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EXECUTIVE REPORT ON THE NOVEL MANAGERIAL APPROACHES FOR COLLABORATIVE HUMAN-ROBOT INTERACTION (HRI)

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EINST4INE

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EXECUTIVE SUMMARY

This report aims to present novel managerial approaches for collaborative human-robot interaction (HRI) in organisations. The relevance of this topic stems from the increasing integration of robots into the workplace and the need for effective management strategies to ensure successful implementation. Introducing robots of all kinds—social, collaborative, or virtual—has brought about numerous benefits to the workplace, including, but not limited to:

- Increase in production speed
- Reduction of labour costs
- Decrease in errors
- Facilitation of communication in remote work scenarios
- Support of humans in service tasks
- Improved customer service assistance

However, implementing robots into existing organisations does come with challenges. As we show in this report, some of these challenges include resistance from employees due to job security concerns, limited knowledge of integration and programming, training difficulties, and the absence of standardised blueprints. Resistance from top management and challenges in system integration on a global scale are also observed. Our results also show that psychological factors affecting human-robot-interaction include concerns about data privacy, security, and safety, potential impacts on human relationships and teamwork.

The process of supporting robot implementation involves analysing and adjusting workflow routines, evaluating, and optimising the robot's environment, training users, collecting feedback, and having effective project management. Past failure cases indicate the importance of managing expectations, addressing the human aspect of change, conducting thorough testing, involving stakeholders, and ensuring product maturity. Successful implementation requires a shared vision and open communication with clients, an understanding of the process and willingness to adapt, time and resource commitment, engagement of stakeholders, dedicated ambassadors, and effective management support.

Professionals find that **policymakers play a crucial role** in promoting the application of robots at work by offering financial incentives, creating awareness about the benefits of robots, facilitating agile policy changes, improving standards, and reducing bureaucracy.

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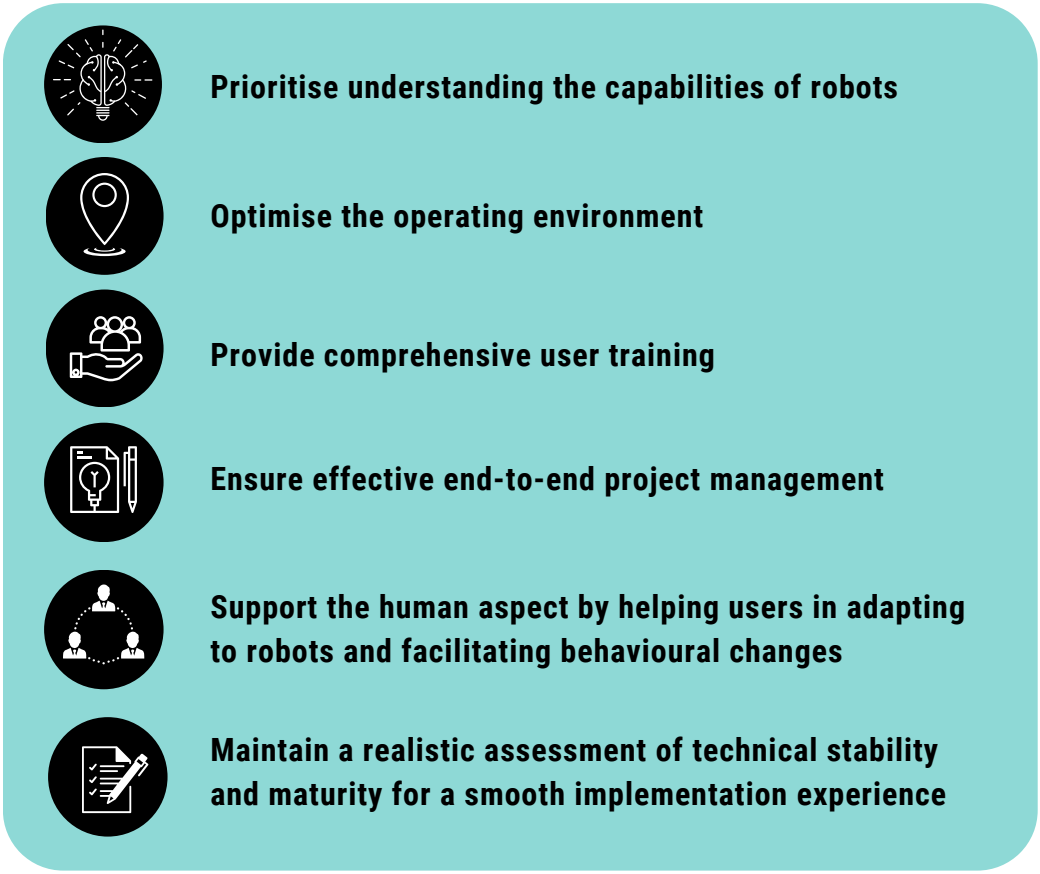
In this report we have summarised the current state of the art of human-robot interaction in the workplace from the literature, engaged with experts from industry on their personal experiences, and discussed with academic opinion leaders on how we can help organisations design our future with robots. The findings of this report emphasise the importance of following some guidelines to achieve successful robot implementation. It is crucial for organisations to:



By following these recommendations, organisations can help maximise the benefits of incorporating robots into their operations while mitigating common implementation challenges. With the insights provided in this report we wish to offer valuable guidance for organisations seeking to adopt and integrate robots successfully.

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1. INTRODUCTION

The rapid advancements in digital technology have brought about a paradigm shift in the way humans and robots interact in various domains. As the field of HRI continues to evolve, novel managerial approaches become crucial to effectively harness the potential of collaborative HRI. This report aims to explore and present the key aspects surrounding the development of such approaches for HRI.

Recently, there has been a growing interest in examining efficient managerial strategies for human-robot collaboration as **the integration of robots into different types of workplaces has significantly increased**. This field's origins may be traced back to the early days of robotics, when research efforts were focused on creating robots that could work with people to complete jobs (Fong et al., 2003). As a result, many management strategies for human-robot-teams have evolved over time, including shared control, contextual communication, and task distribution. Researchers are always investigating novel methods to improve HRI in a variety of contexts, from manufacturing to healthcare (Alami et al., 2006).

Another strategy that has been researched to improve HRI is the development of interfaces that enable successful communication between humans and robots. Contextual information is given to robots so they can understand their environment and tasks better (Belpaeme et al., 2018). Overall, in order to effectively manage collaborative HRI, it is essential to have a thorough awareness of the special opportunities and problems that are given by this kind of collaboration. Managers may ensure that human-robot teams are able to collaborate effectively and accomplish their goals by implementing the appropriate methodologies and technologies (Alami et al., 2006).

A significant decline in earnings has been observed following job loss, and this decline can be partially attributed to technological change. According to an analysis of detailed skill requirements extracted from a comprehensive dataset of online vacancies, it has been estimated that **technological change accounts for 45 percent of the decrease in earnings after job loss** (Braxton et al., 2023). Technological advancements require workers to acquire new skills to perform newly created jobs within their previous occupation. However, when workers lack the necessary skills, they often transition to alternative occupations where their existing skills are still employable. Understanding the impact of technological change on job loss is essential for developing effective managerial approaches that address the challenges and opportunities arising from human-robot collaboration (Braxton et al., 2023) to create a work environment viable for both, humans and robots.

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Throughout this report, we delve into a wide range of topics that shed light on the management of digital transformation and the historical progression of HRI. By examining the different types of robots employed in collaborative settings, we gain further understanding of the diverse roles they play and the potential they hold. Furthermore, the report explores the managerial approaches employed to facilitate human-robot collaboration. Insights from both, industry, and academia, provide a well-rounded perspective on the challenges and opportunities associated with implementing effective managerial approaches for HRI.

The initial insights for the development of this report were gathered during the EINST4INE Robotics Workshop 2022 that took place in Odense, Denmark, that gathered experts from academia and industry and EINST4INE's 15 early-stage researchers. Some of the key takeaways included:

- Humans should only be replaced by robots for dangerous, non-sensitive, disliked tasks or those requiring capabilities beyond those of humans;
- Challenges can be addressed through employee empowerment, task analysis, and constant evaluation;
- Human or robot capabilities should be allocated based on task requirements;
- Effective human-robot-teams can be created through trust, clear responsibility attribution, and technical functionality.

The workshop highlighted an aspect of increasing importance: the adoption of novel managerial approaches to address the unique challenges and opportunities presented by personalised HRI in the context of service, virtual, and collaborative robots. This aspect serves as a prelude to the report.The insights presented in this report serve as a foundation for future research, policy development, and the cultivation of an inclusive and productive work ecosystem that seamlessly integrates human expertise with robotic capabilities.

In the following sections, we will provide a brief historical overview of HRI, discuss the various types of robots involved, delve into existing as well as new managerial approaches for HRI, and present expert viewpoints from industry and academia.

