cooperative use of digital twin and machine learning techniques to reduce pollution by saying, "... our digital twin model designs include sophisticated eco-friendly sensors to track electricity use and GHG emissions. [Thanks to this, we can] rearrange machines to reduce GHG emissions and optimize energy use". Furthermore, the software engineer increases the efficiency of renewable energy systems using automated drones. More efficient use of renewable energy will lead to more sustainable energy production from environmental and financial perspectives. Software engineer expresses this idea by saying, "we conduct research on ... solar panel defect detection utilizing drones." Lastly, digital storage of any data will lead to a more sustainable future by reducing paper use and, ultimately, the rate of deforestation. The company manager is aware of the environmental devastation created by deforestation and points out her opinion on the issue by saying, "digital transformation … decrease the usage of papers. This is extremely important as deforestation is one of the most severe environmental issues".

5.3.2. Efficiency for Sustainability

Another perspective on sustainability is the economic dimension. More efficient use of machine parts and energy will create economic surplus and ease the financial operability of the systems. This ease of operability will lead to sustainable production and sound economics. TEKNOPAR develops solutions to decrease unnecessary part repair and replacement through digital twin-based simulations. The manager clarifies the idea by saying, "we believe that sustainability comes from 'repair' and 'reuse' principles. One of our activity fields is digital twin technology that enables users to repair their machinery before failure and reuse them for much longer periods of time."
The machine learning engineer discusses another solution to increase efficiency in hydroelectric power systems. The company provides software solutions to maintenance scheduling by predicting the optimum time intervals between different maintenance sessions. As seen in this example, two notions of sustainability (economic and environmental) are not fully separated. Increasing the economic value of renewable energy systems will ultimately lead to more companies using these sources to produce energy. This increment will create environmental benefits in the long term because renewable energy sources use less natural sources and result in less pollution and environmental damage.

6. Analysis and Conclusions

In this section, outcomes of background research and findings are analyzed in terms of essential RRI lessons, as described in the Theory section, about digital transformation innovations at TEKNOPAR. Even though TEKNOPAR is seen to implement digital transformation procedures in a relatively responsible manner, our research suggests several ways to improve the RRI practices inside the company in terms of digital transformation. We have also discovered that one of the most important values for the company's operations is sustainability and found ways to increase the address of TEKNOPAR towards environmental issues.

6.1. Strategizing for Stakeholder Engagement

TEKNOPAR provides digital transformation technologies to many companies. Thus, practically every company, its shareholders, and workers can be considered the stakeholders in the digital transformation technologies. In this study, it was discovered that interactions between the stakeholders impacted the development of this technology. Digital transformation technologies produced by engineers and scientists are becoming increasingly capable of accommodating the increasing demands of consumers for additional features from the technology. Applying RRI principles when designing this technology can help achieve this goal by adding new values to the features introduced in the digital transformation technology development process. Thus, the stakeholders may decide on incorporating social and democratic values into digital transformation devices.

The company indeed practices the inclusiveness of the stakeholders in their communication with consumers. They are open about their operations to meet the demands of the clients they serve. However, owing to the delicate nature of some initiatives, they want to maintain confidentiality rather than be transparent. Moreover, this is consistent with the finding made by Van de Poel [1] that one of the barriers to stakeholder participation is privacy concerns caused by competition. Although some projects may indeed have confidentiality issues, the company should also remember that one of the main points of innovative development is stakeholder engagement. Thus, it can be advised that the company should prioritize democratic rationalization whenever the research project allows.

Because TEKNOPAR is active in research and development projects where their efforts are part of a larger initiative involving numerous organizations, they must adhere to particular data

openness and privacy requirements established by the government. These principles address all of the critical components of transparency identified during the background study. This, together with the fact that they make their results available to the public on the internet, demonstrates that they are conscious of their social responsibilities and the modern norms of information exchange.

6.2. Placing Values Center Stage

6.2.1. Privacy and User Experience

In recognizing the potential hazards that workers may encounter during the digital transformation process, TEKNOPAR has taken initiatives to make the process safer. They are also aware of the danger of harmful assaults on their data, and they have stated what precautions they will take to prevent this from happening. These studies demonstrate that their components are capable of reflexivity and responsiveness.

