SEISMEC

Supporting European Industry Success Maximization through Empowerment Centred development

D2.1

Design guidelines, instruments and assessment criteria

TNO, TUB

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Abstract

The SEISMEC project demonstrates the concept of human-centricity across a wide array of industry sectors, scales and sociotechnical contexts in the EU. This deliverable introduces a set of solution directions, defined as tools, technologies, or methods that help place human needs at the centre of technology development. Each solution direction is accompanied by design guidelines, which describe how to apply them effectively and what to consider during implementation. Additionally, it introduces assessment tools that monitor and evaluate the human-centric technology development.

To identify these solution directions, activities including literature reviews, expert interviews, and interactive workshops with researchers, industry professionals, and end users were performed. This process resulted in 41 solution directions, divided into six categories: ecosystem-level, organisational-level, workplace-level (with and without end-user involvement), technologies, and instruments. These were also mapped against SEISMEC's transversal themes of WP4.

The SEISMEC pilot organisations across 14 European industrial ecosystems were surveyed to assess the relevance and applicability of the solution directions. Their feedback informed the refinement of the design guidelines and highlighted the types of information needed to support digital transformation efforts.

To evaluate the effectiveness of the solution directions and their associated guidelines, SEISMEC developed a structured Research Protocol. This framework includes assessment instruments aligned with the CAPS factors and other tasks and work packages within the SEISMEC project. It recommends incorporating ethnographic methods and human-factors criteria to capture how technologies are integrated into daily work practices and their impact on well-being, safety, and productivity. Additionally, continuous assessment across all project phases – Preparation, Action Research, and Evaluation – is encouraged.

D2.1 offers descriptions, guidelines and a practical roadmap for organisations aiming to implement and assess novel technologies in a way that empowers human-centric work in the industry.

Keywords

Industry 5.0, technology, implementation, human-centricity, design guidelines, assessment instruments

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Acronyms and definitions

AI	Artificial Intelligence
DHM	Digital human model
DoA	Description of Action
DT	Digital Twin
DT	Design Thinking
ELSA	Ethical, Legal, and Societal Aspects
HAI	Human-AI interaction
HCI	Human-centric interface
IOR	Integral Organisational Renewal
SAT	Semi-autonomous team
TOP	Technology, Organisation, and Personnel
OST	Open Space Technology
PSP	Participatory Strategic Planning
VCC	Value co-creation
VSD	Value Sensitive Design
WP	Work Package
WPI	Workplace Innovation

1 Executive summary

Labour market shortages and evolving work processes are driving the need for new technologies that support employees, reduce workload, and improve job quality. However, many technological implementations fall short because they are not designed with humans put central, leading to poor adoption and diminished job satisfaction. The SEISMEC project addresses this challenge by identifying and overcoming eight key CAPS tensions – barriers that hinder the creation of human-centric workplaces. The SEISMEC project represents a shift towards Industry 5.0 by embedding these human-centric approaches across 17 diverse industrial pilots in Europe, empowering workers through implementation of technology that is inclusive, ethical, and aligned with real human needs and behaviours.

To alleviate these tensions and promote a human-centric approach, SEISMEC introduces a set of 41 solution directions accompanied by design guidelines. We define a solution direction as a tool, technology, or method (for design, dialogue and collaboration) that might aid in putting the needs of the human (or group) central in the work environment, i.e., the development of a human-centric technology. These represent tools, technologies, and collaborative methods that support the development of human-centric technologies – ranging from participatory design processes to ethical oversight mechanisms and ergonomic interventions. These were categorised into six types: ecosystem-level, organisational-level, workplace-level (with and without end-user involvement), technologies, and instruments. Each solution direction is supported by design guidelines that explain how to apply them effectively in practice. For example, wearables and ergonomic interfaces help reduce cognitive load and improve safety, so practical actions that improve the human-technology interface are provided. Value-sensitive design and ELSA labs ensure transparency, trust, and ethical accountability – offering intervention solutions.

Collaborative design and living labs foster co-creation and ongoing dialogue with workers and other stakeholders – representing participatory solutions.

Additionally, the descriptions of the solution directions include examples of their application, preferably examples of when they were applied in the SEISMEC pilots.

To assess the relevance and applicability of these solution directions, the SEISMEC pilot organisations across 14 European industrial ecosystems were surveyed. Their feedback specified the type of necessary information and simultaneously gave input for the design guidelines. This resulted in a living and dynamic set of practical tools that organisations can use to enhance human-centricity during technology implementation.

To evaluate the human-centric impact of this implementation, SEISMEC developed a structured Research Protocol. This protocol includes instruments and assessment criteria that enable organisations to measure whether their technology implementations truly empower workers and align with ethical, inclusive, and human-centric values. The research protocol addresses three core research areas: (1) identifying relevant human-centric principles, approaches, criteria and instruments (2) designing suitable solution pathways and interventions, and (3) developing tailored assessment instruments and methods. To effectively assess human-centric technologies in industrial settings, it is strongly suggested to include ethnographic approaches as well as human-factors in the assessment criteria. These methods help identify how technologies are integrated into daily work practices, how workers interact with them, and how these interactions influence well-being, safety, and productivity. Including these elements in the assessment ensures that the evaluation captures both functional performance and the broader impact on the workforce within real industrial environments. However, both technical performance and impact on users can shift in different ways – it changes as the project unfolds. To keep up with these changes, it is important to carry out assessments throughout all phases of the pilot project – Preparation, Action Research, and Evaluation. A set of recommended assessment instruments are described within SEISMEC, including how they can be used effectively at each stage together with an example of how to use these instruments.

Combined, the solution directions, design guidelines, and assessment tools offer a practical roadmap for organisations aiming to implement and assess novel technologies in a way that supports meaningful, sustainable, and human-centric work. To help other organisations with successful technology implementation, the descriptions of the solution directions were disseminated among a broader audience by publishing our findings on the SEISMEC website[1].

[1] Solution Directions - SEISMEC | Piloting the Shift to Human-Centric Industry

2 Introduction

Human-centricity is a broad and evolving concept. Within the SEISMEC project, it is defined as "an approach to socio-economic activities that is rooted in the needs, experiences, perceptions and values of humans for the design, deployment and evaluation of technology" (SEISMEC Deliverable D1.1 [2]). While compelling, human-centricity is not easily grasped, nor is there a single method that can make an organisation truly human-centric. This deliverable explores how human-centricity can be implemented and evaluated in practice, particularly in the context of Industry 5.0.

Applying a human centric approach to the design of (elements of) industrial processes is not new. The roots of human-centric thinking can be traced back to Jastrzębowski et al.'s early ergonomic insights (Jastrzębowski et al., 1857). The early disciplines such as ergonomics and human factors engineering, focused on optimising the interaction between humans and machines. Human centric approaches evolved from more than one starting point: from humanities, from engineering and from organisational sciences. With this evolution new human centric approaches were introduced such as socio-technics (1951), human centred design (1988), UX, or user experience, (1993) and humanistic engineering (2000).

A common thread runs through the evolution of these human-centred design disciplines. First of all, the recognition that stakeholders should participate in design processes. The systems they focus on grow from machine interaction level to eco-systems. Outcomes should improve both performance and well-being. Lastly, all disciplines have introduced ethical and social dimensions.

[2] SEISMEC Deliverable D1.1: human acceptance of technology, technology as an assistant for particular worker categories, human involvement in the development of the technology, and work-life balance.

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Although their 'playground' may differ, nowadays human factors and ergonomics, modern socio-technics and humanistic engineering have very similar guiding principles that coincide with the human centrism that the EU presents in Industry 5.0.

Industry 5.0 represents a shift from the efficiency-driven paradigm of Industry 4.0 to one that prioritizes human well-being, sustainability, and resilience. Within SEISMEC, this shift is operationalized through human-centric approaches across 17 pilots in Europe. A truly human-centric industry requires assessing whether companies have meaningfully improved and empowered their workforce. Empowerment is critically linked to inclusion and equality (OHCHR, 2015), and human-centric research integrates these factors with human needs, behaviours, and ethical considerations.

SEISMEC considers the need for human-centric solutions in the context of two major changes in European industry: the development of new technological solutions and the evolving expectations people have of their work. These developments create new tensions and opportunities that must be addressed through thoughtful, human-centred innovation.

The changes in the European industry contribute to tensions in the workplace, previously introduced in SEISMEC Deliverable D1.1 as the CAPS framework. This framework identifies frictions between technological developments, organisational needs, and worker expectations. Technologies such as AI and ubiquitous computing are often designed to empower users. However, as noted in D1.1, many such projects are human-related but not necessarily human-centric. True human-centrism must be rooted in protecting fundamental human rights, addressing user needs, and ensuring empowerment and skill compatibility (Oeij, Dhondt, & Lenaerts, 2023).

SEISMEC identifies four key qualities of human-centrism from the worker perspective. First, human-centricity contributes to a healthy work-life balance, reflecting core human values. Second, technologies should support the worker in achieving their goals. Third, these technologies must be accepted by the worker, which requires thoughtful implementation. Fourth, and most critically, humans must be actively involved in the development and implementation of technologies. An additional organisational perspective considers how work is structured and divided (Oeij, 2024). A geographical perspective – focused on distribution across EU countries – is acknowledged but not discussed in this deliverable.