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2. HUMANS AND ROBOTS
AN OVERVIEW

> What is a robot?
> The word itself derives from the Czech word "robota," or forced labor, as done by serfs. Its Slavic linguistic root, "rab," means "slave."
>
> *– MIT Press Reader, Jordan, 2019*

Robots have long been part of fiction movies until they recently developed into invaluable assets for individuals and organisations. The total robotics market has drastically increased from just 18,5 $ US billion in 2016 to 32.4 $ US billion in 2022 and is predicted to continue growing (Robotics - Worldwide, 2022). Current domination of the market is presented by service robots, followed by industrial robots. The largest robotics market by far is currently in Asia and Oceania, followed by North America and Europe, with the lowest growth rate in South America and Africa.

Figure 1: Robotics - Worldwide, Statista Market Insights, 2022

Robots are developing to become a significant extension of human workers across industries. Those industries using robots today include e.g., (Industrial Robots Market Size, Share & Growth Report, 2021)

- Healthcare & Pharmaceutical
- Food & Beverages
- Electrical & Electronics
- Rubber & Plastic
- Metals & Machinery
- Automotive

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What are some examples of businesses using robots to accomplish their objectives?

The integration of robots in various business sectors has become increasingly prevalent in recent years. Companies across diverse industries have recognised the potential benefits that robots can bring to their operations, enabling them to accomplish their objectives more efficiently and effectively.

One notable example of businesses utilising robots is in the **manufacturing** industry encompassing sectors such as automotive manufacturing, electrical & electronics, metals & machinery, and rubber & plastic. Industrial robots are employed to automate repetitive tasks, enhance production speed, and improve precision. These robots are programmed to perform tasks such as assembly, welding, and packaging, leading to increased productivity and cost savings for businesses. ABB Robotics (https://webshop.robotics.abb.com/es/), a prominent provider of robotics solutions, stands as an exemplary player in this field, offering a diverse range of industrial robots that cater to the specific needs of manufacturers. By leveraging the advanced capabilities and expertise provided by ABB Robotics, businesses can further optimise their manufacturing processes and drive innovation within the industry. Another example comes from Tesla. Robots have long been a part of Tesla's (automotive manufacturing) production process. In its Fremont (USA) facility alone, Tesla employs more than 1,000 robots, which are used to carry out jobs like welding, painting, and assembly, according to an Electrek story. Tesla has been able to lower costs and improve manufacturing efficiency thanks to the usage of robots, which has ultimately assisted them in achieving their objective of mass-producing affordable electric vehicles (Tesla's Fremont Factory Has over 1,000 Robots — Here's How They're Used, 2020). Tesla serves as a compelling demonstration of the widespread adoption of automation within the automobile industry.

Similarly, in the **transportation** industry, self-driving vehicles are revolutionising the automotive sector. Companies like Tesla (https://www.tesla.com/AI), Waymo (https://www.tesla.com/AI), and Uber (https://www.uber.com/us/en/autonomous/) are developing autonomous cars and trucks that utilise AI and sensor technologies to navigate roads, reducing the risk of accidents and increasing transportation efficiency.

In the **healthcare** industry, robots are being utilised to improve patient care and assist medical professionals (Dąbrowska et al., 2022). Surgical robots, for instance, enable surgeons to perform complex procedures with enhanced precision and minimal invasiveness. They provide greater control and dexterity, leading to improved surgical outcomes. Additionally, robots are employed for tasks like patient monitoring, medication dispensing, and physical therapy assistance, enabling healthcare providers to deliver better care and improve patient outcomes. For example, the Cleveland Clinic in the United States has employed the da Vinci Surgical System, developed by Intuitive Surgical. This system is widely used for various procedures, including urological, gynaecological, and cardiac surgeries (Da Vinci Surgery, 2021).

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In the **retail** industry, robots are revolutionising traditional operations and customer experiences. For instance, in some retail stores, autonomous robots are utilised for inventory management. With over 200,000 robots in their warehouses and distribution centres, Amazon is one of the world's largest users of robots. Integrated robots help Amazon to enhance efficiency and lower labour costs by performing jobs like product sorting, picking, and packing. Amazon has also been developing last-mile delivery robots with the intention of utilising them to deliver packages in metropolitan areas (Amazon's 200,000 Warehouse Robots Are a Wake-up Call for the Industry, 2019). The product named Tally by Simbe Robotics is another example of retail robots. Tally is capable of autonomously navigating store aisles and utilising computer vision and RFID technology to scan shelves and monitor inventory levels (https://www.simberobotics.com). These robots help retailers maintain accurate stock levels, streamline replenishment processes, and reduce stockouts. Additionally, customer assistance and engagement have been enhanced with the use of robots like SoftBank Robotics' Pepper (Retail, n.d.). These humanoid robots greet customers, provide information about products and services, and even offer personalised recommendations, enhancing the overall customer experience.

In the **agriculture** industry, robots are being deployed to increase efficiency, productivity, and sustainability. For example, in the field of harvesting, robots such as the strawberry-picking robot developed by Octinion are being used to automate the labour-intensive task of picking fruits (http://octinion.com/). These robots use advanced sensors and algorithms to identify and harvest ripe fruits with precision, reducing labour costs and increasing harvesting speed.

The **hospitality** industry is embracing the integration of robots to enhance guest experiences, streamline operations, and improve overall efficiency. A notable instance can be observed in hotels, including those under the chain of Hilton Hotels & Resorts, where the deployment of robotic concierge services has become prominent (D. Johnson, 2019). Robots produced by Relay Robotics (https://www.relayrobotics.com/robots-in-action) are being utilised to greet guests, provide information about hotel amenities, and even deliver items to guest rooms. These robots enhance customer service, reduce wait times, and add a touch of novelty to the guest experience. Additionally, robots are being employed in housekeeping operations. SoftBank Robotics is a notable company that offers an extensive range of products within this sector. Among their offerings is the autonomous cleaning robot known as Whiz (https://us.softbankrobotics.com/whiz), which possesses the ability to autonomously navigate hotel corridors and public spaces while effectively vacuuming and scrubbing floors. This innovative robot showcases SoftBank Robotics' commitment to delivering advanced solutions for efficient cleaning tasks in various environments.

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The **food & beverages** industry is embracing robotic technologies to improve operational efficiency, enhance food quality, and transform the dining experience. Robots are being utilized in various aspects of this industry, from food preparation and cooking to customer service. For instance, in restaurants, autonomous robots are employed as chefs, capable of accurately measuring ingredients and cooking dishes consistently. Companies like Miso Robotics (https://misorobotics.com/) have developed robotic systems, such as Flippy the robotic kitchen assistant, which can handle tasks like grilling, frying, and plating. These systems have found implementation in restaurants like White Castle (Altus, 2023). Moreover, robots are being used for order taking and automated delivery (https://www.starship.xyz/). These robots ensure efficiency and precision, leading to faster service and reduced errors.

Across industries, virtual robots have become invaluable tools for automating and optimising various processes, leading to improved efficiency and service delivery. In **Business Process Outsourcing** (BPO) these robots serve as "digital workers" and are deployed to handle tasks such as data entry, validation, report generation, and customer support. For instance, in customer service operations, virtual robots efficiently address routine inquiries, provide automated responses, and route complex queries to human agents when necessary. Leading companies in the field, including UiPath (https://www.uipath.com), and Blue Prism (https://www.blueprism.com/), offer robust robotic process automation (RPA) solutions that empower BPO firms to automate repetitive tasks, resulting in faster processing times and reduced operational costs.

The fast-paced development of artificial intelligence (AI) and robotics is paving the way for novel and transformative applications across various sectors. In healthcare, future robots could assist with surgeries by offering real-time guidance to surgeons, leveraging AI algorithms and precise motor control. They could also provide personalized care for patients, delivering medication, monitoring vital signs, and offering companionship ("Don't Expect Robot Surgeons, Expect a Surgeon-AI Partnership," 2022). In education, robots with advanced AI capabilities could support teachers in classrooms, providing personalised tutoring and interactive learning experiences for students (Buchert, 2022). In disaster response scenarios, robots equipped with AI and sensor technologies could navigate hazardous environments, assisting with search and rescue operations and providing crucial information to responders (Frąckiewicz, 2023b). Furthermore, as smart cities continue to evolve, robots could play a significant role in urban settings, performing tasks such as automated delivery, maintenance of public infrastructure, and even acting as guides for tourists (Frąckiewicz, 2023a). These examples showcase the immense potential of robots in shaping our future, improving efficiency, safety, and quality of life across various sectors and aspects of society.