TEKNOPAR is constantly researching and developing new solutions to solve safety concerns. First and foremost, they are continually improving the technology behind their artificial intelligence systems to make them as dependable and accurate as possible for their consumers. Second, to guarantee that their information system designs are ergonomic and straightforward, they regularly solicit input from employees during the design process and throughout the early usage phase. The tracking of employees in an information system is the most common source of privacy infringement. They do not closely monitor their employees or compile any data regarding their job pace, which may put them under further strain.

It is clear from the interviews that the firm places a high value on privacy. They consider privacy while developing their applications and websites, including it in the design process. On the other hand, we learned from some individual interviews that TEKNOPAR sometimes places greater emphasis on the security of the data than on whether or not the data of the user is leaked or the user's privacy is breached. In specific digital transformation applications, the functionality of the platforms that gather and handle the data is more important than the actual data itself. According to the report, to overcome the value friction between privacy and security, the organization may widen its evaluations of how to deal with privacy-based concerns and further comprehend the conflict between privacy and data security. A further solution to this problem may be found in communicating more explicitly with the user about the privacy policy and employing technical solutions such as encryption and authentication.

Finally, the organization asserts that they are sensitive to the personal information of its employees and other critical stakeholders in the course of its digital transformation activities. However, they do not specify what exactly they believe to be private. Users and stakeholders are not informed about whose data is regarded as personal, and they are not told whether they contact them. When deciding which information is private and which data can be tracked, the company should involve stakeholders as much as possible in the process by listening to the users and their concerns, informing them about the content of the data being used, and actively and sincerely communicating with the stakeholders during the decision-making process. As a result, TEKNOPAR will broaden its present values assessments like democracy and transparency and involve stakeholders in discussions about their risk concerns.

6.2.2. Sustainability

In an era where environmental challenges and concerns are becoming more widely discussed, it is critical to stress the importance of sustainability measures whenever feasible. The interviews revealed that TEKNOPAR makes significant efforts to address sustainability challenges through its design procedures and innovation processes. TEKNOPAR is devoting a significant amount of resources to digital twin technology, which they are putting to use in various industries. Commonly, manufacturers establish the approximate useful lives of machine parts. When these components reach the end of their useful life, they are replaced.

On the other hand, the digital twin technology allows these parts to be used nearly until their failure. As a result, maximum efficiency from the components is attained, and less waste material is created, ensuring environmental sustainability. In some circumstances, TEKNOPAR's digital twin model designs include sophisticated eco-friendly sensors to track electricity use and Green House Gas emissions. Their models then collect and connect energy data with production parameters in order to rearrange machines to reduce Green House Gas emissions and optimize energy use.

Through training their personnel, they are pushing the frontiers of environmental and social sustainability due to the advantages of the digital transformation technology outlined previously, particularly in predictive maintenance. Besides that, they are involved in a project called COGNITWIN [32], another collaborative project whose objective states that one of its aims is to develop a sustainability plan and adjust it in response to feedback progress project. In addition, TEKNOPAR donates a sapling to the TEMA Foundation for each of their new employees. The

latter start their jobs with the motto of "One Sapling, One Human" to support sustainable development, with the awareness that our natural resources are getting depleted. According to the findings, TEKNOPAR plays a critical role and fulfills its social obligation in sustainability by investing in environmentally-friendly technologies and practices. All in all, it can be concluded that TEKNOPAR is a company that emphasizes the importance of corporate social responsibility and includes sustainability as one of the critical objectives.

