Co-creation of Ethical Guidelines for Designing Digital Solutions to Support Industrial Work

Päivi Heikkilä[a], Hanna Lammi[b] and Susanna Aromaa[c]
VTT Technical Research Centre of Finland, Tampere, Finland

Keywords: Ethics, Ethical Guidelines, Co-creation, Design, Industrial Work.

Abstract: Digitalization and automation are changing industrial work by bringing a variety of new digital solutions to the factory floor. Digital solutions are primarily developed to make industrial work more efficient and productive. However, to ensure user acceptance and sustainability, the aspect of ethics should be included in the design process. The aim of this research is to increase the role of ethics in design by providing a set of ethical guidelines for designing digital solutions to support industrial work. As a result of a co-creation process, we present twelve ethical guidelines related to six ethical themes, with examples of how to apply them in practice. In addition, we propose a practical approach to help a project consortium in co-creating project-specific ethical guidelines. Both the co-creation process and the guidelines can be applied in the design and development of new digital solutions for industrial work, but also in other work contexts.

1 INTRODUCTION

Digitalization and automation are changing industrial work by bringing a variety of new technologies and digital tools to the factory floor (Kagermann et al., 2013; Romero et al., 2016). The work of factory workers is changing towards a more self-led direction, requiring management of complex systems and problem-solving skills (Gorecky et al., 2014). The work of factory operators includes interaction with a growing number of novel technologies and tools, which highlights the role of appropriate and holistic design of the new tools.

Novel digital tools are designed and adopted to make industrial processes more efficient and productive. However, to ensure user acceptance and to create long-term value, human factors should be given a significant role in the design process. In addition to considering usability, safety, and ergonomics of the new tools, the experience and acceptance-related factors should be considered from a wider perspective, including the aspect of ethics. As the new technologies, such as artificial intelligence (AI) or collaborative robots, may have significant changes in the ways of working and the roles of workers, paying attention to ethical themes, such as workers' autonomy, privacy, and dignity, becomes particularly important.

To consider ethics in the design process, several approaches can be applied (e.g., Friedman et al., 2013; Wright, 2011; Ikonen et al., 2009). One of the most established methods for embedding ethics in the design process is to create and follow ethical guidelines. However, guidelines do not guarantee ethical thinking and commitment in a design project. Even though ethical guidelines or checklists would be created to guide project work and to contribute to design decisions, ethics may remain as an extraneous, isolated, or overlooked area in design (Hagendorff, 2020; Madaio et al., 2020; Kaasinen et al., 2022). We aim to avoid this by engaging the project consortium of our ongoing design and development project to co-create ethical guidelines for the project.

The aim of this research is to deploy a co-creation approach to provide a set of ethical guidelines for designing digital solutions to support industrial work. The work is conducted in a design and development project with a goal to develop digital tools to improve the working conditions on the factory floor by automating monotonous work and increasing the

[a] https://orcid.org/0000-0002-8999-179X
[b] https://orcid.org/0000-0001-7849-0845
[c] https://orcid.org/0000-0001-8843-496X

Heikkilä, P., Lammi, H. and Aromaa, S.
Co-creation of Ethical Guidelines for Designing Digital Solutions to Support Industrial Work.
DOI: 10.5220/0011679700003417
In *Proceedings of the 18th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications (VISIGRAPP 2023) - Volume 2: HUCAPP*, pages 185-192
ISBN: 978-989-758-634-7; ISSN: 2184-4321

value of human work through smart assistance. The project consortium includes end-user manufacturing companies, technical developers of digital solutions, and research partners. The resulting guidelines are created primarily for the ongoing project but can be applied wider, in industrial contexts and beyond.

The paper is structured as follows. First, we present the related work. Then, we describe the co-creation process of the ethical guidelines. In the results section, we present the resulting ethical guidelines and examples of their application. After that, we discuss the ethical guidelines in the design of industrial digital solutions and propose a practical approach for co-creating project-specific ethical guidelines. Finally, we discuss the future work and conclude the findings and our contribution.