Given the complexity and diversity of human-centric challenges, there is no single methodology to address them. Instead, SEISMEC proposes solution directions. These are defined as tools, technologies, or methods that support placing human needs at the center of technological development. These solution directions were identified through a mixed-method approach involving literature reviews, expert interviews, and co-creation workshops with researchers, industry stakeholders, and pilot partners. We explore multiple solution directions as potential pathways to alleviate CAPS tensions and support the transversal themes of WP4 cybersecurity, trust & understanding, worker inclusion, and learning & skills development.

To support practical application, *design guidelines* were then developed to support the application of each solution direction in practice. Design guidelines describe how solution directions can be practically applied to support the human-centric implementation of new technologies. Again, the SEISMEC pilots contributed to the content of the design guidelines, indicating important factors to consider when using the solution directions.

Combined, these activities have resulted in a living list of methods designed to enhance human-centricity during the implementation of novel technologies within organisations. As part of the dissemination strategy, the solution directions and their accompanying guidelines are made accessible to a broader audience through the SEISMEC website[3]. This online resource is continuously updated throughout the project, incorporating new insights and examples from SEISMEC

[3] Solution Directions - SEISMEC | Piloting the Shift to Human-Centric Industry

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pilots that illustrate how these solution directions are applied to foster human-centric technology implementation in other companies as well.

To evaluate how well these solution directions empower users and ensure a human-centric implementation of technology, SEISMEC developed human-centric instruments and assessment criteria. These are defined as tools used to evaluate or measure the nature of implementations that adhere to human-centricity standards and principles. The research protocol developed under Task 2.2 first addresses which factors and criteria are essential for developing human-centric assessments within diverse industrial settings, such as those that are part of SEISMEC.

The goal of the protocol is plural. It first identifies key principles and approaches for a human-centric approach within workplace contexts. Secondly, a distinction is made between two types of evaluations: the evaluation of the solution direction implementation process, which is conducted over a longitudinal period, and the evaluation of technological implementation, which is carried out in a phased manner. Key elements relevant to each type of evaluation are discussed in detail. Thirdly, the protocol elaborates on the instruments used in these evaluations and how they can be designed. Five human-centric methods – referred to as umbrella instruments – are central to this approach: observation, interviews, surveys, testing, and focus group discussions. Each of these instruments is further discussed in the research protocol.

The final objective of the protocol is to explain how and when these human-centric criteria and instruments can be used to evaluate the impact of solution directions and the implementation of advanced technologies in empowering workers. The three key phases – preparation, action research, and evaluation – require different approaches to assessing how technology is used and how users interact with it. Each SEISMEC pilot applies these methods in a unique way. To illustrate this, the protocol includes a case study demonstrating the application of a human-centric assessment.

SEISMEC's instruments and assessment criteria also incorporate the CAPS factors – Creativity, Collaboration, Autonomy, Automation, Productivity, Privacy, Safety, and Job Satisfaction – as indicators of empowered, human-centric technologies. These factors were described in Deliverable 1.1. Furthermore, the instruments developed under Task 2.2 are linked with other tasks in WP2, WP4, and Task 5.1, ensuring connectivity within the project. By linking solution directions with structured assessment tools, Tasks 2.1 and 2.2 jointly provide both the "what" and the "how" of implementing and evaluating human-centric solutions. This report is structured as follows. Chapter 3 covers the solution direction and design guidelines. Section 3.1 discusses the methods used for obtaining and categorising the solution directions and design guidelines. Section 3.2 discusses the categorisation of solution directions and explains their relation to the transversal themes. Section 3.3 summarizes the 41 solution directions with the practical guidelines for application and, where available, examples from SEISMEC pilots. The final section (3.4) of the chapter discusses how the solution directions were validated with the pilots. To maintain readability, the full set of detailed guidelines – spanning nearly 200 pages – is included as a stand-alone appendix in a separate document. The main report presents a concise and accessible synthesis to support efficient reading and comprehension.

Chapter 4 outlines the assessment instruments developed in Task 2.2 and how they can be applied to evaluate both the process and outcomes of solution direction implementation. The first section (4.1) provides information on important human-centric principles and approaches. The second section elaborates on two types of evaluations (4.2), followed by a discussion of the umbrella instruments and research phases (4.3). The final section presents a case study illustrating the application of a human-centric assessment (4.4).

3 Solution directions and their guidelines

3.1 Methods

To gather methods that facilitate a human-centric technology implementation, interviews (10) were conducted in July and August of 2024 with specialists and experts from within the consortium. Experts had knowledge in various fields, namely: human-technology interaction, artificial intelligence and data science, ethics and privacy, safety and security, sociotechnical systems, inclusive technology, human factors and ergonomics, technology implementation, sociology, and (organisational) psychology. The interview protocol can be found in Appendix A – Interview protocol. Combined, approximately 45 possible methods (later called solution directions) were listed and researched further in detail consulting existing and related literature. Short descriptions of the solution directions were created and used to categorise the solution directions into six categories of (design) methods: 'ecosystem level', 'organisational level', 'workplace level (with end user involvement)', 'workplace level (not necessarily with end user involvement), 'technologies', and 'instruments'. This categorisation was done in a workshop including consortium members. During this workshop, overlapping solution directions were identified so they could be described together, and solution directions irrelevant for SEISMEC purposes were excluded. Finally, each category consisted of at least 3 solution directions. An overview of all included solution directions, divided into categories, can be found in section 3.3. A second workshop was held to map each of the solution directions to one or more of the transversal themes as described in WP4. Full descriptions of the solution directions were written with input from consortium members. These consisted of a general description, application and referral to the transversal themes of WP4. The application section comprises of practical examples that have been gathered from literature that showcase the implementation of the solution directions. A working document of the results has been produced, which final version constitutes the completion of MS8, due in M15 (March 2025).

The solution directions are the foundation for design guidelines (T2.1) that support the systematic implementation of the solution directions. Pilot partners were consulted to validate the selection of solution directions. Hereafter, design guidelines were written based on literature, descriptions of the solution directions, expert interviews, and input from pilot companies. The guidelines were added to the descriptions of the solution directions. In the next section, this consultation of the pilots is discussed in detail.

3.2 Categories of solution directions

Figure 1 shows the categories of solution directions as defined in a workshop with consortium members. The table also shows how each solution direction is connected to the central themes. Other design approaches which are innately human centric, are previously mentioned in section 2 and placed in historical context.

Solution directions' ability to address central themes

Solution directions \ Central themes	cyber security and privacy	human trust & understanding	inclusion and critical issues*	in-work learning & skills development
Design methods - ecosystem level (work-life balance)				
Settings-based approach	☐	☑	☐	☐
Value sensitive design	☑	☑	☑	☑
Quadruple helix model	☑	☑	☑	☑
Innovation camp	☑	☑	☑	☑
ELSA-lab	☐	☐	☐	☑
Design methods - organisational level				
Integral organisational (re)design	(☑)	☑	(☑)	(☑)
Workplace innovation	(☑)	☑	(☑)	(☑)
(Semi-) autonomous teams	(☑)	☑	(☑)	(☑)
Design methods – workplace level *with end user involvement*				
Collaborative design	☐	☑	☑	☐
Value-co-creation	☐	☑	☑	☐
Co-creation workshops	(☑)	☑	(☑)	(☑)
Living lab	☐	☑	☑	☐
Lead user innovation	☐	☑	☑	☐
Learning community	☐	(☑)	☐	☑
Intervention mapping	☐	☑	☑	(☑)
Design methods – workplace level *not necessarily with end user involvement*				
Design thinking	☑	☑	☑	☑
Customer journey / journey map	☐	☑	☑	☐
Human centric interface	(☑)	☑	☑	☐
Co-active design	☐	☑	☐	☐
Personas	(☑)	☑	☑	☐
Inclusive design	☐	☑	☑	☐
Universal design	☐	☑	☑	☐
Technologies				
Human-AI interaction - Human AI co-learning	☐	☑	☑	☑
Human-AI interaction - Explainable AI	☐	☑	☑	☑
Human-AI interaction - Human-in-the-loop	☐	☑	☑	☐
Digital human models	☐	☐	☑	☐
Digital twins	☐	(☑)	(☑)	(☑)
Privacy preserving feedback technology	☑	(☑)	(☑)	(☑)
Serious gaming	☐	☐	☑	☑

* covers worker participation, inclusion, job quality, and other critical issues

Figure 1. All solution directions and their ability to address the central themes; grey check boxes indicate that the solution direction is indirectly connected to the theme.

3.3 Overview of solution directions and design guidelines

This section presents the the solution directions and their guidelines, including information of the solution direction in general (what is it), when to apply it, an application example, and how to apply it (design guidelines). In addition, this information can be found on the SEISMEC website[4] and is meant for organisations to decide whether a solution direction could be useful for them. Note that the extended versions can be found in the stand-alone appendix (Appendix B) provided separate from this document due to size.

3.3.1 Ecosystem level (work-life balance)

3.3.1.1 Settings-based approach

What is it: A settings-based approach focuses on the various environments where people live, work, and play, making these contexts the primary targets for health promotion and intervention (Poland, Krupa and McCall, 2009). It focuses on enhancing the environment rather than just the individual, promoting health by implementing changes in physical, organisational, and social settings, often utilising technology to improve these areas (Neufeld and Kettner, 2014).

When should you apply it: This approach is applicable in health-related contexts, particularly when aiming to enhance the effectiveness of health initiatives by addressing the specific needs and capacities of individuals within different settings. Technology can be integrated to monitor health metrics, facilitate communication, and provide tailored health interventions.