6.3. Broadening Current Assessments

As described numerous times above, we believe that TEKNOPAR indeed deploys some RRI procedures in their research & development, design, and production processes. They consider values like privacy, transparency, user experience, and sustainability and try to provide their customer with responsible technologies and innovation. However, there are some aspects where they can improve their RRI procedures to further incorporate values like sustainability into their company objectives. They can utilize the life-cycle assessment (LCA) methodology described in the Background Research section. Technologies like digital twins are undoubtedly subject to enhance the sustainability aspect of our daily lives, and their effect can be further assessed using life-cycle assessment. In general, LCA is used for assessing environmental impacts associated with all stages of a commercial product's life cycle. In their case, they can employ the LCA approach in digital twin technology to assess the environmental aspect, starting from the design of the digital twins, their deployment, the use of the product by the customers, and eventually the effect of these twins on sustainability in terms of their customers. One other method they can use in assessing their activities is product life-cycle management. Although the company takes a role in researching and developing software-oriented aspects of digital transformation, they also provide hardware-related solutions to its customers to further increase its digitization operations. These hardware solutions can utilize product life-cycle management to oversee the whole life-cycle of their hardware products, from conception through design and production to sales, servicing, and finally, retirement and disposal. The PLM method would assist them in the responsible development of their new goods and introducing such RRI-monitored items to the market.

To summarize, it is reasonable to conclude that RRI advancements are already underway in TEKNOPAR as part of its digital transformation efforts. However, we feel that the scope of values should be widened and that some risks (privacy and safety, in particular) should be considered,

and viable remedies should be implemented in greater depth. The breakthroughs in digital transformation being made by TEKNOPAR are encouraging, yet, social and democratic ideals must be integrated into the technology. Because of the emphasis on responsible innovation features such as reflexivity, inclusion, anticipation, and responsiveness, the technology produced under TEKNOPAR has the potential to be further bolstered by incorporating values and broadening their assessments, as shown in previous paragraphs. By implementing the solutions presented in this research and exploring any difficulties that may arise due to digital transformation in the technological, social, cultural, and environmental context, this technology will likely evolve more responsibly.

7. Participation

Şahan wrote the Introduction and Theory sections. Tolga found the sources for the background research. Tolga and Şahan wrote the Background Research section. Arda and Ufuk wrote Methods and Findings sections. Fırat and Şahan wrote the Analysis and Conclusions section. Tolga, Arda, and Şahan did the formatting of the report. Fırat, Şahan, and Ufuk were the interviewers, and Arda and Tolga transcribed the interviews. Ufuk and Arda did the coding of the interviews.

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9. Appendix

9.1. Interview – 1

With R&D Manager at TEKNOPAR

Question 1) Please inform us about the developments in TEKNOPAR.

Answer 1) In TEKNOPAR, we are operating in various areas of activity like defense industry, hydroelectric power industry, construction applications, and information technologies (IT). In terms of IT, we work on information systems, M2M (machine-to-machine) & IoT (Internet of things), digital twins, big data, and other applications of artificial intelligence. An information system is a system that provides the storage, distribution, and communication for the information required by enterprises. A digital twin is a digital model of a physical system which enables users to test out the environmental conditions, usage settings, and design decisions. We provide services to many businesses in such areas.

Question 2) Who are the stakeholders?

Answer 2) As I said before, we are providing these technologies to many companies as such a lot of people are affected by them. For example, practically every company is investing in digital transformation because of the current digitalization of the world. As a more specific example, companies that have big machinery can use applications of digital twin technology in their factories for predictive maintenance. This is also very good and desirable for shareholders of such companies because digitalization decreases the cost and increases the profit and efficiency. Digital transformation is also very important for workers. For example, information systems are used by workers daily. If these systems are easy-to-use and comfortable, it would make their lives much better. How intrusive these systems are in terms of privacy could also heavily affect their workplace peace.

Question 3) What are the risks associated with the technology?

Answer 3) Of course, there are some risks associated with digital transformation. First of all, in some cases, digital twins and artificial intelligence systems can be faulty. Then, this may cause

unwanted machinery failures which lead to dangerous workplace accidents that could be very harmful for workers. In addition, as I said previously, some parts of the information systems that are used by workers may violate their privacy, which is also a big concern. Lastly, with all the digitalization going on, protection of information became a very delicate issue. Before, when all the documents were in paper, protection of private information was very easy as stealing physical documents was hard. But now, because all information is stored online, all companies should be very careful about data piracy.

Question 4) Could you please explain how the company attends to sustainability through technological designs and/or organizational practices?