2 RELATED WORK

This section focuses on the related work relevant to our research. First, we provide a background for understanding ethics in design and ethical guidelines; we then address ethics in designing digital solutions for industrial work. Finally, we introduce the co-creation approach in the design of ethical guidelines.

2.1 Ethics in Design and Ethical Guidelines

Ethics addresses the issues of what is 'right' and what is 'fair' (Hosmer, 1995). Thus, ethics describes moral principles influencing conduct; accordingly, the study of ethics focuses on the actions and values of people - what people do and how they believe they should act in the world (Luppicini, 2010). In technology design, several approaches have been applied to consider ethics, such as assessing the possible impacts of technology (Wright, 2011), identifying the values of the intended technology users and responding to them (Friedman et al., 2013), or by following ethical guidelines (e.g., Ikonen et al., 2009). The Ethics by Design approach (Niemelä et al., 2014) promotes positive and proactive ethical thinking in the early phases of the project. Thus, considering ethics should not only focus on identifying ethical problems, but also on design decisions that are based on ethical values and can positively support developing ethically sound solutions.

Ethical reflection is based on the tradition of several disciplines. In biomedical ethics, a strong point of reference is the patient-centered approach, giving clinicians clear guidelines for their interaction with patients, based on four fundamental principles: beneficence (doing good), non-maleficence (not doing harm), autonomy (respect for the person and his/her rights), and justice (distributing benefits, risks, and costs fairly) (Beauchamp & Childress, 2001). As the patient-centered approach has a similar value base as the human-centered approach in technology design, the same principles are also applied and included in the guidelines targeted for human-centric design and designers. Wright (2011) bases a framework for ethical impact assessment on these four principles. Ikonen et al. (2009) base a framework for mobile intelligent applications on six ethical principles: privacy, autonomy, integrity and dignity, reliability, e-inclusion, as well as benefit to society. The principles include the same elements as the patient-centered approach but emphasize aspects relevant to the design of digital solutions, such as privacy and inclusion. Ethical guidelines may also emphasize other aspects, depending on the purpose of the guidelines. For example, Nihan (2015) lists ten ethical values related to employing ubiquitous technology at the workplace and includes the aspects of health and safety, as well as social interactions and integrations in the values.

Regarding novel technology, the need for discussion on ethics and creation of ethical guidelines has increased due to the growing significance of AI. In a review of 84 ethics guidelines for AI by Jobin et al. (2019), 11 clusters of principles were found: transparency, justice and fairness, non-maleficence, responsibility, privacy, beneficence, freedom and autonomy, trust, sustainability, dignity, and solidarity (Jobin, Ienca & Vayena, 2019). Floridi and Cowls (2021) created an ethical framework of AI principles set by the four principles of bioethics (beneficence, non-maleficence, autonomy, and justice) and an additional AI-enabling principle – explicability.

Several approaches have been proposed and applied in addressing ethics in design (e.g., Friedman et al., 2013; Wright, 2011; Ikonen et al., 2009) and development of AI-based solutions has further increased the role of ethics. Still, concrete examples of the research and design processes that include ethics are scarce and would be needed to support the adoption of an ethical mindset and true integration of ethics into design.

2.2 Ethics in Designing Digital Solutions for Industrial Work

The fourth industrial revolution (Kagermann et al., 2013) is changing the industrial work, and new technologies are emerging on the factory floor.

Romero et al. (2016) describe how novel technologies and tools, such as exoskeletons, augmented and virtual reality (AR/VR), wearable trackers, intelligent assistants, collaborative robots, social network services, and big data analytics could support and empower future workers. The future intelligent manufacturing systems are described as a composition of humans, cyber systems, and physical systems (i.e., human-cyber-physical systems), working together to achieve manufacturing goals (Zhou et al., 2019).