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Brief history and concepts of HRI

The field of research known as "human-robot interaction" (HRI) focuses on interactions between human beings and robots. It is a multidisciplinary field that includes different facets of robotics, AI, and human behaviour (Goodrich & Schultz, 2007). **The mission of HRI is to create robots that can engage with people in a way that is safe, efficient, and acceptable to society.** HRI is split into several categories, including perception, thought, and behaviour. Robots' awareness and interpretation of human actions and behaviours are known as their perception. Robots' ability to analyse and comprehend human language and other kinds of communication is known as cognition. Robotic bodily interactions with people, such as touching or moving around, are referred to as action (Fong et al., 2003).

There are several challenges to developing successful HRI systems. Making robots that can correctly read human behaviour is one of the most difficult tasks. Humans convey meaning through a variety of signals, including body language, tone of speech, and facial gestures. Robots must be able to correctly interpret these signals in order to comprehend what people are attempting to say (Lee, 2004). Another problem is developing socially appropriate robots. Humans have preconceived notions about how machines should act in social settings, such as politeness and regard. Robots that fall short of these standards may be viewed negatively or even as dangerous. HRI system designers must consider these expectations when building robots that will communicate with people (Hinds et al., 2004). The robot's degree of control is a crucial factor in HRI. **Robots with a high degree of autonomy can make choices on their own, whereas robots with a lower degree of autonomy may need more human direction.** The type of contact between a robot and a person can vary depending on the degree of autonomy (Dautenhahn, 2007). As robots are more and more incorporated into society, HRI is a crucial field of study. We can build a world where humans and robots can collaborate to accomplish shared objectives by creating robots that can engage with people effectively and securely (Breazeal, 2003).

Personalising the way people interact with robots

Individualised HRI refers to the ability of robots to work together with humans in a personalised way, taking into account the unique needs, preferences, and abilities of each individual. This requires the use of enabling technologies, such as (Müller, 2020):

- Multi-lingual speech and gesture recognition and human intention prediction: These technologies allow robots to understand and respond to human language and gestures, making communication more natural and intuitive.
- Tracking technologies for mental and physical strain and stress of employees: These technologies help robots to monitor the physical and mental well-being of humans, enabling them to adjust their behaviour and provide appropriate assistance.
- Augmented, virtual, or mixed reality technologies, especially for training and inclusiveness: These technologies can be used to provide training and education to humans, as well as to create inclusive and accessible environments for people with disabilities.

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- Enhancing physical human capabilities: Exoskeletons, bio-inspired working gear, and safety equipment: These technologies can help to enhance the physical capabilities of humans, enabling them to perform tasks that would otherwise be too difficult or dangerous.
- Enhancing cognitive human capabilities: Technologies for matching the strengths of Artificial Intelligence and the human brain (e.g., combining creativity with analytical skills), decision support systems: These technologies can help to enhance the cognitive capabilities of humans, enabling them to make more informed decisions and work more efficiently.

Types of Robots

Virtual robots, collaborative robots, and service robots are all examples of robots that can benefit from individualised HRI. In order to successfully implement individualised HRI, it is important to consider the unique needs and preferences of each individual, as well as to ensure that robots are designed to be safe, reliable, and easy to use. This requires a collaborative effort between engineers, designers, and managers, as well as a willingness to experiment with new technologies and approaches to HRI.

Social and Service Robots

Social and service robots are socially situated embodied agents that are able to perform specific tasks (Yan et al., 2014). The difference between social and service robots is the interaction capabilities. Social robots are able to follow social cues such as physical boundaries and rules like turn taking within a group (Yan et al., 2014). As social robots are capable engaging socially like humans in an autonomous or semi-autonomous manner, this type of robots may eventually displace humans in some tasks (Šabanović, 2010). For example, a social robot that helps a disabled person to eat by holding a spoon and moving it towards a person's face only when the mouth is open. On the contrary, service robots present lower degrees of autonomy and sometimes simpler tasks with a fairly limited range of interactions, for example, robot vacuum cleaners.

Some service robots might be teleoperated, such as mobile telepresence robots, which are wireless internet-connected wheeled devices that can be remotely controlled by a user in a different location to move the robot locally. For example, GoBe from Blue Ocean Robotics is being used in workplaces to help remote employees to interact in hybrid teamwork. Also, this type of robot is being used in healthcare settings to facilitate interactions between clinicians, patients, and family members.

Source: © GOBE ROBOTS | PART OF BLUE OCEAN ROBOTICS

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Did you know?

As a humanoid robot gets closer to but falls short of achieving a lifelike appearance, a person's response would suddenly change from empathy to aversion. This transition is referred to as the uncanny valley. For example, people seldom feel affinity for industrial robots given their lack of resemblance to human beings, which is not the case with humanoid robots. The more it looks like a human, the more affinity we may feel. However, the point when we realise it is not a real human, we might experience an unsettling feeling.

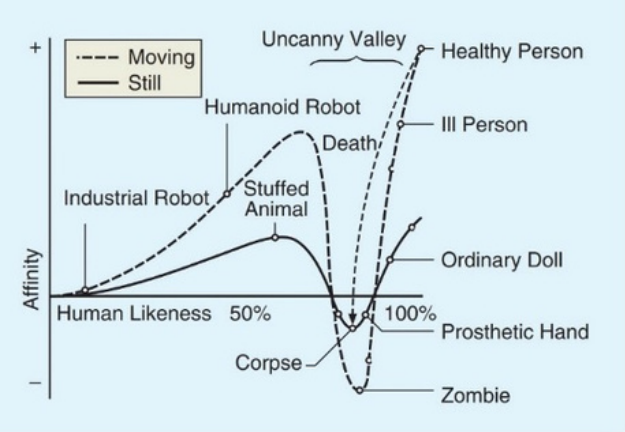

Figure 2: The Uncanny Valley, adapted from: Mori, M. (1970/2005). The uncanny valley. (MacDorman, 2006)

Virtual Robots

The representation of robots as we know it from books, illustrations, or movies is often a mechanical or human-like one—something physical. However, robots are increasingly entering the virtual space. Virtual robots can, just as physical robots, provide services to companies and individuals. Examples for virtual service robots are Apple's Siri or Amazon's Alexa, chatbots that companies use to answer customer's questions through their website (Wirtz et al., 2021), or so-called virtual assistants or robo-advisors that companies such as the Bank of America (Hodge et al., 2021), or investment management company BlackRock use to serve a large customer base online, providing automated processes for private investors (Tokic, 2018).

ChatGPT has recently received a lot of attention across industry and academia and is becoming an incredibly relevant example of virtual robots. ChatGPT is a chatbot that uses artificial intelligence. It is a so-called generative pre-trained transformer (GPT) using large language models based on extensive datasets able to generate responses just as a human being would. This technology offers immense potential to extent existing virtual robots across several application areas to provide smart advice and more to its users.

Source: © OPEN AI L.L.C.

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Virtual robots are free from a physical location and can serve human beings through any computer or smartphone, making it, first and foremost, a cost-effective and easily scalable solution (Wirtz, 2019). While often a virtual robot does not have any representation of a human being at all, it still tries to mimic e.g., a written human-like response or a human-like voice or receives a human-like name (such as Alexa). In order to increase the resemblance to a human service worker, the virtual robot uses databases it can access and the algorithms it uses, in some cases including mechanisms of artificial intelligence or machine learning (Wirtz, 2019). The tasks performed by service robots can be defined as either cognitive-analytical or emotional-social (Lu et al., 2020), defining the extent of human-like features required based on the tasks performed.

Collaborative Robots (Cobots)

Automation and the integration of industrial robots are currently peaking at an all-time high. Despite the COVID-19 pandemic and subsequent production bottlenecks, annual robot installations were more than doubled within the past six years (WR Report: All-Time High with Half a Million Robots Installed, 2022). Traditional industrial robots require heavy guards and peripheral safety devices that limit flexibility while increasing cost and space occupation. However, the current market demands shorter lead times and mass customisation, requiring flexible and versatile assembly systems (Boschetti et al., 2021). This trend towards individualisation, resource efficiency and shorter development periods triggered a change in manufacturing systems (Lasi et al., 2014). The concept 'Industry 4.0' symbolises this shift of automation technologies in the manufacturing sector by integrating enabling technologies, such as collaborative robotics (Xu et al., 2018).

German glass manufacturing company Hofmann Glastechnik implemented cobots to free up workers from mundane tasks. They started with one Universal Robots UR10 to load glass tubes and added seven more for various tasks. The cobots stabilised production, allowed workers to focus on more complex tasks, improved product and work quality, and increased customer satisfaction. The CEO was thrilled and tempted to purchase more. Cobots have had a significant impact on the manufacturing industry and Hofmann Glastechnik's success serves as inspiration for other companies.