Application example(s): An example application is health promotion at the workplace for individuals with intellectual disabilities, where the focus shifts from individual interventions to creating an inclusive and supportive environment (Joyce, 2024). Accessible wellness programmes, clear communication channels,

[4] Solution Directions - SEISMEC | Piloting the Shift to Human-Centric Industry

and support peer networks were implemented, thereby enhancing socialisation and mental health.

How to apply:

- Take differences and similarities across types of settings into account
- Account for the temporal patterning of behaviour
- Look for unanticipated effects and unintended consequences
- Be reflexive regarding ethics associated with actions, assumptions, and use of power
- Develop a coherent, but nonlinear, ecological logic model
- Engage participants in the process and address a variation of topics to deepen the social analysis of root causes that affect their health

3.3.1.2 Link across and beyond Value sensitive design

What is it: Value Sensitive Design (VSD) is a theoretically grounded approach to technology design that systematically and comprehensively integrates human values (Friedman, 1996). It ensures that the technology is not only functional but also ethically sound, aligning with the values of all stakeholders involved.

When should you apply it: VSD is relevant to all innovation and design of new technology and technological artifacts, prioritising the values of stakeholders in the design and implementation of novel technologies. It is suitable for various use cases, including healthcare, defence engineering, and public sector design.

Application example(s): An example of VSD in practice is demonstrated through an engineering design case study involving the development of a supervisory command and control system for the U.S. Navy's Tactical Tomahawk cruise missile (Cummings, 2006). This highlights the first fundamental canon of engineering ethics: engineers should prioritize the health, safety, and welfare of the public. This raises the ethical question: "Is it ethical for an engineer to design a weapon?"

How to apply:

- Consider seeking support from experts in VSD

- Identify and engage stakeholders
- Conduct empirical investigations to understand and prioritize the values of stakeholders
- Implement an iterative design process that incorporates continuous feedback from stakeholders
- Conduct conceptual investigations
- Incorporate sustainability into the design process
- Continuously evaluate the ethical implications of the design choices

3.3.1.3 Quadruple helix model

What is it: The Quadruple Helix Model is an innovation framework that integrates input from four key stakeholders: the State, Industry/Business, Academia, and Citizens. It emphasizes dynamic interactions among these groups to foster comprehensive and inclusive innovation (Carayannis and Campbell, 2009).

When should you apply it: Apply this model when aiming to incorporate diverse stakeholder perspectives in the development and implementation of innovative solutions. This approach is useful to use by the public sector, public-private partnerships, and for larger ecosystems or regional incentives.

Application example(s): It is applied in initiatives like the European Digital Innovation Hub in Transylvania[5], where academia, tech companies, government, and civil society collaborate to drive digital transformation. Here, support to small and medium enterprises is offered in, for example, artificial intelligence and advanced manufacturing technologies.

How to apply:

- Select a venue that is accessible, comfortable, and conducive to collaboration.
- Involve representatives from all sectors of society: public authorities, industry, academia, and citizens

[5] https://transilvaniadih.ro/en/homepage-en/

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- Use instruments, methods and approaches in the Quadruple Helix Model design as suits best with your goal and the actors you aim to include
- Find a purpose or goal that all partners rate as an important investment

3.3.1.4 Innovation camp

What is it: An Innovation Camp is an intensive, time-bounded collaborative approach designed to generate creative solutions to complex challenges. It involves structured yet dynamic participatory processes based on co-creation and problem-solving and lasts for multiple days. A wide range of quadruple helix stakeholders should be present, bringing diverse backgrounds and expertise (Aranguren et al 2018; Rissola, Kune, & Martinez, 2017).

When should you apply it: Apply this methodology when aiming to foster collaboration among diverse stakeholders within an innovative ecosystem. It is particularly useful for addressing regional development challenges, facilitating learning (Svennevig and Thorstensen, 2019), and community building. Use an Innovation Camp to address societal and site-specific issues that require a holistic approach.

Application example(s): An example of an Innovation Camp is the Cluj Innovation Camp in 2023, where 80 specialists from 11 countries gathered to develop solutions for challenges in technology and sustainability. The primary outcomes included practical solutions, enhanced collaboration, and contributions to regional and international innovation strategies (Transilvania IT Cluster, 2023).

How to apply:

- Assign a Camp Convener to take responsibility for the process
- Allocate at least a year to execute the entire innovation camp process
- Include a diverse range of stakeholders with varying expertise, backgrounds, and nationalities

3.3.1.5 ELSA-lab

What is it: An ELSA Lab (Ethical, Legal, and Societal Aspects Lab) ensures that ethical, legal, and societal aspects are integrated into the development and

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deployment of technologies. It promotes the alignment of AI systems with societal needs and values through structured, iterative processes (Van Veenstra, Van Zoonen and Helberger, 2021).

When should you apply it: Use an ELSA Lab if you want to develop and use advanced technologies in a responsible way, or if you want others to learn how to do so. It is particularly useful for ensuring that fundamental rights and public values are considered from the start, fostering ongoing learning and adaptation.

Application example(s): ELSA Labs have been initiated by the Dutch AI Coalition to ensure responsible AI development in the Netherlands. For example, the ELSA AI Lab Northern Netherlands developed an online tool to integrate ethical, legal, and societal considerations into AI systems used in healthcare (ELSA AI Lab Northern Netherlands, *n.d.*).

How to apply:

- Include ethical, legal and societal aspect into the process
- Take time to understand and define the complexity of the challenge you aim to address
- Collaborate with all actors from the quadruple helix
- Organise regular reflection sessions with multidisciplinary experts
- Use structured tools such as the DEDA framework (Utrecht University) and Aanpak Begeleidingsethiek (ECP) to guide discussions
- Use methodologies as described in the sections "workplace level with end user involvement" and "instruments" to co-design and collect ideas

3.3.2 Organisational level

3.3.2.1Integral organisational (re)design

What is it: The organisational (re)design approach “Integral Organisational Renewal” (IOR) is a modern sociotechnical design approach that aims to improve organisational performance and job quality by viewing an organisation as a social interaction network. It focuses on reducing structural complexity and increasing worker autonomy (Kuipers, Van Amelsvoort and Kramer, 2020).

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When should you apply it: Apply IOR when aiming to enhance both efficiency and human-centric work within an organisation. It is particularly useful for creating flexible, humane organisations with low complexity and high-quality jobs. This approach is also beneficial when an organisation needs to be better structured to effectively implement new technologies.

Application example(s): IOR principles have been applied in various organisational settings to achieve better business performance and employee outcomes. It involves minimising coordination needs and division of labour to ensure comprehensive tasks and decision-making roles.

How to apply:

- Assess what products to you sell to which customers in which markets and what your targets are.
- Assess the requirements to improve efficiency, effectiveness, flexibility and innovativeness
- It is important not to jump to conclusions by pointing out what causes the problem
- Define the systems and their borders of what needs to be (re)designed: organisation, department, team
- Define output requirements or 'functional specifications'
- Often it is helpful to describe and lay-out the primary process
- Design the structure of the organisation
- Design of support systems
- The process of change and implementation of new technology, and the application of IOR, should cover the points of departure of human-centricity
- Realise that applying this solution direction is not easy
- Pay attention to a human-centric application of implementing new technology
- Involvement and commitment are crucial
- Critically assess the possible Inputs of employees and co-workers
- Make a project with a project teams and a project planning based on human-centric values to apply this guideline.
- Consider calling in external experts

- Look into the overarching guideline for an organisational level solution direction based on modern sociotechnics (MST) and similar human-centric approaches to designing work

3.3.2.2 Workplace innovation

What is it: Workplace Innovation (WPI) is an organisational intervention aimed at simultaneously improving business performance and the quality of work through human-centric innovations in Technology, Organisation, and Personnel (TOP) (Oeij and Dhondt, 2024). This approach ensures that new technologies are integrated in a way that supports and augments the work of employees, rather than merely controlling or monitoring them.

When should you apply it: Apply WPI when aiming to foster a participative and human-centric approach to organisational change and technology implementation. It is particularly useful for integrating structural and cultural aspects to improve performance and working conditions.

Application example(s): WPI has been applied in various organisational settings to enhance both business outcomes and job quality. Examples include interventions documented by Eurofound, EUWIN and the Workplace Innovation Knowledge Bank.

How to apply:

- Use the TOP model to arrange your arguments
- From a human-centric stance make an inventory of the effects of the new technology on jobs, tasks and employees
- For the negative outcomes on the quality of work, determine the relationship with the newly implemented technology
- Implement alternative solutions whenever possible
- Look into the overarching guideline for an organisational level solution direction based on modern sociotechnics (MST) and similar human-centric approaches to designing work

3.3.2.3 (Semi-) autonomous teams

What is it: Semi-autonomous teams (SATs) are teams of workers who have partial control over a complete unit of work or a specific task (Van Amelsvoort, Seinen, Kommers and Scholtes, 2003; Van Amelsvoort and Van Amelsvoort, 2000). They have autonomy in decision-making, development, and process improvements, while management retains control over strategy, business, investment, and financial decisions. By granting teams partial control over decision-making and process improvements, therefore also technology selection, the technology ought to be better aligned to the needs of the workers and increases success of implementation.