Along with the development of cyber-physical systems, the discussion related to ethics has gained more attention in the context of industrial work, and different taxonomies and checklists are provided to understand multifaceted ethics in the design of emerging technologies. In line with the Ethics by Design approach (Niemelä et al., 2014), Palm and Hansson (2006) highlight that the ethical assessment of technologies should be a continuous dialogue with technology developers rather than a single evaluation of a specific technology. They propose an ethical technology assessment method to consider the social consequences of the technology early in the design phases. Brey (2012) agrees that it is important to consider ethics in the early development phases, even though it is difficult to fully predict ethical issues related to emerging technology use in society. Thus, Brey suggests adapting forecasting approaches to study technological devices, their use, and their social consequences. Related to AI, Dignum (2018) proposes three levels for considering ethics: 1) ethics by design: ethics as a part of the behavior of an autonomous system; 2) ethics in design: regulations and methods to support ethical design of systems, and 3) ethics for design: conducting development and research in an ethical manner.

From the industrial workers' perspective, the adoption of new technologies has raised concerns among employees, for example, regarding learning new skills, the perceived demands to work faster, and the safety of new tools (Kadir & Broberg, 2021). Novel technological solutions are often based on gathering data of the work environment and even workers, and this may be ethically sensitive (Moore & Piwek, 2017; Heikkilä et al., 2018). When designing new solutions, it would be important to pay attention to both work performance as well as workers' well-being (see e.g., Heikkilä et al., 2021).

To support transformation of industrial work and work practices, as well as a desired user experience of new technology, it is important to design the new tools in a holistic way. One method is to define user experience goals including ethical aspects. For example, a user experience goal to make workers feel encouraged and empowered at work (Heikkilä, Honka & Kaasinen, 2018) drives the design of a digital solution towards an ethically sustainable direction.

To support ethics-aware design, Kaasinen et al. (2019) define five ethical guidelines related to modern factory work, based on the earlier work by Ikonen et al. (2009). The guidelines describe the guidance related to each selected ethical theme with one guiding sentence. For example, to support workers' autonomy, the designed solutions should allow operators to choose their own way of working. However, as the guidelines are presented with only one sentence and on a high level, they form a good basis for project work, but benefit from elaboration within a project for their application.

2.3 Co-creation Approach in the Design of Ethical Guidelines

Co-creation has become a common practice of involving different stakeholders in the design process (Sanders & Stappers, 2008; Robertson & Simonsen, 2012). Co-creation is referred to as any act of collective creativity, i.e. creativity that is shared by two or more people, and it has been described as a certain collective creativity that is applied throughout the whole design process (Sanders & Stappers, 2008).

Madaio et al. (2020) brought out that organizations rarely produce ethical checklists with active participation from the practitioners. Without involving practitioners, the checklists have proved to be misused or even ignored. When utilizing a co-creation approach, different perspectives, and a productive combination of them (Steen, Manschot & De Koning, 2011), may lead to successful outcomes, and it would be important to include the various perspectives also in ethics-related design activities.

In our project, the goal is to keep the project partners involved and informed about ethics along the project to maintain ethics-aware mindset throughout the project. In the following section, we describe the co-creation process utilized in our project.

3 CO-CREATION PROCESS OF ETHICAL GUIDELINES

Ethical guidelines to support the design activities of the project were iteratively created with the project consortium through a co-creation process, described in Figure 1. As our general approach, we applied the

Ethics by Design approach (Niemelä et al., 2014) that emphasizes addressing ethical issues in the early project phases. Co-creation methodology was selected due to its potential to engage all project partners to generate common understanding of ethics and to increase ethics awareness within the project. The co-creation process was part of the project work in a design and development project with an aim to develop technological solutions to support human work in the manufacturing industry. The participants represented several European manufacturing companies, solution developers, and research institutes. Thus, the design and development perspective was complemented with the considerations on the context of use, needs of end-users and integration to other tools and equipment.