Source: © UNIVERSAL ROBOTS A/S

Collaborative robots (cobots) are designed to interact with human operators in a shared workspace and thus provide an uncontested potential by combining machine strength and inimitable human skills. Typical characteristics of cobots are light-weight constructions, better kinematics and easy programmable user interfaces, which aim to improve user satisfaction, health, safety and performance at the same time (Kopp et al., 2021). These attributes are especially suitable for dynamic production environments of small and medium-sized enterprises (SMEs), since the product flow can change on an hourly basis (Vidoni, 2021). Therefore, experts attribute a great market potential to cobots.

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There are many levels of collaboration between humans and robots and varying degrees within and between each of these levels.

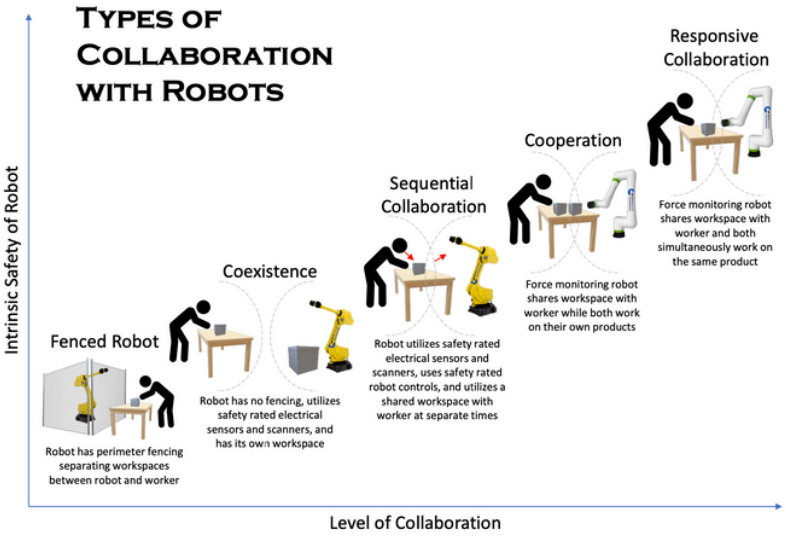

Figure 3: Types of Collaboration with Robots from Zeta Group Engineering (https://www.zetagroupengineering.com)

What is the difference?

Social and Service Robots	Cobots	Virtual Robots
Appearance		
Anthropomorphic (with human characteristics), animal-like or machine-like. As robots are designed more human-like, people tend to feel more affinity for them. However, there is a point where humans experience an unsettling feeling known as the uncanny valley. Therefore, deliberately following a nonhuman design can potentially create a safe level of affinity.	Cobots typically have a smaller form factor compared to traditional industrial robots. They are designed to be compact and lightweight, with a rounded shape and softer edges for safety.	A virtual robot is commonly a software that is accessible through a screen such as a computer or smartphone. Some virtual robots are not recognisable as such as they do not have any visual characteristics, although anthromorphism in form of e.g., human-like names or representation is also becoming increasingly relevant for virtual robots.

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Social and Service Robots	Cobots	Virtual Robots
Technology & design characteristics		
• Embodied/physical-Physically interact with humans • User Interface: e.g., tablets-physical robot Involve multiple disciplines such as computer vision, artificial intelligence, and mechatronics, user experience (UX) and software engineering.	• Embodied/physical-Physically interact with humans • User Interface: e.g., tablets-physical robot Designed to work in close proximity to humans and are equipped with sensors and other safety features to ensure they can operate safely. They often have intuitive interfaces and can be programmed by non-experts.	• Virtual-Virtually interact with humans • User Interface: e.g., computer / smartphone Virtual robots are created with the intention of simulating human behaviour and interactions using virtual or digital interfaces.
Level of interaction with humans		
Social robots are able to follow social cues such as physical boundaries and rules like turn taking within a group. Service robots present lower degrees of autonomy and sometimes simpler tasks with a fairly limited range of interactions.	Intent to work alongside humans, rather than replacing them. They are intended to assist humans in their tasks, and can be programmed to work autonomously or under the supervision of a human operator.	Virtual robots are able to interact with humans in a variety of ways, including text-based interaction, speech-based interaction, gesture-based interaction and visual interaction etc. The capabilities and design decisions of the virtual robot determine the precise techniques of interaction.

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3.ROBOTS @ WORK
INDUSTRY INSIGHTS

The concept of human-robot collaboration was discussed among participants from the EINST4INE consortium at the Robotics Workshop held in Denmark in October 2022. Additional insights were gathered from EINST4INE industry partners and individual interviews conducted by EINST4INE early-stage researchers.

The overall aim was to get insights on the general concept of human-robot collaboration, challenges, and benefits for companies to use robots in the workplace. We include insights from providers as well as users of robots on service, collaborative and virtual robots. Participants provided various views on the barriers to implement and work with robots, do's and don'ts, as well as suggestions for policy and research that we have summarised in the following infographics.

> "Clearly, robotics companies have a lot of decisions to wrestle with quickly. For instance, established companies, which are mostly manufacturing conventional industrial robots, must decide whether to enter the mobile robotics markets, where a lot of growth is expected. Separately, software will play a bigger role in the robotics sector, and large and small companies need to determine if they can compete in that area. To do so, they need to be among the first movers and scale as fast as possible. Those are just two of the most obvious immediate questions, but there are others to address as well. More broadly, robotics companies of all types must balance their innate capabilities, DNA, customer base, product design plans, and resources while choosing whether to double down on their current business models or alter them."
>
> *- Robotics Outlook 2030, Lässig et al. 2021*

What practical insights can we get from robot users and providers?

Take a look at our infographics.

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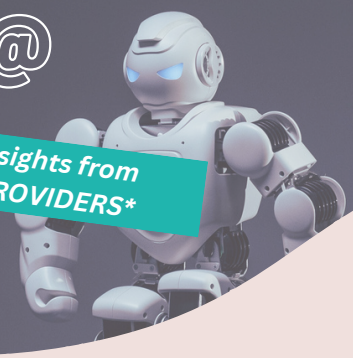
ROBOTS @ WORK

Pitfalls & Potentials

*Insights from PROVIDERS**



EINST4INE

"People realize that robots are helpful but they might be scared of using them properly."

– Marc Moretti, Head of Digital Innovation, Enel

WHY DO COMPANIES USE ROBOTS... AND WHY SHOULD THEY?

- optimise the use of resources
- improve work satisfaction
- fill a need
- reduce effects on staff
- reduce CO2 emissions

DO'S

- [ ] Be clear about the robot's capabilities
- [ ] Evaluate, prepare and optimise the environment where the robots will operate.
- [ ] Train direct users and collect feedback.
- [ ] Offer full project management (pre, per, post installation).

DON'TS

- [ ] Don't neglect the human aspect, help users change their habits.
- [ ] Don't understimate testing with real users.
- [ ] Don't involve the users only in the end of the implementation process.
- [ ] Don't overestimate the technical stability and maturity of the products.

WHAT PSYCHOLOGICAL FACTORS AFFECT THE INTERACTION OF WORKERS WITH ROBOTS?

- concerns about data privacy, security, and safety
- concerns of impacting the human-to-human relationship
- the feeling of being watched and monitored

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ROBOTS @ WORK

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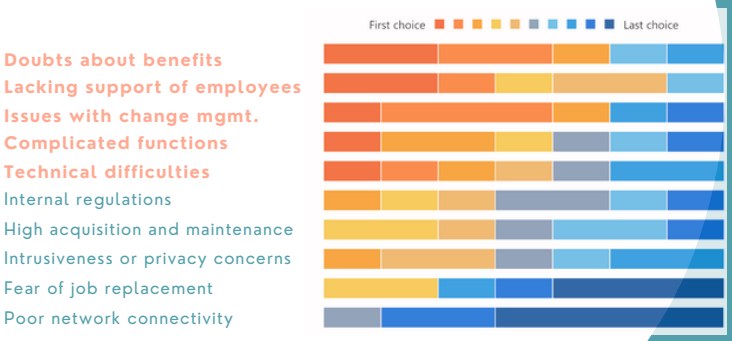
POLICY

WHAT ARE THE MAIN IMPLEMENTATION BARRIERS?



"Policymakers can be instrumental in promoting the utilization of robotics [...] by offering financial incentives to businesses that make the switch."

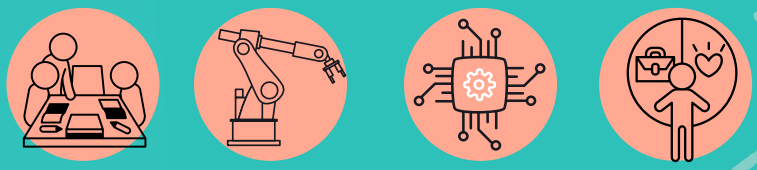
– Thomas Willemann, VP Sales, GoBe Robots

WHAT SHOULD BE DONE BY POLICY MAKERS TO SUPPORT THE IMPLEMENTATION AND USE OF ROBOTS?