When should you apply it: Apply SATs when aiming to improve organisational performance and job satisfaction through increased worker autonomy. This approach is particularly useful in environments that benefit from sociotechnical participation and human-centric work design.

Application example(s): While team concepts are widely applied, semi-autonomous teams are much less. Such non-hierarchical teams differ from traditional teams (Bernstein et al., 2022; Oeij et al., 2023). The autonomy of these SATS depends on dealing with disturbances that can be caused by internal structures and external causes, which is why they are linked to socio-technological thinking. Truly, SATS have autonomy that goes beyond their own operational functioning and includes autonomy with regard to strategy and planning Ravn et al., 2022).

How to apply:

- To define the boundaries of a SAT, one can first follow the steps of the solution direction of IOR
- It is needed to create a competencies matrix, of tasks to be executed by humans and qualifications required
- The compositions of team members can be such that all team members together have the required skills and qualifications at their disposal

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- Each SAT has a link with the rest of the organisation, must render account for its performance to higher levels, and needs to manage internal leadership
- One of the pitfalls of designing SATs is to make them responsible for a team task without providing the appropriate authority or decision latitude and resources
- Look into the overarching guideline for an organisational level solution direction based on modern sociotechnics (MST) and similar human-centric approaches to designing work

3.3.3 Workplace level with end user involvement

3.3.3.1 Collaborative design

What is it: Collaborative design approaches prioritise end-users and other stakeholders to create solutions that match their needs, preferences, and expectations, improving user satisfaction and overall accessibility. The three main branches are co-creation, participatory design, and user-centred design (UCD) (McCaffrey et al., 2015; Robertson and Simonsen, 2012).

When should you apply it: Apply collaborative design when aiming to develop solutions or technology that fit end-user needs. These approaches are particularly useful in contexts where user input is crucial but may be less suitable for applications requiring system stability and consistency, such as financial or cybersecurity systems.

Application example(s): User participation can be applied to different types of technology, including web applications and wearable devices, and is widely used in fields such as healthcare, education, technology-enabled services, software development, and enterprise systems. Its principles enable the development of products that align with user behaviours, preferences, and environments (Ertz, 2024).

How to apply:

- Involve end-users from diverse user groups and with distinct abilities
- Ensure a fair distribution of responsibilities and accountability among stakeholders

- Integrating participation of end-users into traditional development methodologies can also pose difficulties
- Tailored strategies may be required to ensure meaningful participation from complex or hesitant groups

3.3.3.2 Value co-creation

What is it: Value co-creation (VCC) involves creating, delivering, and exchanging value through a symbiotic relationship between customers, businesses, and other stakeholders. It emphasises the joint creation of value through interactions during the design process, recognising that value is co-created through experiences and interactions (Saxena, 2021).

When should you apply it: VCC can be used to make the transition from a goods dominant logic to a service dominant logic (Saha, Mani and Goyal, 2020). This method is preferred if your aim is to enhance business outcomes by designing products, technology or services that are more tailored to customer needs and preferences. Also, use this method when long term user participation is desired and realistic. This requires addressing key conditions such as overcoming organisational resistance to change, ensuring proper tools to measure progress, and managing potential legal and regulatory issues.

Application example(s): VCC has been successfully implemented in various fields. For example, LEGO Ideas uses VCC to engage customers in the product development process, and ING used VCC to develop a new life insurance product by involving employees and customers in the design process (Ramaswamy and Gouillart, 2010).

How to apply:

- Arrange sessions with stakeholders, following the guidelines on collaborative sessions, workshops and brainstorm sessions as described in other sections
- Facilitate an environment for open interaction
- Clarify roles and expectations by clearly defining what is expected from customers in terms of their involvement
- Ensure to have a strong brand and create a loyal customer base

3.3.3.3 Co-creation workshop

What is it: Co-creation workshops are collaborative sessions designed to actively involve diverse stakeholders in the design process. These workshops aim to achieve shared goals by leveraging the collective creativity and insights of all participants (Kuhn *et al*, 2021).

When should you apply it: Apply co-creation workshops when aiming to better understand design problems from different perspectives, identify opportunities, and ideate innovative solutions. They are particularly useful in development trajectories that include end-users in the design process.

Application example(s): As part of the SEISMEC project, Ateş Wind Power conducted a co-creation workshop to gather valuable input on a VR training application under development. The session included engineers, operators, and inspectors, who provided feedback on the VR demo. This collaborative effort led to an improved workflow, with participants appreciating the opportunity to contribute and expressing interest in testing the final VR application.

How to apply:

- Schedule enough time to perform the session
- Limit the group size to no more than 15 participants to ensure a productive and effective session
- Preferably consult an expert in designing and organising co-creation workshops
- Structure the session in phases, typically four
- Document everything extensively and report this back to the participants
- Prepare one or two questions you aim to address in the session
- Adjust the level of difficulty and challenges to the participants and make the session more immersive than instructional
- Prepare materials that belong to the design approach you choose

3.3.3.4 Lead user innovation

What is it: Lead User Innovation involves collaborating with advanced users who are ahead of market trends and have unmet needs, leveraging their insights to co-create innovative products or solutions (Brem, Bilgram and Gutstein, 2018, Von Hippel, 1986).

When should you apply it: Apply this method when developing new products or services, or when optimising business processes, especially in industries undergoing digital transformation. Lead users are particularly beneficial in participatory design processes due to their critical insights and ability to develop their own solutions.

Application example(s): This approach is widely used in technology, healthcare, and consumer goods industries, where early adopters and advanced users drive significant innovation. For example, AI-driven workplaces benefit from lead users to test and integrate new technologies before company-wide implementation.

How to apply:

- Form an interdisciplinary team and define the goals for the involvement of lead users
- Identify trends and needs relevant for the project
- Search for lead users through network and screen initial ideas
- Create first concepts with lead users

3.3.3.5 Learning community

What is it: A Learning Community brings together diverse parties to collaboratively tackle urgent, complex societal issues through structured activities, promoting collective problem-solving, innovation, and skill development. It fosters an environment where participants learn from each other, enhancing both individual and collective expertise. Participants can be individuals but also representatives of organisations (Zamiri and Esmaeili, 2024).

When should you apply it: Apply this method when addressing complex, multidimensional challenges that require diverse expertise and perspectives, particularly in fields like education, social domains, technology, and sustainability (Nederlandse AI Coalitie, 2022; Prenger *et al.*, 2018; Schipper, Vos and Wallner, 2022). It's especially beneficial for start-ups or MKB companies, being able to learn from bigger companies.

Application example(s): Learning communities are used in various domains, including education to enhance teaching and learning processes, and in the social domain to solve societal challenges. For example, the Netherlands AI Coalition uses learning communities to develop AI knowledge and training programs, leveraging regional collaboration structures to produce tangible outcomes (Nederlandse AI Coalitie, 2022).

How to apply:

- Involve representatives from policy, education, practice, research and the target group to ensure diverse perspectives
- Appoint a learning community leader to coordinate multiple activities and maintain engagement
- Allow community members to allocate dedicated work hours for community activities and support a positive learning culture within the organisation
- Define the expected duration of the learning community
- Encourage synergy and collaboration by pooling resources
- Use interactive formats
- Allocate physical or digital spaces that facilitate collaboration
- Develop a structured learning framework
- Sustain the learning community

3.3.3.6 Intervention mapping

What is it: Intervention Mapping (IM) is a structured planning approach used to develop behaviour change interventions, ensuring they are tailored to the needs and contexts of the target population (Bartholomew-Eldredge et al., 2016). It shares principles with human-centred design, such as user involvement and iterative development (Melles, Albayrak, & Goossens, 2021).

When should you apply it: Apply this method when developing, implementing, and evaluating health promotion interventions, public health programs, or behavioural change programs. It's particularly useful for big governmental funded health initiatives and behavioural change programs, ranging in context from occupational safety to digital health (Marcos et al., 2024; van der Beek, Steijn and Groeneweg, 2023).

Application example(s): IM is widely used in health promotion programmes, such as increasing physical activity in adolescents, designing mental health interventions, and developing digital health tools like the iSMART program for stroke survivors. It ensures interventions are practical, acceptable, and feasible through stakeholder involvement (Wong *et al.*, 2023).

How to apply:

- Involve an expert
- Target a wide population
- Use IM primarily for achieving behavioural change in large populations
- Continuously improve and monitor the process and keep doing so even after the intervention is implemented
- Thoroughly document the entire process

3.3.4 Workplace level not necessarily with end user involvement

3.3.4.1Design thinking

What is it: Design Thinking (DT) is an established process with iterative steps, used in organisations and aiming at solving problems and promoting innovation (Brown, 2008). This human-centred approach emphasises empathy, creativity, and iteration to develop innovative products, services, and processes, prioritising the needs and viewpoints of users and stakeholders.

When should you apply it: Apply this method when addressing complex challenges that require innovative solutions, particularly in rapidly evolving industries. DT is beneficial for fostering creativity and solving problems in sectors like technology, healthcare, and public services.

Application example(s): DT has been widely used across various sectors, including the design of government services in Singapore, an employee onboarding program at Telstra, and patient-centred innovations in healthcare, such as GE Healthcare's Adventure Series for MRI machines.