During the co-creation process, two workshops were organized to involve the project consortium in identifying possible ethical challenges related to project work and in creating ethical guidelines for the project. The consortium had an opportunity to provide comments to the initial guidelines and later, to the modified guidelines.

The first ethics-related workshop was organized as a part of the first consortium meeting of the project. The aim of the workshop was to identify potential ethical challenges and questions in the very early phases of the project. Twenty-four project members participated in the workshop. The participants were divided into pairs or small groups and instructed to write down one ethical challenge related to conducting research work in an ethically sustainable way or to developing and deploying ethically sound solutions during the project.

The workshop resulted in eight ethical challenges that formed a starting point for formulating the initial ethical guidelines. The challenges were categorized by three researchers under six ethical themes, identified as important in earlier research (Ikonen et al., 2009): privacy, autonomy, dignity, reliability, inclusion, and benefit to society. Some of the challenges were related to one theme, but some had several connections. For example, a notion that machines should assist people, not take over their work, had a connection to the ethical theme 'autonomy' from the workers' perspective, but it was considered also as a wider societal issue, connected to the theme 'benefit to society.' Specific research ethics-related questions were responded to separately in the guidance given to the project consortium for conducting user studies. Still, most of these questions were also included in the guidelines; for example, a question on handling personal data had an impact on the guidelines related to privacy. In the end, twelve initial guidelines, two for each category of ethical themes, were formulated.

The second workshop was arranged to introduce the twelve initial ethical guidelines to the consortium and to collect feedback to them, as well as to discuss topical ethical questions arisen in the project work. The workshop was organized as a separate online meeting, and all project members were encouraged to participate, even if they had no previous experience with ethics-related work. Eighteen project members participated in the workshop. After a brief introduction of the guidelines, the participants were divided into three subgroups with moderators to discuss and give feedback on the clarity and relevance of the guidelines. After the second workshop, the guidelines were refined to include aspects raised in the comments and discussions of the participants. The guidelines were modified to make them easier to understand and more aligned with the different perspectives of the workshop participants. To clarify the ways to apply the guidelines, remarks to suggest concrete ways for following the guidelines were added. The modified guidelines were shared with the project consortium to be commented on and to remind everyone of them. Based on the comments received, minor refinements were made.

The final guidelines are described in the results section. The project consortium is guided to apply the guidelines in the design-related activities throughout the project. At the end of the project, the guidelines will be reviewed and updated if new challenges and needs arise during the project.

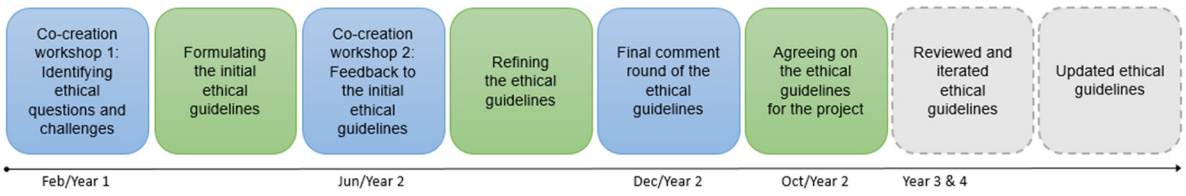


Figure 1: Phases of the co-creation process.

4 RESULTS: ETHICAL GUIDELINES

The co-creation process resulted in twelve ethical guidelines related to six ethical themes: privacy, autonomy, dignity, reliability, inclusion, and benefit to society (Table 1). In the following, the guidelines are described with examples of how to apply them in the project work. The guidelines cover the aspects of designing ethically sound solutions and piloting the solutions at work in an ethical way; the first guideline relating more to the design of the solutions and the second one more to the trials at workplaces.

Table 1: Ethical guidelines for designing industrial digital solutions.