- offer financial incentives
- support more agile change in policies and regulations
- improve standards
- reduce bureaucracy
- create awareness on the advantages of service robots

RESEARCH

WHAT QUESTIONS WOULD INDUSTRY LIKE TO GET ANSWERED?



- Address **new modes of working** with robots and its challenges and potential gains (decline in productivity, feelings of alienation, issues with sustaining company culture, keeping employees loyal);
- Explore how the **introduction of robots** into the workplace can be done without sacrificing workers time and focus;
- Empirical data on actual **success and usefulness of robots** in the workplace and positive side effects;
- Ways to **motivate end-users** to use robots

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ROBOTS @ WORK

Pitfalls & Potentials

*Insights from USERS**

EINST4INE

WHAT BENEFITS DO ROBOTS PROVIDE TO COMPANIES?

- increased production speed
- reduced labor costs
- reduced errors
- elimination of repetitive tasks
- reassignment of workers to value-adding tasks

WHAT ARE THE MAIN CHALLENGES WHEN IMPLEMENTING ROBOTS AT YOUR COMPANY? ...AND WHAT DO THEY TELL US?

1. difficulty in training the workforce
   - **What do we need?** Appropriate approaches for workforce training
2. lack of knowledge and understanding
   - **What do we need?** Education and awareness on robots, how to use and integrate them
3. absence of standards
   - **What do we need?** The development of best-practices and guidance on robot implementation and usage
4. resistance from employees & top management
   - **What do we need?** Change management support to guide individuals through the process
5. difficulty integrating robots into existing systems & processes
   - **What do we need?** Understanding and direction on how to integrate robots into workplaces

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ROBOTS @ WORK

EINST4INE

HOW WOULD YOU DESCRIBE THE IMPLEMENTATION PROCESS FOR ROBOTS AT YOUR COMPANY?

***WORK REDESIGN** | Eventually the work process will be redesiged the so that one worker could navigate multiple robots*

***SCALING** | Then, the use of robots is gradually scaled up*

***AMBASSADOR SELECTION** | Subsequently, only a number of employees are pre-selected to be introduced to the robot*

***COMMUNICATION** | The implementation process for robots starts with open communication from management*

"Once the benefits of using the robots has been experienced working without them would seem like a regression."

– Robot Specialist

* insights provided from a selection of users and providers of service, collaborative and virtual robots. Insights are based on a small case number.

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4. MANAGING HRI RECENT APPROACHES

HRI has a holistic impact on organizations, spanning from individual employees to the entire system. To harness the competitive advantage of HRI, organisations need to focus on improving the skills and abilities of employees to collaborate with robots, optimizing the effectiveness of human-robot teams, and developing management systems that promote synergy within the institution, while addressing the ethical and security concerns associated with HRI (Kim, 2022). The following diagram illustrates the interconnectedness of these elements, for example, how safety, and ethical integrity in HRI are influenced by employee attitudes toward robots.

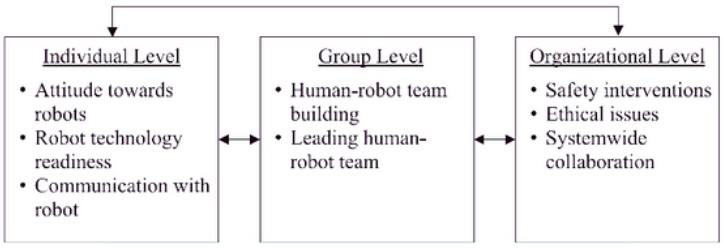

Figure 4: Adapted from: Kim, S. (2022) Working With Robots: Human Resource Development Considerations in Human–Robot Interaction

How to manage the change?

The implementation of robotic technologies brings fundamental changes into the workplace context and provokes a range of feelings among employees. Widespread uncertainty has far-reaching consequences and is related to higher stress levels, higher turnover rates, and lower job satisfaction (Charalambous et al., 2015). “The quick pace of technological change, lack of proper staff training, an increased workload, lack of standardization of technologies and unreliability of hardware and software" (Olalude, 2013, pp. 5–6) are further causes of significant stress to individuals caused by technology.

Researchers and practitioners alike have long been exploring approaches in order to ease uncertainty and decrease resistance during periods of technological change (Charalambous et al., 2015; Keller & Schaninger, 2020; Kotter & Schlesinger, 2008). **We have selected 9 key strategies to address common challenges in robot implementation projects.** In sum, those involve communicating within the company, involving, and empowering each individual affected by this change, offering training and career development opportunities, and creating a fully immersed support system from bottom-up to top-down. Furthermore, robots have to become a key element of current workflows requiring a rethinking of work activities and a significant involvement of the human resource team.

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> "Executives at companies that took the time and trouble to address mind-sets were four times more likely than those that didn't to rate their change programs as at least 'successful'."
>
> *– McKinsey, Keller & Schaninger, 2019*

#1 | Communicate the change

In any change undertaking, the number one rule is to create vision and mindset from the very beginning so that everyone in the organisation can understand the objectives of the ongoing changes (Whelan-Berry & Somerville, 2010). Communicating the introduction of a new technology is crucial in order to increase acceptance and reduce resistance to change. This means to ensure employees understand why, how, and when changes will occur. This can happen in three ways (Chin & Benne, 2017):

1. Encourage beliefs and values for own re-education (normative-educative)
2. Appeal to rational self-interest to accept change (rational-empirical)
3. People with less power comply with those of greater power (power-coercive)

To help leaders in their communication efforts, they can do the following (Keller & Schaninger, 2020):

1. Understand what it is like to hear the message by testing it on others
2. Make the message stick by relentlessly repeating it with simple and memorable language
3. Move from "telling" to "asking", encouraging employees to engage more actively
4. Ensure to share the message on various channels e.g., speech, print, online, symbols, rituals

#2 | Involve and empower employees

Employees will resist to go along with the changes for a number of reasons, including a fear of losing or unfairness, lack of trust and misunderstanding, lack of information, and emotional inability to change (Kotter & Schlesinger, 2008). To increase the success of change programs, identifying roles and responsibilities is crucial (Keller & Schaninger, 2020). A study has shown that 94% of workers in fact would like to be more actively involved when technologies are being implemented in their organisation (Sweis, 2022).

In order to make employees feel heard and take on a more active role in change efforts, opportunities are required that create an environment where that is possible. This can be done in a number of ways, for example (Charalambous et al., 2015; Gleeson, 2017; Keller & Schaninger, 2020):

- Create a shared sense of purpose: Communicate purpose and objective of the new technology and allow to receive individual feedback
- Take the time to understand your employees: Uncover the mindset of your employees that might be restraining change efforts and reframe those beliefs
- Align systems, processes, and structures to the vision: Facilitate organisational means that support the change by e.g., allowing decentralised decision-making
- Create ownership opportunities: Make room for autonomy and reduce micro-management by supporting active participation within given structures

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Socially responsible robotisation involves a thorough consideration of employees' needs, motivation, and well-being during the process of robotisation by empowering them with shared decision-making and considering their social and ethical demands for their particular job activities (Turja et al., 2022).

#3 | Offer training and career development opportunities

As organisations incorporate robots into the workplace, it is crucial to provide training and career development opportunities to employees to:

- Help them develop new skills and adjust to the changes brought about by the introduction of robots
- Provide instruction on how to operate and maintain the robots
- Teach them how to work collaboratively with robots
- Upskill employees to take on new roles in the organisation that are more strategic and require higher-level skills

Offering these opportunities demonstrates an organisation's commitment to their employees' professional growth and fosters a culture of learning and innovation. This can lead to (Liao et al., 2018):

- Improved productivity
- Increased job satisfaction
- Better retention of skilled employees

#4 | Assign a process champion

> "[We need] dedicated contact persons or ambassadors who are granted the time to support the implementation. And the 'green card' of being excited about new technology"
>
> *quote from the EINST4INE Industry Insights Robots @ Work (this document, p.18)*

A process champion is an individual who:

- Understands the technology and its benefits
- Is passionate about the potential impact it can have on the company's operations
- Acts as a liaison between the robotics team and the rest of the company
- Identifies areas of the manufacturing process where automation can be implemented
- Determines the type of robot that will be most effective for the task
- Leads the training of the company's workforce in the use of the new technology
- Promotes a culture of continuous improvement within the company

The process champion can play a crucial role in the success of integrating robots into a manufacturing process by:

- Ensuring that everyone is on board with the changes being made
- Identifying areas for automation and understanding the capabilities of different types of robots available

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- Developing tailored training programs for the workers to be comfortable and confident in using the new technology
- Encouraging colleagues to be open to change and see the implementation of robots as an opportunity to improve the company's operations.