How to apply: Guidelines for application are given for each design phase

- In the *empathise* phase, engage with end-users; observe users in their work environment; and conduct interviews and surveys
- During the *define* phase, synthesize findings; formulate problem statements; prioritize challenges; and align with organisational goals
- The *ideate* phase includes encouraging diverse participation; facilitating brainstorming sessions; using creative techniques; and promoting a safe environment for sharing ideas
- As part of the *prototype* phase, develop low-fidelity prototypes; iterate rapidly; engage users in testing; and document learnings
- During the *test* phase, conduct user testing; analyse results; refine solutions; and plan for implementation

3.3.4.2 Customer Journey

What is it: The customer journey describes a user's interaction path to achieve the goal of a product or service (Moura, Reis and Rodrigues, 2021), providing a visual overview of incidents, interactions, and experiences to identify what works and what needs improvement.

When should you apply it: Apply this method to better understand a user's interaction with technology or services and create technology experiences that enhance user engagement, control, and self-confidence. It is particularly useful in innovation processes where the user's interaction with products and services is complex and meeting their needs is central.

Application example(s): The customer journey is used in various contexts, such as AI-driven customer experiences (Moura *et al.* 2021), including chatbots and voice assistants, and well-being applications to engage users and improve service quality.

How to apply:

- Identify why you are building a customer journey map and set clear objectives
- Identify profiles and personas and focus on one specific audience at a time
- Determine and plot the touchpoints users have with your technology
- Create your customer journey map template
- Follow the 5 phases of a customer journey: awareness, consideration, decision, retention, and advocacy
- Digitalise your journey map for easy updates and sharing
- Provide a summary explaining your key takeaways
- Clearly state the follow-up actions

3.3.4.3 Human-centric interface

What is it: A human-centric interface encompasses the design of digital interfaces, focused and based on human needs and experiences. This ensures intuitive and accessible interaction through various technologies like screens, voice commands, and virtual environments.

When should you apply it: Apply this method to enhance user experience, safety, and productivity by aligning technology with natural behaviour and integrating it smoothly into existing workflows. It's particularly useful in industries where efficient and safe human-machine interaction is critical.

Application example(s): HCI is used in diverse industries such as construction, where interfaces are designed for gloved hands and safety warnings, warehouses with voice-based systems functioning in noisy environments, and healthcare settings to protect patient privacy and manage data efficiently.

How to apply:

- Identify clearly to what extent the system is autonomous at a given time and the interdependence between all the actors involved in the activity
- Use general guidelines for HCI for the interface design such as:
    - Ensure adaptability to the user profile
    - Prevent and allow for recovery from human errors
    - Make sure there is consistency in design: the same action should produce the same result

    - Interacting with the system should be efficient: minimum required interactions
    - Interacting with the system should not increase cognitive workload
    - Enable trust by creating a system that is understandable
- Use additional guidelines for specific media. For eXtended Reality (XR) these include:
    - Developers shall ensure that XR applications are quick to respond to users' inputs to maintain engagement and willing to use
    - XR applications shall be developed with respect to new standards
    - Focus on privacy and cybersecurity
    - XR applications shall not hinder reliability and functionality and it is mandatory to include user feedback to continuously refine and improve the application design.
    - XR application shall enable more natural interactions (gaze, voice, gestures) to reduce physical and cognitive workload

3.3.4.4 Personas

What is it: Personas are hypothetical archetypes of actual users that represent distinctive user groups for a technology (Värmland County Administrative Board, 2019), created based on real user data to guide a human-centric implementation of technology.

When should you apply it: Apply this method to enhance understanding of target users (Dam and Teo, 2024), prioritise product requirements, and challenge assumptions, ensuring designs are user-friendly and meet actual user needs (Miaskiewicz and Kozar, 2011). Additionally, personas can be used if you do not wish to have a lot of iterative testing with a group of end-users, for example because they belong to a vulnerable group or are lacking time or resources.

Application example(s): Personas are used in various fields, such as developing an eHealth platform for chronic disease management (Klooster *et al*, 2022), where they help align technology with target users throughout development.

How to apply:

- Make a time frame of the technology implementation and development process and determine which methods you will use to gather data
- Collect data of your end users
- Decide on the number of personas
- Identify a primary persona that represents the main user group
- Use the retrieved information to give content to the personas
- Make a tangible document of the personas
- Make your personas specific and tailored to the goal that you want to achieve with implementing a technology
- Validate you personas to check if the personas are different, complete, believable and trustworthy
- Conduct research to identify outliers and make sure to have access to a diverse and representative sample of users to create accurate personas

3.3.4.5 Inclusive design

What is it: Inclusive design is a design approach that aims to create products, services, and environments that are usable and accessible to specific user groups, particularly those who are traditionally excluded (Clarkson and Coleman, 2015).

When should you apply it: Use inclusive design if you aim to develop objects, systems, and environments that can be accessed by a maximum number of people by considering limitations such as accessibility, age, economic situation, geographic location, and language. It's particularly useful when designing digital information and communication tools.

Application example(s): Inclusive design is used in various fields from architecture to software development. An example is the SAM (Stress Autism Mate) app, which addresses the unique needs of people with Autism Spectrum Disorder (ASD) by involving them throughout the design process to ensure accessibility and user-friendliness (Toolkit Inclusie, n.d).

How to apply:

- Engage relevant stakeholder groups

- Use interviews, surveys and usability testing to determine the needs of various users
- Apply the five key principles of inclusive design[6]
- Ensure compliance with accessibility standards

3.3.4.6 Universal design

What is it: Universal Design is a human-centric approach aimed at creating accessible and usable products, environments, and services for everyone, regardless of age, ability, or other factors (Connell *et al.*, 1997; Mace *et al.*, 1991).

When should you apply it: In essence, Universal Design principles can be applied to all kinds of products and services, including technology, buildings and public services. They are particularly useful for addressing a large and varied group, ensuring accessibility and usability for the widest range of users.

Application example(s): Universal Design is applied in technologies like text-to-speech (TTS) and high contrast text settings, enhancing accessibility for individuals with visual impairments or reading difficulties (Sizemore, 2022).

How to apply: We refer to the guidelines of Inclusive Design:

- Place people at the heart of the design process
- Acknowledge diversity and difference
- Offer choice where a single design solution cannot accommodate all users
- Provide for flexibility in use
- Provide solutions that are convenient and enjoyable to use for everyone

3.3.5 Technologies

3.3.5.1HAI: Human-AI interaction (General)

Human-AI interaction (HAI) is a multidisciplinary field focused on designing and evaluating systems where humans and AI collaborate. It aims to enhance trust,

[6] https://principles.design/examples/the-principles-of-inclusive-design

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usability, and performance through improved task allocation and interaction quality, encompassing approaches like human-AI co-learning, explainable AI, and human-in-the-loop.

3.3.5.2 HAI: Human AI co-learning

What is it: Human-AI co-learning is a collaborative process where humans and AI systems learn from each other to improve their capabilities and decision-making. This mutual learning enhances both the AI's adaptability and the human's understanding of the AI's strengths and weaknesses (Dellerman, Ebel, Söllner, and Leimeister, 2019; Settles, 2011; Zagalsky *et al.*, 2021).

When should you apply it: Apply human-AI co-learning when developing systems that require continuous adaptation and improvement through mutual learning between humans and AI. It is particularly useful in complex tasks where human expertise and AI capabilities can complement each other (Liao and Varshney, 2021).

Application example(s): This technique is used in adaptive learning platforms and collaborative robotics, where human feedback helps AI systems improve over time. It is also applied in marketing analysis and manufacturing to enhance decision-making and operational efficiency.

How to apply:

- Assess the need of human-AI co-learning
- Involve the end users in the design process
- Define the roles that humans and AI play
- Enable effective human-AI interaction
- Consider stakeholder impact beyond direct users
- Evaluate and improve the system

3.3.5.3 HAI: Explainable AI

What is it: Explainable AI (XAI) refers to techniques and methods that make an AI system's decisions and behaviour understandable to humans, addressing the complexity and lack of transparency in advanced models like Deep Learning and

Generative models (Mamalet *et al.*, 2021; Salahuddin, Woodruff, Chatterjee and Lambin, 2022).

When should you apply it: Use explainable AI when transparency, trust, and accountability are critical, especially in high-stakes domains like healthcare, finance, and autonomous systems (Alexander, Chau and Saldaña, 2024; Hossain *et al.*, 2025).

Application example(s): Explainable AI is applied in medical diagnosis systems, financial decision-making tools, and autonomous vehicles to ensure users understand and trust the AI's decisions, enhancing collaboration and safety.

How to apply:

- Establish communication between research and pilot teams
- Define the purpose of explainability
- Identify target users and needs
- Define data and system type
- Conduct literature review
- Select suitable explainability techniques
- Integrate explainability layer into AI development
- Provide user-centric explanations
- Facilitate collaboration between roles
- Establish feedback loop
- Remain flexible
- Assess explainability effectiveness
- Perform pre- and post-explainability comparisons

3.3.5.4 HAI: Human-in-the-loop

What is it: Human-in-the-loop (HITL) systems involve both humans and automated components in the operational process, allowing human intervention and oversight to improve productivity, safety, and quality of output (Sheridan and Verplank, 1978; Shneiderman, 2020).

When should you apply it: Use a HITL approach in contexts where decisions have significant consequences, require nuanced judgment, or involve high-risk environments. Ensuring alignment with human values and enhancing performance, HITL is particularly useful in tasks that are complex, ambiguous, or where ethical considerations are crucial.