Ethical theme	Ethical guideline
Privacy	- Workers' privacy should be respected when collecting and storing data - Workers should be made aware when their personal data is collected/stored, and they should control access to it
Autonomy	- Task allocation between workers and technology should support meaningful work and appropriate human oversight and control - Workers' autonomy and rights should be considered when organizing pilots and informing of participation
Dignity	- The solutions should support discreet use - Opting out of the pilots should not cause negative consequences to the workers
Reliability	- The solutions must not compromise workers' safety - Workers should be informed of the reliability of the solutions
Inclusion	- The solutions should be accessible to workers with diverse backgrounds, capabilities, and skills - Workers with diverse backgrounds, capabilities, and skills should be able to participate in trials
Benefit to society	- The solutions should assist workers, supporting focus on value-adding work - The solutions may not cause harm to anyone – to their users or stakeholders

The guidelines related to privacy emphasize the respect for workers' privacy when collecting and storing their data, as well as the importance of informing workers of the personal data collected. Privacy of the participants of user studies needs to be protected in accordance with the general data protection regulation, which is facilitated by guiding the project members to use an appropriate informed consent form in all user studies. For example, storing the personal data only as long as necessary and giving access to the data only to researchers who need access, are practical methods to protect the privacy of the trial participants.

The guidelines related to autonomy emphasize the desired outcome of smart-task allocation between workers and technology, so that human work would be meaningful, and workers would be and feel like they are in control of the operations. Smart-task allocation supports interesting and variable human tasks, while technology or machines can perform repetitive, monotonous, or non-ergonomic tasks. When organizing user studies and pilots, the participants' autonomy needs to be considered by ensuring true voluntariness for participation, not pushed by the employer.

The guidelines related to dignity guide applying practices and designing solutions that respect the dignity of workers and stakeholders. The solutions should support discreet ways to convey information. For example, all notifications that include content that may be interpreted as negative, or embarrassing should only be accessible by the user of the solution, not others (e.g., health or work-performance-related information). In pilots and user studies, all potential participants – whether they want to participate or opt out – should be treated equally, not causing any negative consequences for those workers who decide not to participate.

The guidelines related to reliability emphasize two aspects: First, the solutions must not compromise their users' or other people's safety; and second, the users should be informed of the reliability of the solutions. When the solutions are tested during the pilot phase, the users and other stakeholders should be informed as to whether the solutions are still under development and whether some problems are likely to occur. When offering solutions to be adopted at workplaces after the pilot phase, liability and responsibility issues should be defined and users informed of them.

The guidelines related to inclusion emphasize design and demonstration of the solutions in a way that they are accessible to workers with different backgrounds, genders, ages, cultures, and nationalities, as well as capabilities and skills. Accordingly, users with diverse backgrounds, capabilities, and skills should be able to participate in the trials. In practice, this can be supported, for example, by providing clear guidance for using the solutions and different language versions when feasible to provide those.

The guidelines related to the benefit to society encourage designing solutions that assist workers, not

replace them, supporting focus and transformation towards value-adding work. To benefit society, the solutions must not cause harm to anyone, neither the users nor stakeholders. The solutions should support workers' well-being, for example, by not causing unnecessary cognitive load or by not demanding usage in non-ergonomic positions. In addition, the designed technology should not conflict with environmental sustainability.

5 DISCUSSION

In this section, we discuss the co-creation of ethical guidelines for industrial work and propose a practical approach to help a project consortium in co-creating project-specific ethical guidelines. After that, we discuss application of the guidelines and future work.