Having a process champion who can effectively communicate the value of automation can ultimately lead to improved productivity, increased job satisfaction, and better retention of skilled employees (Charalambous & Stout, 2016).

#5 | Commit top management

Successful implementation of robots in an organisation requires committed top management, as their support can establish a culture of innovation and change. This involves:

- Understanding the benefits and potential of robotics, and acting as role models for the rest of the organisation to encourage adoption of new technologies
- Allocating resources and making strategic decisions that can facilitate the integration of robots in the workplace
- Ensuring that employees receive necessary training and support for the transition, leading to higher job satisfaction and productivity

Without the support of top management, implementation of robots may face resistance and struggle to gain traction in the organisation.

#6 | Integrate robots into current workflows

Organisations that are planning to incorporate robots into their work environments will need to redefine current workflows to accommodate this new technology. Although incorporating robots into daily routines may seem straightforward, it presents several difficulties, particularly regarding safety and work organisation. Employees might be reluctant to change. As mentioned by a service robot provider,

> "[…] implementation takes time, and a change in workflow is required, which takes them out of their comfort zone".
>
> quote from the EINST4INE Industry Insights Robots @ Work (this document, p.18)

Challenges include (Kadir & Broberg, 2021):

- Stress related to the acquisition of new skills
- Ensuring workers' safety
- Fear of human displacement
- Information overload
- Unwillingness to change

To address these issues, **it is essential for managers to adopt a human-centered approach that prioritises human values and the greater good** (Ulhøi & Nørskov, 2022).

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#7 | Redesign work to successfully implement robots

Work consists of tasks, knowledge, social, and contextual elements (Morgeson et al., 2010). Therefore, redesigning work involves changing all or some of its elements. For example, redesigning work with robots may imply:

- Strategically assigning responsibilities between robots and humans
- Changing work methods to facilitate HRI
- Reducing or accelerating work pace
- Redesigning the physical workplace space
- Including new interactions between robots and clients

When work redesign is carried out effectively, it usually results in higher work satisfaction and motivation because employees may feel they have opportunities for personal growth and development in their job and thus are intrinsically motivated to work hard and perform well (Hackman, 1980).

#8 | Create a dedicated multidisciplinary team for work redesign

It is essential to establish a dedicated team to oversee the work redesign process when integrating robots into an organisation.

- Relying only on technical teams may result in a weak human resource perspective
- It is crucial to train human resource employees in work redesign to ensure the successful integration of robots

For example, in the case of cobots, a multidisciplinary team is required to integrate robots into factories' automated processes while maintaining safety and efficiency in a fenceless environment (Mateus et al., 2019). Such a team should include experts from various fields, including technical, organisational, and managerial, to overcome the challenges that robots may present. Companies require a multidisciplinary team because robot implementation must be approached from different perspectives to ensure a positive outcome (Ulhøi & Nørskov, 2022). The multidisciplinary team includes not only members of the company that is integrating robots but also members of the company selling such robots to act as implementation consultants. As put by one service robot provider,

> "[…] I need customers to be more aware of telepresence robots and be open to discussing the issues they're facing for me to suggest appropriate telepresence solutions. Furthermore, customers need to comprehend that, as with any other tool, the successful deployment of telepresence robots relies on the proper introduction and readiness to discard old practices […]."
>
> quote from the EINST4INE Industry Insights Robots @ Work (this document, p.18)

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Meaningful work and robots

Understanding how robots might affect meaningful work is crucial because humans spend a significant portion of their time at work, therefore, any negative impacts that robots may have on meaningful work could significantly disrupt their lives (Smids et al., 2020). **Companies should create contexts that are conducive to workers being able to find meaningfulness in their daily work** (Lips-Wiersma & Morris, 2009).

How to do that? By understanding, reflecting and acting on how the following aspects of work are being affected by the implementation of robots (Smids et al., 2020):

- Pursuing a purpose
- Social relationships
- Exercising skills and self-development
- Self-esteem and recognition
- Autonomy

How to approach ethical concerns?

The implementation of robots into the workplace is, just like the implementation of any other digital technology, a complex and challenging organisational and ethical undertaking. The key ethical issue with autonomous or semi-autonomous robotic systems is that they affect humans in new and profound ways compared with other types of technologies. These robotic systems bring issues of human displacement and deskilling because they are not only substituting the instruments, but also the human work (Gunkel, 2020). Hence, their socio-cultural impact may be more challenging. For example, robotic systems that serve the healthcare market are likely to take over caregiving tasks that seem mundane, which may deskill caregivers by eliminating the opportunity to engage in the caregiving process's repetitive practices that are, in spite of their mundane nature, necessary to cultivate in order to achieve, e.g., practical wisdom and moral habituation (Vallor, 2015). These shifts in human practices may thus jeopardise the cultural sustainability in such settings (Stahl & Coeckelbergh, 2016; Ulhøi & Nørskov, 2020; Vallor, 2015). That is, **undermining human practices, norms and values that may ultimately result in moral, social, intellectual and/or emotional deskilling** (Ulhøi & Nørskov, 2020). To balance the potential benefits of robots with human capabilities, distributing responsibility can help guarantee the success of robotic technologies for tomorrow:

- Be accountable: Even when some robots may be very sophisticated, they cannot solely be held responsible for their actions; however, holding responsible the developers simplifies a complex phenomenon which tends to exclude other stakeholders that may be relevant in negotiations about the technology's design and implementation (D. G. Johnson, 2015).
- Distribute responsibility across a network of stakeholders: users, designers, developers, implementers, and regulators, must be accountable and act within a more robust responsibility attribution scheme where each actor has different responsibility depending on the type of robot, the development stage, the sector of use, and the type of robot acquisition (van Wynsberghe, 2021).

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Reflections on guilt and (or?) responsibility for autonomous robots

"I think that it is interesting to reflect on guilt and responsibility in relation to the impact of autonomous robots, that is, artificial agents that can do human tasks with no direct human control (D. G. Johnson, 2015). Even if robotics technology is not yet ready to deploy fully autonomous robots, it is a good practice to think about what could and should happen in the future. Intelligent machines will become autonomous, meaning that the designers, developers and deployers have no full understanding and control over the behavior of such technologies. This causes challenges to assign responsibility because it seems unfair to blame humans for the actions and consequences of robots.

Research shows that designers and developers of AI systems in startups don't FEEL responsible for the unintended consequences of technology (Rojas & Tuomi, 2022). For example, a robot designer does not FEEL accountable for the impact of an autonomous bartender robot on human bartenders, clients, service workers and managers of an automated hotel bar. The robot designer is just doing his or her job: developing a new technology that solves problems.

I think a distinction between guilt and responsibility is interesting in this context because responsibility is not a feeling nor an emotion, such as guilt. When designers, developers, salespeople, -and anyone involved in the long chain of stakeholders- say they don't FEEL responsible for the impact of autonomous robots, they might be thinking about guilt instead. Guilt is an unhappy emotion that arises after you consciously or subconsciously feel that you did something WRONG. This might be the reason why robot designers and developers are not feeling accountable for the social impact of the technology they produce, they are just doing their job, why would that be WRONG? They don't feel guilty, and therefore, they don't acknowledge responsibility.

Responsibility is not synonymous with guilt, it not an emotion that arises when you did something wrong, it comes from taking accountability despite your feelings or beliefs of right and wrong. This means that people are liable even when there is no obvious reason to be guilty. I think it is relevant to understand that although is not wrong to produce autonomous robots, and thus, it does not make you guilty, it does make you responsible because technology is not only technically constructed but also socially and politically (Stilgoe et al., 2013). The impact of robots does not end in the 1 to 1 human–robot interaction, it continues in sociotechnical systems (van Wynsberghe, 2021).

What does it mean to be responsible? To be accountable. To respond. To take action that will protect someone else's interests. Then, for what are autonomous robot producers responsible? For anticipating impacts, reflecting, engaging in dialogue, influencing the direction of technology (Stahl & Coeckelbergh, 2016). And to whom are autonomous robot producers responsible? Being responsible implies responding to someone, including robot users in development processes, and being open and able to answer their questions (Coeckelbergh, 2022). And robot implementers and users should be responsible too. We would all have a share of responsibility, we would be co-responsible (Stilgoe et al., 2013), as we are today with everything that is happening with climate change and many other societal problems."

Alejandra Rojas, ESR 5
Originally published in EINST4INE's Blog

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5. MANAGING HRI
FUTURE APPROACHES

This chapter provides an extensive examination of the critical subject of managing HRI and explores novel approaches that have the potential to shape the future landscape of collaboration between humans and robots. Given the rapid advancements in robotics and artificial intelligence, the effective management of human-robot interaction has gained utmost significance. Valuable insights and perspectives are presented within this chapter, contributed by various experts affiliated with the EINST4INE consortium, who possess extensive expertise and experience in the field of HRI. Their contributions offer valuable perspectives on the adaptation of managerial approaches to foster collaborative human-robot interaction in the forthcoming years. The goal of the chapter is to inspire researchers, practitioners, and decision-makers to proactively embrace novel strategies and frameworks for enhancing HRI through the following question:

"In the next 5-10 years, how can we adapt managerial approaches to facilitate collaborative human-robot interaction?"