Answer 4) In TEKNOPAR, sustainability is a very important concept for us, we attend to sustainability in many ways. We believe that sustainability comes from “repair” and “reuse” principles. One of our activity fields is digital twin technology that enables users to repair their machinery before failure and reuse them for much longer periods of time. Digital transformation and especially use of information systems heavily decrease the usage of papers. This is extremely important as deforestation is one of the most severe environmental issues. On top of these, we supplied electrical and hydraulic systems to over hundred hydroelectric power plants & dams in Turkey. We know that renewable energy is the solution to the climate change crisis.

Question 5) What changes to the technology have been done or will be made in response to stakeholder interests or risk concerns?

Answer 5) I want to address the risk concerns I mentioned previously. Firstly, we continuously work on the technology of our AI systems to make them as reliable and accurate as possible for our users. Secondly, in order to ensure that our information system designs are ergonomic and easy-to-use, we try to constantly take feedback from workers during both the design and early usage phase. As I have said, another highly considered issue is privacy of workers in information systems. Privacy violations are mostly caused by tracking of workers in the information system. We try not to heavily track workers and create any statistics about their work speed, which could put them under pressure.

Question 6) What does the future of digital transformation look like?

Answer 6) I see the future of digital transformation as very bright. Due to the COVID pandemic, a lot of companies and businesses had to speed up their digital transformation process. However, I believe that even when the pandemic is over, the speed of digital transformation will not slow down. In our current highly digital world, I think that many more stakeholders will invest in digital transformation for many years to come. For instance, even though it is currently used by many different areas of industry, I believe that digital twin technology still has many more possible usage domains. Moreover, obviously, artificial intelligence is a very a hot topic nowadays, and I am sure that it will be developed a lot in the future.

9.2. Interview – 2

With Software Engineer

Question 1) Please inform us about the developments in TEKNOPAR.

Answer 1) Here in TEKNOPAR, we keep up with the newest digital transformation technologies and develop solutions to meet industrial needs. We work in a number of different fields. Our organization, for example, provides end-to-end customizable digital twins based on customer requirements. We may utilize these digital twin models to anticipate the remaining useful life of machines using predictive maintenance algorithms based on the collected data, present machine status, present 3D models of machinery, and more. TEKNOPAR's research in digital transformation also includes defect detection systems. AI-assisted flaw detection systems are available for X-Ray and optical images. We conduct research on undersea cable defect detection using remotely operated vehicles and solar panel defect detection utilizing drones.

Question 2) Who are the stakeholders?

Answer 2) We provide technological assistance and services to a variety of businesses; thus, these technologies influence a lot of stakeholders. For once, Because of the world's present digitalization, practically every organization is investing in digital transformation. For example, if you are a company of any size in robotics, machine vision, cybersecurity, or remotely operated vehicles sectors, you are bound to be interested in digital transformation. Consequently, personnel

of such companies are also direct stakeholders of digital transformation process, as they are first-hand experiencers of how these technologies affect daily life.

Question 3) What are the risks associated with the technology?

Answer 3) It's no secret that digital transformation can bring with it some dangers and unintended consequences. One thing to keep in mind is that industrial digital transformation is not always without danger. When controlled by untrained workers, computer systems that manage heavy machines or robots can cause serious injuries. Another crucial aspect is data security. Dangerous individuals gaining access to the system that collects data from the entire manufacturing process might cause major problems for the organization. Similarly, hostile attacks on the production line might result in financial losses.

Question 4) Could you please explain how the company attends to sustainability through technological designs and/or organizational practices?

Answer 4) Normally, manufacturers establish the approximate useful lives of machine parts. When these components reach the end of their useful life, they are replaced. The digital twin technology, on the other hand, allows these parts to be used nearly until their failure. As a result, maximum efficiency from the parts is attained, and less waste material is created, ensuring environmental sustainability. In some circumstances, our digital twin model designs include sophisticated eco-friendly sensors to track electricity use and GHG emissions. Our models then collect and connect energy data with production parameters in order to rearrange machines to reduce GHG emissions and optimize energy use.

Question 5) What changes to the technology have been done or will be made in response to stakeholder interests or risk concerns?