Application example(s): HITL systems are used in data processing, manufacturing, and critical decision-making scenarios (Zagalsky *et al.*, 2021). For example, in data entry and validation, human oversight ensures accuracy and reliability. In manufacturing, HITL systems help monitor and control automated processes, enhancing safety and efficiency. In high-stakes environments like healthcare and finance, human oversight ensures that AI decisions align with ethical standards and regulatory requirements.

How to apply:

- Assess the need for a human-in-the-loop approach.
- Define the roles that humans and AI play
- Involve the end user in the design process
- Consider stakeholder impact beyond direct users
- Evaluate and improve the system

3.3.5.5 Digital human models

What is it: Digital Human Models (DHMs) are sophisticated computer-generated representations of human beings used to simulate and analyse human interactions with products, environments, and systems. They incorporate detailed anthropometric, biomechanical, and physiological data to create realistic simulations of human movements, postures, and behaviours.

When should you apply it: DHMs could be used when designing products, workstations, and work processes to quickly test various scenarios (Demirel, Ahmed and Duffy, 2022; Reed, n.d.). This includes suitability for different sized users, and evaluating the impact of design choices on physical loads and ergonomics.

Application example(s): DHMs are used in vehicle cabin design to assess reach, operation, and viewing aspects, as well as in manufacturing to optimise

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workflows and minimise non-value-added movements. They are also used in workstation design to ensure optimal postures and body loads.

How to apply:

- Decide whether DHM's have added value in the design process and whether to invest in DHM's from a software and skills point of view
- Involve an expert
- Engage stakeholders early
- Define clear goals and criteria
- Make sure to have a skilled team and proper tools
- Use up-to-date anthropometric data covering the range of your user population
- Set aside adequate time and budget
- Schedule a kick-off session and define the project scope and objectives with stakeholders
- Build the digital model
- Run the simulated tasks in the DHM software and observe results
- Present the results in an accessible format (charts, heatmaps, or animation of the digital human) and review them
- Build a quick/paper prototype
- Apply improvements to address the identified issue, test them in the model and do this iteratively
- Train the team and set expectations
- Include a diverse range of digital humans to represent your actual users
- Check results against human factors guidelines
- Don't trust the model blindly
- Avoid using rough estimates or out-of-date data
- Don't model every minor detail at the start

3.3.5.6 Digital twins

What is it: A digital twin (DT) is a virtual representation of an object or system designed to accurately reflect its physical counterpart (IBM, n.d.). Industrial digital twins leverage real-time data, simulations, and advanced analytics to optimise performance and decision-making.

When should you apply it: Apply digital twins in scenarios where real-time monitoring, predictive analytics, and optimisation of physical systems are crucial. They are particularly useful in complex industrial processes and environments, or for example in situations where you do not have access to the real environment.

Application example(s): Digital twins are used in manufacturing to optimise production processes, in predictive maintenance to anticipate equipment failures, and in smart cities to manage infrastructure and resources efficiently.

How to apply:

- The application of DT's should be accompanied by worker participation and mock-up testing
- Validate the use-case and domain
- Engage stakeholders and end-users
- Assess data readiness and IT fit
- Technology and data infrastructure
- Time and budget allocation
- Training and support materials
- Define goals and secure stakeholder input
- Plan design and integration
- Develop iteratively (start small, at best with a prototype)
- Test and validate with users
- Deploy pilot and evaluate
- Focus on human and business benefits
- Ensure high-quality data
- Prioritise security and privacy
- Don't "boil the ocean"
- Don't neglect the people side
- Don't ignore maintenance
- Don't remove human oversight

3.3.5.7 Privacy preserving methods and models for worker feedback

What is it: Privacy-preserving human state monitoring methods ensure privacy when using wearable technologies and sensors to collect and analyse bio-signals, such as heart rate and skin conductance, to monitor workers' physical and mental states while ensuring their privacy (McDevitt *et al.*, 2022; Poitras *et al.*, 2019).

When should you apply it: Apply these methods when wearables are used to assess physically demanding jobs, high-stress environments, and remote or hazardous locations to enhance worker safety and well-being while ensuring compliance with GDPR regulations (Alhejaili, 2023; Gupta, 2021; Poitras *et al.*, 2019; Qian *et al.*, 2022).

Application example(s): These methods are used in industries like construction, manufacturing, and healthcare to monitor biomechanical risks, stress levels, and fatigue. They are also applied in remote work environments to ensure safety through real-time monitoring. Privacy-preserving techniques, such as edge processing and differential privacy, are employed to maintain data security and comply with regulations like GDPR.

How to apply:

- Involve an expert
- Take privacy concerns into account
- Take ethical considerations into account
- Include action perspectives when providing feedback
- Determine the type of data to collect and set up measurement methods
- Process and analyse the data
- Ensure valid and accurate data collection

3.3.5.8 Serious gaming

What is it: Serious gaming uses video game technology, design, and mechanics for education and training purposes, focusing on providing immersive and engaging learning experiences through game mechanics like rewards, levels, and leaderboards.

When should you apply it: Apply serious gaming when aiming to encourage specific behaviours, improve adherence in training or recurring courses, and provide personalised, interactive learning experiences. It is particularly useful in domains requiring experiential learning and practice.

Application example(s): Serious gaming is used in healthcare (e.g., games for training and prevention, patient rehabilitation and surgeon training) (Kato, Cole, Bradlyn and Pollock, 2008; Olgers, bij de Weg and ter Maaten, 2021), military and defence (e.g., strategy training), education (e.g., Minecraft Education Edition) (Bar-El and Ringland, 2020), and social awareness (e.g., promoting empathy and critical thinking) (Mun *et al.*, n.d.). Other examples are flight simulators (Nisansala *et al.*, 2015), but also simulators of production processes applied in logistics to simulate supply chain management and in workplace safety training to internalise safety protocols (Ozelkan and Galambosi, 2009).

How to apply:

- Match the motives and preference in the game, with those of the target group, to optimally benefit from the intrinsic motivation that can be achieved through serious games (de Vries, van Dieën, van den Abeele, Verschueren, 2018)
- Make sure the serious games elicit the desired stimulation (de Vries *et al.*, 2020)
- The serious games should be easy to find and to get access to by the end-user
- Involve end-users in the development and testing phase
- If VR technology is used, consider the fact that it might require a large dedicated space and that acclimatisation to the VR-system might be necessary

3.3.6 Ideation methods and others

3.3.6.1Brainstorming

What is it: A brainstorm is an activity in which participants are encouraged to freely share ideas in response to a question or topic. Brainstorming can be used

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to generate, present and evaluate ideas to build a strong foundation for progress and innovation (Wilson, 2013).

When should you apply it: A brainstorm is therefore suitable for situations where there is a need for exploratory research, where many ideas and perspectives should be generated and where out-of-the-box thinking is encouraged. It applies to both small and large scale problems.

How to apply:

- Include a diverse range of stakeholders in the brainstorm
- Create the right setting and environment
- Appoint a moderator, possibly two
- Set up an agenda of the session and present this at the start of the session
- Use diverse brainstorming techniques
- Gather generated ideas and evaluate them in the group for individuals to give feedback on them and rank them
- Post-brainstorm, categorize, and refine ideas into actionable insights

3.3.6.2 Workshop

What is it: A workshop is a facilitated session designed for idea generation regarding a particular topic, question or problem. Within a workshop, it is intended that participants will be put to work, including collaboration and executing tasks.

When should you apply it: Workshops are suitable for both small groups (for deeper discussions) and larger groups (for diverse input), as a goal to encourage creativity (Gabriel et al, 2016).

How to apply:

- Ensure that your workshop follows a pattern of divergent and convergent thinking
- Create a workshop agenda, with no more than two topics to discuss and enough short and active breaks in between
- Create a script, including the agenda, duration of each part, involved people, and required materials for each part

- Follow up on determined actions after the workshop and keep participants posted on the progress of those actions

3.3.6.3 World café

What is it: A World Café is a structured activity in which an informal "café"-setting is created for participants to explore an issue by discussing it in small table groups (The World Café Community Foundation, 2015).

When should you apply it: It is best suited for creative and exploratory purposes, with large and diverse groups, encouraging relaxed and open conversations in an informal setting.

How to apply:

- Set the context
- Select participants and assign a role in the session
- Collect materials
- Develop discussion questions
- Encourage everyone's contribution
- Set up the agenda for the session
- Provide participants with a clear overview of next steps

3.3.6.4 Focus group

What is it: A focus group is a setting in which a small group of people share their thoughts, experiences, and attitudes about a specific product or topic, guided by a moderator.

When should you apply it: Focus groups are especially relevant for exploring new ideas and opinions, enriching quantitative findings (e.g., from a survey) and when interaction matters (Krueger, 1988), since the conversations go deeper compared to other ideation methods. They could be used in the beginning of the research phase, where topics and ideas are explored and elaborated, as well as the end, where results and progress is evaluated.

How to apply:

- Use a focus group if you are interested in discovering ideas not previously considered and aiming for opinions from a broad scala of stakeholders
- Determine the different stakeholder groups relevant to the technology implementation and decide on the participant composition
- When conducting a focus group discussion, include 4 to 8 participants in the discussion and ensure that at least two organisers are present
- Structure the discussion, starting with an introduction of the participants, general information on the discussion and the goals of the session
- Gather opinions on the topics you want to address

3.3.6.5 Neo-Socratic dialogue

What is it: The Neo-Socratic dialogue is a structured conversation between 5 to 12 persons about a complex ethical or philosophical question, guided by a facilitator (Socratic Dialogue Foundation, n.d.).