5.1 Ethical Guidelines in the Design of Digital Solutions for Industrial Work

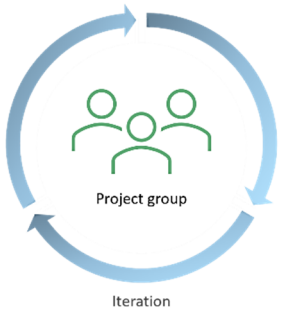
The co-creation process resulted in twelve ethical guidelines that support designing digital solutions for industrial work. Our goal was to provide a set of guidelines which would be jointly understood and committed to by the project consortium. We aimed at short and condensed guidelines, that would be easy to internalize, and thus apply, in design. The resulted guidelines are based on the ethical themes of the framework for intelligent mobile applications (Ikonen et al., 2009), but they have similar elements with several ethical guidelines and checklists (Nihan, 2015; Wright, 2011, Palm & Hansson, 2006), most closely with the more general one-sentence guidelines developed for the context of modern factory work (Kaasinen et al., 2019). Even though these guidelines, developed for modern factory work, could have been applied in our work as such, we wanted to experiment with the co-creation approach, to elicit ethical thinking in the project, and to agree on guidelines relevant for the project consortium. To be applicable in the separate design tasks of the project, the guidelines were formulated to reflect the common goals and contents of the project but also to cover different solutions developed in the project.

In a design and development project, it is important to provide guidelines for research ethics as well as for designing ethically sound solutions. Even though the focus of this work was on supporting the design of ethically sound solutions, we noticed that the project members could not always differentiate between these two sides but rather discussed mixed ethics-related topics. On the other hand, the topics are not always easy to separate; for example, testing the solutions in real environments includes the same ethics-related questions and principles as considering end users during the design process. According to Dignum (2018), ethics related to AI can be analyzed on three levels: 1) focusing on the behavior of an autonomous system; 2) covering regulations and methods to support ethical design of systems; and 3) focusing on the code of conduct in carrying out development and research. In this study, all these levels were relevant, but the guidelines mainly support the second level, while the detailed guidance for research ethics (level 3) was provided separately. In addition, as most of the digital solutions designed in the project are not autonomous systems, level 1 was not focal; instead, we focused on the principles relevant to the design of digital tools utilizing novel technologies.

The ethical guidelines of this paper can be adopted for the development of other digital solutions in an industry context as such. However, even though the use of ready-made guidelines is beneficial, the highest benefits may be achieved by engaging the project consortium in the co-creation process.

This ensures that the guidelines are suitable for the project and is likely to increase the project members' commitment to implementing the guidelines. In addition, this ensures that all project members become familiar with ethics. This is beneficial, for example, as technology developers may lack prior skills in identifying and analyzing ethical aspects (Palm and Hansson, 2006).

To support a co-creation process of ethical guidelines, we suggest a practical approach for project groups to define the guidelines based on relevant ethical themes and purposes or contexts of use for the guidelines. An illustrative example of this approach (Figure 2) includes six ethical themes (Ikonen et al., 2009) and three purposes for the ethical guidelines: ethics related to design of solutions, ethics related to adoption of solutions, and ethics in executing research and design work. This example of the categorization is based on our co-creation process, but the themes can also be based on the needs of the project or existing categorizations (e.g., Dignum, 2018). As ethics may be considered as an abstract perspective to design, this kind of a categorization may make it more tangible to approach and reduce the challenge of ethics remaining an extraneous or overlooked area in design (Hagendorff, 2020; Madaio et al., 2020; Kaasinen et al., 2022).



	Ethical guidelines for selected purposes		
Ethical themes	Ethics-aware design of digital solutions	Ethics in adoption of the solutions at the workplace	Ethics in research and design activities
Privacy	Ethical guideline 1: *E.g., The workers' privacy should be respected when the solution is collecting and storing data*	Ethical guideline 2: *E.g., At workplace one needs to ensure that the developed solutions do not unnecessarily collect data of passers-by*	Ethical guideline 3: *E.g., The identity of the participants testing the solution prototype should not be revealed when presenting results*
Autonomy	*[To be filled by the co-creation team]*	*[To be filled by the co-creation team]*	*[To be filled by the co-creation team]*
Dignity	*[To be filled by the co-creation team]*	*[To be filled by the co-creation team]*	*[To be filled by the co-creation team]*
Reliability	*[To be filled by the co-creation team]*	*[To be filled by the co-creation team]*	*[To be filled by the co-creation team]*
Inclusion	*[To be filled by the co-creation team]*	*[To be filled by the co-creation team]*	*[To be filled by the co-creation team]*
Benefit to society	*[To be filled by the co-creation team]*	*[To be filled by the co-creation team]*	*[To be filled by the co-creation team]*

Figure 2: Illustration of a practical approach to facilitate considering ethics in a co-creation project.