Answer 5) The feedback we receive from consumers is fed into our system, and it's a never-ending cycle of improvement that leads to complete customer engagement. TEKNOPAR works with customers from the beginning of a project to the end, and during the design phase, we cooperate with them to meet all of their needs. Furthermore, we are always improving the accuracy and reliability of our AI systems and digital twin models to ensure that they perform as good as possible

for our consumers. Last but certainly not the least, our information systems' cybersecurity layers have been reinforced to prevent worker and user tracking.

Question 6) What does the future of digital transformation look like?

Answer 6) As technology progresses toward virtual reality, digital transformation will become an increasingly important element of our lives. Artificial intelligence (AI) and machine learning (ML) will become more prevalent and integrated into our daily lives. In order to comprehend and analyze the market structure, data management and information systems will be useful. As a result of the integration of computer softwares into many aspects of daily life, I believe that increasing the robustness of nearly all types of processes to human errors is the future of digital transformation. I believe that in the future, digital transformation will play an even larger role in our lives.

9.3. Interview – 3

With Machine Learning Engineer

Question 1) Please inform us about the developments in TEKNOPAR.

Answer 1) TEKNOPAR provides answers to difficulties in a variety of industries using the most up-to-date technologies available. One of the areas in which we are now undertaking research is digital transformation. We work in a variety of sectors in this area, including artificial intelligence, where we program AI systems to operate without the need for human involvement. Machine learning is a subset of AI systems that allows computers to learn from their own experiences without the need for human intervention. Digital twin systems, which are essentially computer models of real systems, is another area in which we study. Our goal there is to continuously get knowledge about the machine's and system's state. Computer vision and robotics are also among the subjects on which we work.

Question 2) Who are the stakeholders?

Answer 2) There are a lot of people involved in the digital transition. Almost every company that works with machines desires to adopt this technology in order to save money. Aside from that, huge corporations with a lot of data, such as banks, have begun to store their data in cloud platforms

rather than on paper. Unmanned aerial vehicles, as you may be aware, use computer vision and radar systems to scan the environment and detect items such as hostile vehicles, supplies, and so on. Overall, digital transformation involves a large number of workers from various businesses.

Question 3) What are the risks associated with the technology?

Answer 3) Although it may appear at first that digital transformation is entirely virtual and without hazards, this is not the reality. There may be some issues about the users' privacy. If we take the banks' move to cloud memory storage as an example, a malicious hacker may gain access to these data, and the same could be said for other such circumstances. There are numerous hazards linked with an algorithm's precision. Furthermore, in the case of unmanned aerial vehicles (UAVs), a miscalculation in aiming could have disastrous effects. This situation also applies to other applications of machine learning. Finally, the privacy of personal information (such as that of employees who use company websites) is a major problem.

Question 4) Could you please explain how the company attends to sustainability through technological designs and/or organizational practices?

Answer 4) As you would be familiar, many manufacturers employ machines in their production processes. TEKNOPAR's digital twin technology gives them the capacity to fix machinery before it becomes obsolete. Our goal is to accurately predict the time of failure for the machinery so that it can be fixed proactively. We also supplied electrical and hydraulic systems to over a hundred Turkish hydroelectric power facilities. The solution to the climate change dilemma is renewable energy, as we all know.

Question 5) What changes to the technology have been done or will be made in response to stakeholder interests or risk concerns?

Answer 5) To begin with, we aim to create technology in such a way that it performs as efficiently and precisely as feasible, based on what we are asked to design. However, the feedback we receive from our customers is, of course, an extremely important factor. We solicit feedback from our consumers during the design and development stages of our products. Furthermore, because we involve our clients in practically every step of the process, the technology is designed as transparently as possible, so it does not conflict with their privacy concerns.

Question 6) What does the future of digital transformation look like?

Answer 6) I am optimistic about the future of digital change. I believe that many more stakeholders will invest in digital transformation for many years to come in our contemporary highly digital world. Despite the fact that it is being employed in a variety of industries, I feel that digital twin technology still has many more potential application fields. For example, municipalities could use digital twins for scheduling bus, road maintenance or ML/AI related analysis methods to regulate public transportation. Furthermore, artificial intelligence is clearly a trendy topic these days, and I am confident that it will be further improved in the future. Artificial intelligence (AI) and machine learning (ML) will become more prevalent and integrated into our daily lives with each passing day.