When should you apply it: It is particularly useful for reaching mutual understanding and consensus amongst participants about ethical questions where diverse viewpoints may exist. It does not have the purpose of convincing participants to join a certain viewpoint.

How to apply:

- Define the central question and make sure it is open-ended
- Shift to personal experience-based reasoning
- Apply rigorous questioning (Socratic Method)
- Encourage collective inquiry
- Establish dialogue rules
- Guide the dialogue to a conclusion (but not necessarily a final answer)
- Document key insights

3.3.6.6 Interview

What is it: Interviews are a widely used method for gathering information by asking participants questions. They can be structured with fixed questions for consistency, unstructured for informal and flexible conversations, or semi-structured, combining both approaches.

When should you apply it: Use interviews if you want to gather in-depth information on one or more topics. Structured interviews are best suited for situations where quantitative or comparable data is important, such as large-scale studies. Unstructured interviews are suitable for a deeper conversation on complex issues. Semi-structured interviews are best suited to research where some consistency is needed, but flexibility is required to explore new insights that emerge during the interview.

How to apply:

- Design an interview guide that outlines key topics and questions
- Identify and recruit participants who can provide relevant data for your topic of interest
- Arrange a convenient time and location for the interview
- Explain the purpose, format, and length of the interview
- Address ethical considerations
- Create a comfortable environment where participants feel safe to share their experiences
- Ask open-ended questions to encourage participants to elaborate
- Listen actively and use non-verbal communication
- Focus on self-reflections
- Note down key words, phrases, observations, or moments that strike you while recording the interviews
- Transcribe the interviews as soon as possible after the interviews
- Reflect on how your perspectives may have influenced the interpretation of data
- Remove any identifying information and details

3.3.6.7 Observation

What is it: Observations involve systematically looking and documenting how people behave, interact, or respond when using tools or performing tasks. It helps uncover real-world needs and challenges that might not be clear through interviews or surveys. Observations are a means to gain insight into the situation one wants to improve. Especially in combination with interviews it also serves to show real interest in those who are direct stakeholders.

When should you apply it: Observations are useful for acquiring a more thorough understanding of the actual conditions, which can inform product and work-flow improvements. As a tool in itself it may not be sufficient to discover users' internal attitudes, as these may be hidden from the observer.

How to apply:

- Define the purpose of observation
- Select appropriate observation tools
- Develop a task checklist or protocol
- Organise the visit; make sure what you want to observe, can be observed
- Communicate with employees and inform the purpose of the observation
- Ensure ethical conduct and let the participant sign an informed consent
- Observe objectively and take notice of context
- Take your time
- Review and revise procedures

3.3.6.8 Hackathon

What is it: Hackathons are events where individuals collaborate in teams to develop innovative solutions (Chau & Gerber, 2023). The events typically have a set time-frame of a few days, in which a challenge is posed that is tackled in a competitive manner across multiple teams.

When should you apply it: Hackathons are well-suited for situations requiring swift product development or addressing urgent challenges, and are specifically suitable for use in software development.

How to apply:

- Take your time organising the event
- Define clear objectives and themes
- Secure appropriate sponsorships
- Develop a detailed event schedule

- Establish judging criteria and panels
- Provide technical resources and support
- Foster positive energy and provide a learning opportunity
- Plan for participant well-being
- Prepare for post-hackathon follow-up

3.3.6.9 Open space

What is it: Open Space, also known as Open Space Technology (OST), is a technique for running meetings where the participants create and manage the agenda themselves (Wirtz, 2024). In these self-organised discussions around a central theme, suitable for larger groups, people go where they feel they can contribute the most.

When should you apply it: Open space meetings could be used for a wide range of purposes, ranging from organisational change processes to community development and conflict resolution. It is most effective for complex issues when no one knows the answer and you need people with different perspectives to get there. It is a useful method if determining priorities and an optimal agenda is difficult beforehand. It should not be used if tight control of the process is required.

How to apply:

- Define the central open question
- Choose a committed facilitator
- Draft a clear invitation that explains the event's goals, the central question, and the process
- Prepare the space by arranging the physical setup and tools and materials
- Engage participants early and clarify expectations
- Welcome participants and begin with a speech by the facilitator
- Describe the open space process
- Allow participants to propose topics they would like to discuss
- Group similar topics if needed and adjust the agenda as required
- Make sure session times and locations are visible

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- Facilitate sessions
- Support and maintain energy
- Wrap-up sessions by summarising key outcomes, decisions, and any action points
- Process and document results
- Evaluate the event's success
- Track progress and continuous communication
- Incorporate learnings by assessing the open space method itself
- Create a feedback loop to keep participants involved after the event

3.3.6.10 Participatory strategic planning

What is it: Participatory Strategic Planning (PSP) is a method used by groups, teams, or organisations to create long-term plans for their activities through a collaborative, stakeholder-driven approach. It is used to include stakeholders in a decision-making process.

When should you apply it: PSP is suitable for aligning organisational goals with the priorities of those directly impacted by changes, and its applications are broad, including urban development, environmental planning, organisational management, and community development. Use PSP if you aim to adjust and improve strategies as conditions change, help plans stay responsive to new developments (Hidalgo and Morell, 2019) and ensure effective operational strategies (Khakee and Grassini, 2015).

How to apply:

- Use PSP to make long-term planning for work-related activities or a change in direction
- Encourage participants to discuss their perspectives collaboratively, in a consensus-oriented way rather than top-down
- Include a broad range of stakeholders, including people who can give authorisation for changes in strategic planning

- Reserve one or two days for the workshop, create an agenda and prepare the workshop
- Within the session, make sure to get aligned on the vision and long-term goals
- Perform a SWOT analysis, identify the current state of the organisation and potential threats, and build a roadmap

3.4 Consultation and validation with SEISMEC pilot companies

Our SEISMEC pilots responded to the first questionnaire that queried the familiarity and the intention to use the solution direction (**Figure 2**). For all the solution directions at least two pilots were familiar with it and had the intention to use it. For the solution directions related to task 2.3-2.6 of the SEISMEC project at least 6 pilots intended to implement this technology. Solution directions that related to identifying the needs of the user (co-creation, lead-user innovation, participatory design, personas) were relatively popular as for all these methods at least 8 pilots indicated to use this solution direction in their pilot implementation. For the technologies, the AI related solution directions, explainable AI and human AI interaction were selected by 10 pilots to be implemented where the other technologies scored 6 or lower. 10 pilots responded to the second questionnaire (**Figure 3**). On average the pilots gave feedback on 10.5 solution directions. For approximately half of these responses (average 5) they indicated that they had intermedia or higher. Responses on the detailed and open questions about the familiarity and the intention to use the solution directions were used in the review process of this document.

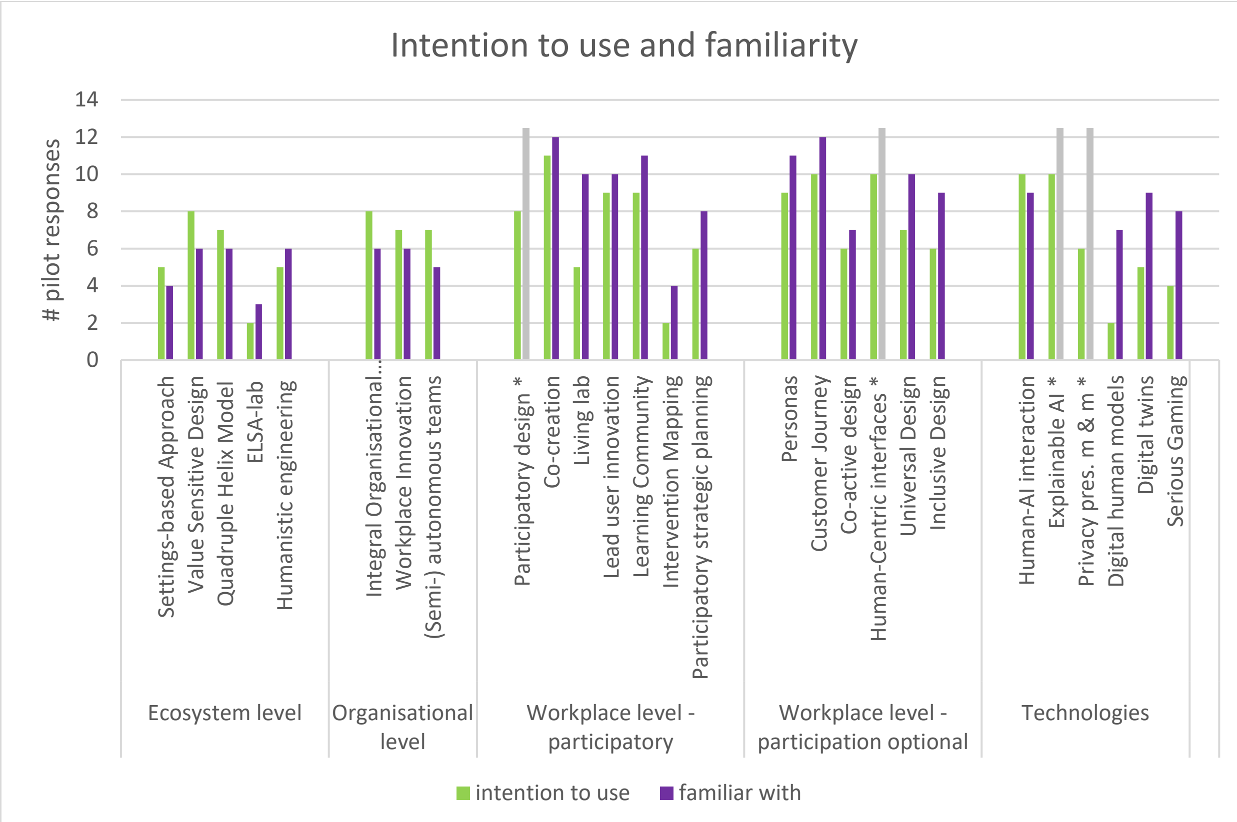

Figure 2. Intention to use and familiarity with the solution directions (N=15). Note that for the solution directions marked with an * no data is available on the familiarity. Familiarity was assumed because these solution directions are explicitly discussed in the SIESMEC grand proposal.