5.2 Application of the Ethical Guidelines and Future Work

Both the co-creation process and the ethical guidelines presented in this paper can be applied in the design and development of new digital solutions, by professionals of human-technology interaction and by practitioners of other fields. The guidelines are designed particularly to support designing digital solutions for industrial work, but they are also applicable in other work contexts. Still, we also encourage the project groups to co-create ethical guidelines of their own. Existing guidelines or ethical themes can be used as a basis for co-creation, not to overlook important ethical aspects, but still to allow the project group to define joint ethical principles relevant for the project.

In our project work, the project partners were given the freedom to use the methods familiar to them in applying the co-created ethical guidelines. At its best, this may lead to innovative and integrated ways to apply the guidelines, yet it may also be perceived as a challenge. In the future, developing and applying methods to explicitly support embedding ethical guidelines in design work would be a further step in increasing the role of ethics in design. Also involving workers in defining the guidelines would be an interesting track for research, strengthening the role of end-users in design.

6 CONCLUSIONS

This paper presented a co-created set of ethical guidelines for designing digital solutions to support industrial work. To support design of industrial digital solutions, we introduced twelve ethical guidelines related to six ethical themes.

Both the co-creation process and the guidelines can be applied in the design of new digital solutions, particularly to support industrial work. However, we also encourage project groups to co-create ethical guidelines of their own. This may lead to deeper engagement with ethics, stronger commitment of the project partners, and in the end, better integration of ethics into design.

ACKNOWLEDGEMENTS

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No. 873087 (project SHOP4CF).

The authors are grateful to project partners who have participated in the ethics workshops and contributed to the work presented in this publication.

REFERENCES

Beauchamp, T. L., & Childress, J. F. (2001). *Principles of biomedical ethics.* Oxford University Press, USA.

Brey, P. A. (2012). Anticipatory ethics for emerging technologies. *NanoEthics*, *6*(1), 1-13.

Dignum, V. (2018). Ethics in artificial intelligence: introduction to the special issue. *Ethics and Information Technology, 20*(1), 1-3.

Ehrwein Nihan, C. (2015). Ubiquitous computing in the workplace: ethical issues identified by the interdisciplinary IWE and HRM Research Group. In *Ubiquitous Computing in the Workplace* (pp. 75-93). Springer, Cham.

Floridi, L., & Cowls, J. (2021). A unified framework of five principles for AI in society. In *Ethics, Governance, and Policies in Artificial Intelligence* (pp. 5-17). Springer.

Friedman, B., Kahn, P. H., Borning, A., & Huldtgren, A. (2013). Value sensitive design and information systems. In *Early engagement and new technologies: Opening up the laboratory* (pp. 55-95). Springer, Dordrecht.

Gorecky, D., Schmitt, M., Loskyll, M., & Zühlke, D. (2014, July). Human-machine-interaction in the industry 4.0 era. *In 2014 12th IEEE international conference on industrial informatics (INDIN)* (pp. 289-294). IEEE.

Hagendorff, T. (2020). The ethics of AI ethics: An evaluation of guidelines. *Minds and Machines*, *30*(1), 99-120.

Heikkilä, P., Honka, A., & Kaasinen, E. (2018). Quantified factory worker: designing a worker feedback dashboard. In *Proceedings of the 10th Nordic Conference on Human-Computer Interaction* (pp. 515-523).

Heikkilä, P., Honka, A., Kaasinen, E., & Väänänen, K. (2021). Quantified factory worker: field study of a web application supporting work well-being and productivity. *Cognition, Technology & Work*, *23*(4), 831-846.