Prof. Anne-Laure Mention | Global Business Innovation Enabling Impact Platform Director at RMIT University

"The co-existence of humans and co/robots in the workplace, and more broadly in public spaces, is already a reality, and forecasts on the widespread acceleration of those technologies abound. Statista, for example, reports that revenue in the robotics market is projected to reach US$37.37bn in 2023, with an expected annual growth rate CAGR 2023-2028 of 3.83%, resulting in a market volume of US$45.09bn by 2028 (Robotics - Worldwide, 2023). Service robotics represent the market's largest segment with a projected volume of US$28.49bn in 2023. As impressive as these figures are, they should not overshadow the **challenges arising from the deployment of co/robots** across contexts. Those challenges can be **operational** (e.g. workplace safety – how can robots operate in crowded places, navigating among humans and obstacles?), **human** (e.g. how to overcome resistance to adoption and change triggered by fear of job redundancies as a result of automation?), **organisational** (e.g. how to design optimal work processes, building upon human and "machine" capabilities?), to name a few.

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Key **managerial considerations should embrace a dual human and socio-centric approach** to robotics. A human-centric approach recognises human needs and interests as the foundation and the heart of all production processes, and departs from examining technologies from the sole lens of their affordances to increase productivity. A socio-centric approach emphasises that technologies are part of systems aimed at promoting responsible innovation, and fostering societal and ecological advances. A complement, rather than substitute or replacement, logic is key to success, and requires strategic thinking, long term planning and carefully crafted interventions (e.g. upskilling and reskilling initiatives) as well as incentives and policies (e.g. national agendas to support workforce transformation)."

Prof. Ferran Giones | Assistant Professor at the University of Stuttgart and Deputy Director of the Institute of Entrepreneurship and Innovation Science

"The question has many elements that interplay among them. The objective is to get an opinion on a desirable future where humans interact with robots for collaboration. I take collaboration as "voluntarily helping others to achieve common goals or one (or more) of their private goals" (Castañer & Oliveira, 2020). With this in mind, **managerial approaches should "facilitate" that the interactions between humans and robots are collaborative** - contribute to achieving common or private goals. Interestingly, this requires the existence of different elements:

- Humans and robots should have goals.
- There is a managerial approach that (can) influence both, probably with distinct mechanisms and tools.
- A collaborative outcome is more desirable than a non-collaborative outcome.

Thus, assuming that robots keep developing their capabilities to interact, mimic, or even surpass humans' physical and mental capacity.

At the same time, humans remain (in the next 5-10 years) at a similar capacity level. The managerial approach should:

- Offer a **high compensation** to humans for guidance or non-predicable inputs in the collaboration.
- Ensure that both **robot and human can revise** how the collaboration has contributed to achieving goals.
- Offer **possibilities to remove, exchange**, and include tasks that can contribute to achieving common and private goals.
- **Reassess** how the approach contributes to competing behaviors that do not contribute to shared goals, adjusting accordingly depending on the task or activity being managed"

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Prof. Agnieszka Radziwon | Associate Professor of Innovation Management at Aarhus University and the University of California, Berkeley

“Already in the discussion about Smart Factories Radziwon et al. (2014) highlighted the importance of smart collaboration beyond adaptive and flexible manufacturing solutions. As much as human–robot interactions may be more and more often located on the shop floor these also start to emerge outside of manufacturing areas.

We see many bioinspired robots in use in hospital operating rooms as well as telepresence robots facilitating doctor visits with patients. This calls not only for further development and widespread of technologies but also for changes in the managerial approaches both in the manufacturing firms as well as in organizations and institutions, which could utilize collaborative and service robots to increase their efficiency, accuracy, and quality of products and services. In the next 5-10 years, **managers should further develop and maintain a culture of collaboration between humans and robots**. This requires the education of employees about the benefits and challenges of human-robot interactions (Dąbrowska et al., 2022). These trainings should predominantly target employees who will be working with robots and designing work environments that facilitate open communication with colleagues and managers. Additionally, managers should look for ways to integrate human and robotic tasks in a way that can benefit both, such as having robots perform repetitive tasks while freeing up human workers for more complex and creative tasks. Finally, managers should strive to **create an environment in which robots are seen as a complement to human workers**, rather than a replacement, by utilizing the strengths of both and creating a collaborative working relationship.”

Prof. Paavo Ritala | Professor of Strategy and Innovation in the School of Business and Management at Lappeenranta-Lahti University of Technology LUT

"In the future, the interfaces in which people interact with robots will change dramatically. With the development of large language models and conversational AI (such as ChatGPT), **it will be increasingly convenient and intuitive to collaborate with robots, cobots, and any software-driven systems** in general. Meanwhile, the development in automation technologies mean that robots will also gain greater autonomy in how they operate and will actually require less interaction and human intervention than previously."

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Dr. Justyna Dabrowska | Vice Chancellor's Research Fellow, Innovation Management at RMIT University

"I'd share few thoughts in relation to social robots, in particular. As we know, social robots are designed to interact with humans in a social and emotional way and can be used in various settings such as healthcare (provide comfort, and assistance for children and elderly, autistic, and handicapped persons), education, entertainment, and hospitality (Sheridan, 2016; Tsai et al., 2022).

According to IMARC Group report, the global social robot market size reached 3.4 billion USD (approx. 3,085,000,000 EUR) in 2022 and is expected to reach 17.2 billion USD (approx. 15,610,00,000 EUR) by 2028 (Social Robots Market Size, Share, Industry Trends Report 2023-2028, n.d.). Considering recent accelerated advancements in machine learning and AI and by applying the Moore's Law, **we can expect significant changes** in the next 5-10 years, which puts an enormous pressure on managers, engineers and decision makers on how to design, program and deploy social robots in culturally sustainable and ethical way to ensure positive outcomes and avoid unintended consequences (Dąbrowska et al., 2022; Ulhøi & Nørskov, 2020). This will require for example, developing standards and regulations for social-human robot collaboration that **specify the rights, responsibilities and obligations of both humans and robots in different contexts and situations**. In addition, this requires establishing codes of conduct and ethics for social robots that define the principles and values that guide their actions and decisions in collaboration with humans, also emphasizing different types of diversity.

Some questions that may arise when designing social robots and guiding principles:

- How can social robots ensure the **safety and well-being** of humans when on the task (and who is responsible when human is harmed)?
- Considering robots can be hacked or used for malicious purposes how minimize such **risk**?
- How can social robots cope with **ethical dilemmas and moral conflicts** that may arise?
- How can humans (social robots) deal with potential **misuse or abuse** by robots (humans)?
- How to prevent **de-skilling** of humans when relying more and more on robot presence and assistance?"

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Prof. Sladjana Nørskov | Associate Professor at Aarhus University

"In workplaces where robots and AI are used for collaborative purposes, managers may need to develop a deeper understanding of how the use of such technologies impacts the employees not only at the operational but also at the psychological level. **Human-robot collaboration may require managers to take a more proactive role** in identifying the desirable and undesirable design features and functionalities of such collaborative machines to make better informed decisions on whether and how such technologies would need to be adapted to the work context and subsequently implemented. This means that the role of managers may change as it will require a greater involvement in the techno-social side of collaborative activities. It will thus require them to **develop in-depth technical knowledge related to those technologies** as well as competencies to properly identify and grasp the critical technology requirements for the tasks and activities that the machine is expected to perform. In addition, human-robot collaboration may necessitate an increased managerial attention to what employee skills are required for human-robot collaboration and how they can be developed under new working conditions."

Dr. Petra Nylund | Researcher, consultant, and teacher of strategy and innovation at the University of Stuttgart

"Human-robot interaction requires a robot to discern human communication patterns. However, not just any patterns, but those of the person they are engaging with. With artificial intelligence (AI), robots can be trained to discern such patterns through the input of great quantities of communication data. The effectiveness of the training depends on the appropriateness of the data. For example, data on the communication between American middle-aged men will be very different from that on young, Asian women. Such biases have always existed in managerial models, but can be amplified by AI (Brem & Nylund, 2021). The **increased reliance on and availability of data means that our approaches to management and innovation need to consider the inclusion of meta data**. Such distributed and indirectly related data can be systematically scanned and analyzed to detect trends and generate innovation (Ferràs et al., 2023). In this context, we also need to consider the use of AI by non-technological firms. AI-as-a-Service is becoming the dominant business model, which means firms that are not specialized in AI can still use it for e.g., adapting their offering to their customer (Ferràs-Hernández et al., 2023). Just as AI is moving towards standardization and a service-based offering, human-robot interaction is also likely to do so. Hence, most **firms wanting to excel in human-robot interaction can skip investing in robotics skills in favor of investments in communications data** that reflect their customer base."