Heikkilä, P., Honka, A., Mach, S., Schmalfuß, F., Kaasinen, E., & Väänänen, K. (2018, October). Quantified factory worker-expert evaluation and ethical considerations of wearable self-tracking devices. In *Proceedings of the 22nd International Academic Mindtrek Conference* (pp. 202-211).

Hosmer, L. T. (1995). Trust: The connecting link between organizational theory and philosophical ethics. *Academy of management Review*, *20*(2), 379-403.

Ikonen, V., Kaasinen, E., & Niemelä, M. (2009, July). Defining Ethical Guidelines for Ambient Intelligence Applications on a Mobile Phone. *In Intelligent Environments (Workshops)* (pp. 261-268).

Jobin, A., Ienca, M., & Vayena, E. (2019). The global landscape of AI ethics guidelines. *Nature Machine Intelligence*, *1*(9), 389–399.

Kaasinen, E., Anttila, A.-H., Heikkilä, P., Laarni, J., Koskinen, H., & Väätänen, A. (2022). Smooth and Resilient Human–Machine Teamwork as an Industry 5.0 Design Challenge. *Sustainability*, *14*(5), 2773.

Kaasinen, E., Liinasuo, M., Schmalfuß, F., Koskinen, H., Aromaa, S., Heikkilä, P., ... & Malm, T. (2018, August). A worker-centric design and evaluation framework for operator 4.0 solutions that support work well-being. In *IFIP working conference on human work interaction design* (pp. 263-282). Springer, Cham.

Kadir, B. A., & Broberg, O. (2021). Human-centered design of work systems in the transition to industry 4.0. *Applied Ergonomics*, *92*, 103334.

Kagermann, H., Helbig, J., Hellinger, A., & Wahlster, W. (2013). Recommendations for implementing the strategic initiative INDUSTRIE 4.0: Securing the future of German manufacturing industry; *final report of the Industrie 4.0 Working Group*. Forschungsunion.

Luppicini, R. (2010). *Technoethics and the Evolving Knowledge Society: Ethical Issues in Technological Design, Research, Development, and Innovation*. IGI Global.

Madaio, M. A., Stark, L., Wortman Vaughan, J., & Wallach, H. (2020, April). Co-designing checklists to understand organizational challenges and opportunities around fairness in AI. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (pp. 1-14).

Moore, P., & Piwek, L. (2017). Regulating wellbeing in the brave new quantified workplace. *Employee Relations*, *39*(3), 308-316.

Niemelä, M., Kaasinen, E., & Ikonen, V. (2014). Ethics by design - an experience-based proposal for introducing ethics to R&D of emerging ICTs. In *ETHICOMP 2014-Liberty and Security in an Age of ICTs.*

Palm, E., & Hansson, S. O. (2006). The case for ethical technology assessment (eTA). *Technological Forecasting and Social Change*, *73*(5), 543-558.

Robertson, T., & Simonsen, J. (2012). Participatory Design: an introduction. In *Routledge international handbook of participatory design* (pp. 1-17). Routledge.

Romero, D., Stahre, J., Wuest, T., Noran, O., Bernus, P., Fast-Berglund, Å., & Gorecky, D. (2016, October). Towards an operator 4.0 typology: a human-centric perspective on the fourth industrial revolution technologies. In *Proceedings of the international conference on computers and industrial engineering (CIE46), Tianjin, China* (pp. 29-31).

Sanders, E.B.N., & Stappers, P.J. (2008). Co-creation and the new landscapes of design. *Co-design*, *4*(1), 5-18.

Steen, M., Manschot, M., & De Koning, N. (2011). Benefits of co-design in service design projects. *International Journal of Design*, *5*(2).

Wright, D. (2011). A framework for the ethical impact assessment of information technology. *Ethics and information technology*, *13*(3), 199-226.

Zhou, J., Zhou, Y., Wang, B., & Zang, J. (2019). Human–cyber–physical systems (HCPSs) in the context of new-generation intelligent manufacturing. *Engineering*, *5*(4), 624-636.