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10 KEY TAKEAWAYS

Define the purpose and setting of robots to align with specific goals: It is important to clearly define the intended purpose and context in which robots will be utilised. Aligning their design and deployment with specific goals helps ensure their effectiveness and relevance in the given setting.

Design and deploy robots in a culturally sustainable and ethical manner: When creating and implementing robots, it is crucial to consider cultural sensitivities and ethical implications. This involves understanding and respecting diverse cultural backgrounds, values, and norms, and ensuring that the deployment of robots adheres to ethical guidelines and principles.

Develop standards and regulations for human-robot collaboration: To ensure safe and responsible integration of robots in society, it is essential to establish standards and regulations governing their use. These guidelines can help address issues related to privacy, data protection, safety, and overall ethical conduct in human-robot interactions.

Establish codes of conduct and ethics for robots, emphasising diversity: Codes of conduct and ethics specific to robots should be developed, highlighting the importance of diversity and inclusion. These guidelines promote fair and unbiased interactions between robots and humans, fostering an environment that respects and appreciates individual differences.

Prioritise safety and well-being during human-robot interactions: Safety and well-being should be paramount considerations when humans and robots interact. Implementing measures to ensure physical safety, emotional well-being, and data security for both humans and robots is crucial for fostering positive and productive interactions.

Mitigate risks such as hacking and malicious use of robots: Given the increasing reliance on robots, it is necessary to address potential risks associated with hacking and malicious manipulation. Robust security measures, such as encryption and authentication protocols, should be in place to protect against unauthorised access and prevent misuse of social robots.

Address ethical dilemmas and conflicts that may arise: Human-robot interactions can present ethical dilemmas and conflicts. Organisations should actively engage in discussions and frameworks to address these challenges, considering the ethical implications of decisions, potential biases, and potential impacts on human well-being and societal norms.

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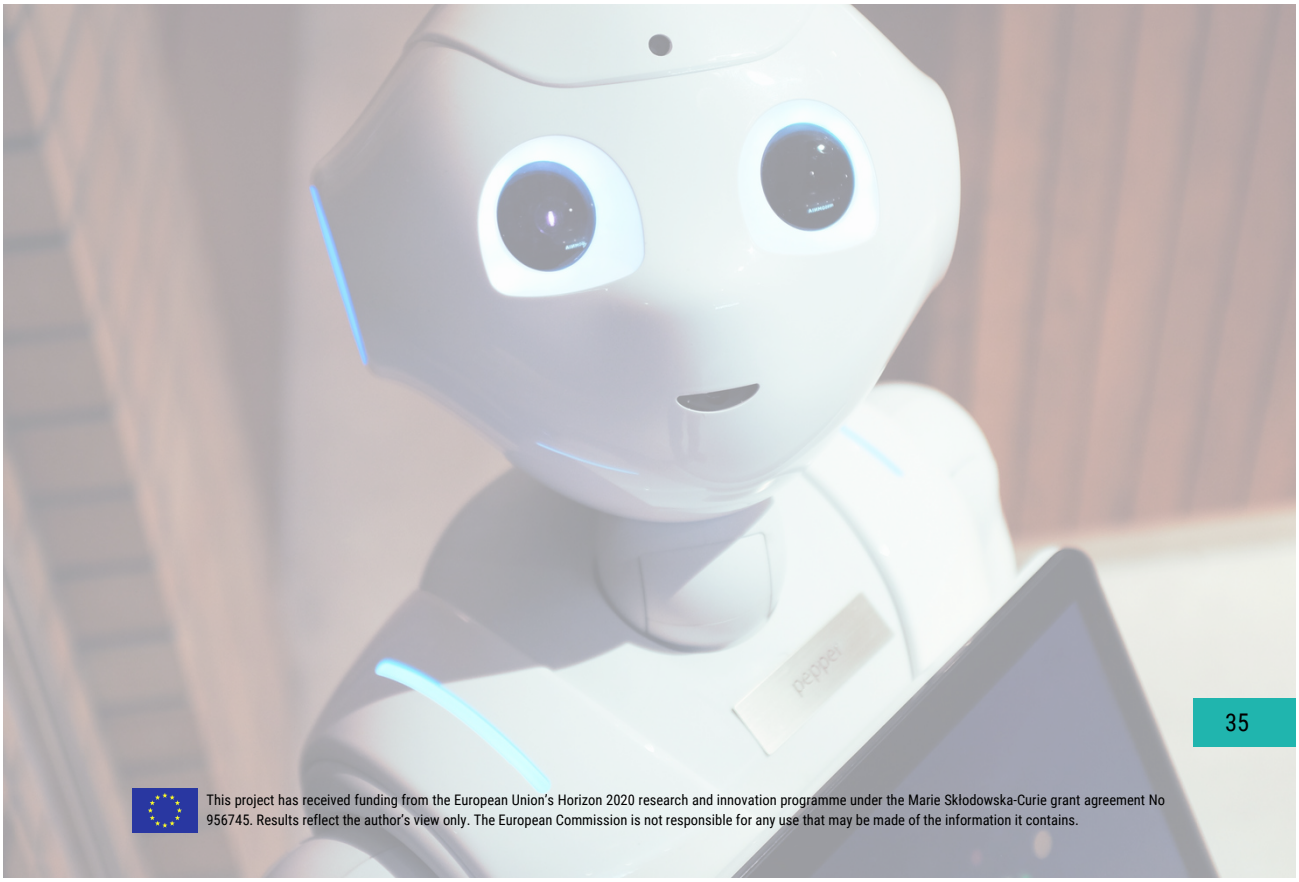
Prevent de-skilling of humans by providing training and upskilling opportunities: Instead of replacing human workers, robots should be seen as tools for enhancing human capabilities. Organisations should provide training and upskilling opportunities to ensure that humans can effectively collaborate with robots, acquiring new skills and knowledge to thrive in a human-robot collaborative environment.

Interfaces for human-robot interaction will undergo significant changes in the future: The way humans interact with robots will experience substantial transformations in the future. New interface technologies and modalities, such as voice, gestures, augmented reality, and virtual reality, will redefine how humans and robots communicate and collaborate.

Managers should foster a collaborative culture between humans and robots, educate employees about human-robot interactions, and integrate tasks in a way that benefits both: Managers play a crucial role in creating a collaborative culture that embraces the integration of humans and robots. They should educate employees about the potential benefits and challenges of human-robot interactions and find ways to integrate tasks that optimise the strengths of both humans and robots, fostering an environment where robots are viewed as complementary to human workers rather than replacements.



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6. CONCLUSION

The successful integration of robots in the workplace requires a comprehensive approach that encompasses **effective communication, employee involvement, training and career development opportunities, dedicated process champions, committed top management, workflow integration, work redesign, and promotion of meaningful work**.

DO'S

- It is essential to communicate the change from the outset, ensuring employees understand the objectives and benefits.
- Actively involving and empowering employees, creating a shared sense of purpose, and aligning systems and structures support engagement and acceptance of the changes.
- Offering training and career development opportunities enables employees to adapt and take on strategic roles.
- Assigning process champions fosters a culture of continuous improvement.
- Committed top management establishes an innovative culture and provides necessary support.
- Redesigning workflows with safety and human values in mind is crucial. Establishing multidisciplinary teams and involving human resource expertise ensures a comprehensive approach to work redesign.
- Lastly, promoting meaningful work enhances job satisfaction and employee well-being.

By embracing these principles, organizations can navigate challenges and realize the benefits of incorporating robots into their workplaces. In this report we have provided valuable insights into the benefits, challenges, and suggested improvements for successful robot implementation in organisations.

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About the EINST4INE Project

The European Training Network for InduStry Digital Transformation across Innovation Ecosystems (EINST4INE) is a consortium of universities, research organisations and industry partners working in the domain of industrial digital transformation. EINST4INE aims to develop new concepts, approaches and methods in the area of digital transformation and brings together a unique group of world-leading experts in the areas of Open Innovation, Industry 4.0, digital transformation and innovation ecosystems.

About the Work Package 1: Human side of digital transformation

The general objective of WP1 is to develop the knowledge base on the human side of Industry 4.0 - skills, capabilities, knowledge transfer between individuals within and across organisational networks and effects of digital transformation and human/robot interaction on organisational performance and behaviour. It will investigate the effects of the introduction of emerging process technologies (e.g. social, collaborative robotics, mobile telepresence robots, robo-advisors) in terms of organisational and change both at the firm level and at the individual level.

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