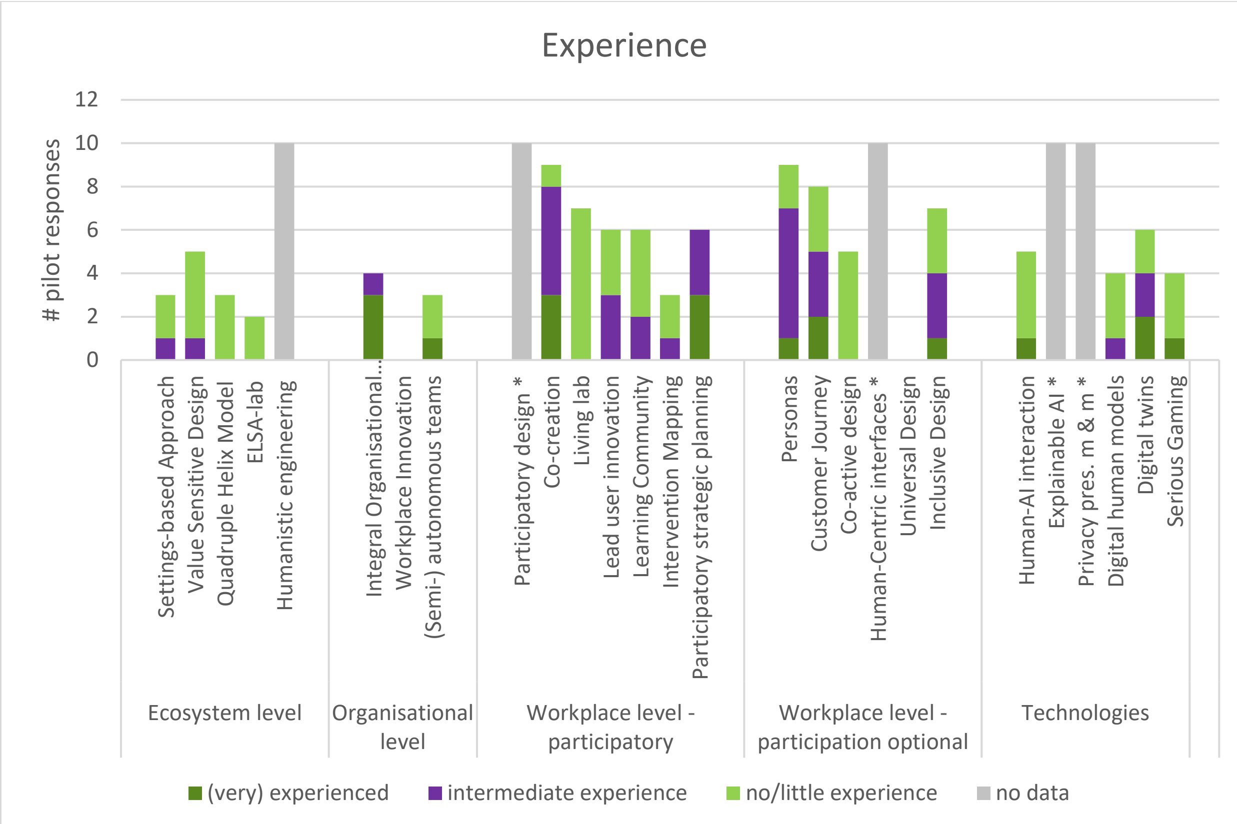

Figure 3. Experience with the solution directions. Note that for the solution directions marked with an * no data is available on the experience since support on these themes is available through task 2.3-2.6.

4 Instruments and assessment criteria

4.1 Human-centric Assessment Principles and Approaches

4.1.1 Understanding Human Behaviour for Human-centric Assessment through Ethnography

Human behavioural patterns are closely related to their cultural practices and the norms they share (Spradley, 2011; Frese, 2015). Understanding these requires an approach that captures meaning from within the community. Ethnography, in what Spradley (2011) described as the work of "learning from people", is a methodology and approach for narrating culture and generating context-rich insights into people's attitudes, behaviours, and interpretations towards their surroundings from their own point of view (Spradley, 2011; Reeves et al., 2008). Rooted in anthropological studies, in ethnographic approach, researchers immerse themselves in the social arrangements of specific communities over extended periods (Reeves et al., 2008). Owing to its immersive nature, ethnography is particularly valuable for capturing social interactions, cultural practices, behaviours, and perceptions of people within groups and organisations, enabling researchers to deeply engage and explore with how distinct groups perceive and interpret (Reeves et al., 2008). Within field work, ethnographers make cultural inferences from three sources: (1) from what people say; (2) from the way people act; and (3) from the artifacts people use, emphasising the phenomena into their meaning (Spradley, 2011).

Four frames of Ethnographic Approach for Human-centric Assessments

For developing human-centric technology, ethnographic measures and approaches should also consider capturing human perspectives, behaviour and interactions in a multi-dimensional framework. In diverse environments, across industries, or different research subjects of technologies, it is crucial to be capable of understanding the context beyond space. Boellstorf, et al. (2024)

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described four frames pertinent in ethnography which are relevant for developing human-centric assessment in diverse environments:

1. **Multi-sited: contextual and holistic understanding**
   Human societies have always involved migration, trade, and the exchange of ideas across distances. This frame encourages researchers to understand the perspectives, and practices of people in their natural settings to see each group how they see the world (Reeves, et al., 2008; Maxwell, 1990), and conceive of their field site holistically, across multiple sites, including physical and virtual (when necessary).
2. **Multi-method: flexible methodology and intersubjectivity**
   Ethnographic research is methodologically flexible. It encourages ethnographers to combine qualitative techniques such as participant observation and ethnography interviews (Spradley, 2011) with quantitative tools like surveys and censuses. Multi-method enables ethnographers to capture the complexity of human actions and interactions within their natural contexts. The key distinction lies not between qualitative and quantitative methods but in prioritising coherent narrative through experimental and field-based approaches, in order to provide as much of the living context as possible, rather than constant variables within controlled laboratory settings. Therefore, it offers balanced subjective and objectivite interpretations on the meanings and contexts of social interactions (Maxwell, 1990). This frame also provides flexibility for multiple perspectives, allowing the inclusion of new methods when it is necessary.
3. **Multi-authorial: reflexivity and collaborative knowledge**
   Multi-authorial means collaborative, not only among researchers but also with participants as co-creators. It values participation agency ofinterlocutors who contribute not only data but also frameworks for analysis and conduct fieldwork together as a team. It is also possible for ethnographers to collaborate as authors despite their absence in research activities.
4. **Multi-disciplinary: situated insights and non-generalisation**

Ethnography is inherently cross-disciplinary, united by its commitment to understanding people in context. This frame stems from the researcher's curiosity, values, and ethos. It is guided by questions such as 'How do they live, interact, and produce culture together?', 'What are their values?', 'How do they understand their experiences?', 'What stories do they tell themselves and each other about who they are?'. Therefore, it offers context-specific insight, recognizing that findings are not meant to be broadly generalized but to illuminate the complexity of particular settings and communities (Savage, 2000).

Framed by multi-sited, multi-method, multi-authorial, and multi-disciplinary principles, ethnography enables researchers to engage across diverse spaces and adapt to complex human realities. This approach supports the design of technologies and systems that genuinely reflect human values, needs, and perspectives.

Analysing Ethnographic Approach

Analysing ethnographic research can use qualitative analysis framework (Dumitrica & Pridmore, 2021) which includes:

1. **Rhetorical analysis**

   examines how various communicators, such as politicians, advertisers, and educators, use persuasive strategies to influence their audience. It examines the structure and composition of messages to reveal how semantic and structural elements achieve persuasive intent, helping individuals to critically understand and evaluate subtle messages in media.

2. **Semiotic analysis**

   Semiotic analysis is a well-established method that examines how meaning is created through signs and symbols. Rooted in Ferdinand de Saussure's work, it explores the relationship between reality, language, and meaning-making.

3. **Narrative analysis**

Narrative analysis focuses on understanding how stories shape and reflect the world, emphasising the structure and performative role of narratives. It interrogates whether stories are personal expressions or reflections of broader social circumstances. Though it provokes disagreement among scholars due to lack of standardised methods, essential elements in narrative analysis examine how stories are structured and used to convey meaning or reflect social values.

4. **Thematic analysis**

Thematic analysis is used to identify, analyze, and report patterns or themes within a data set. It involves systematically coding data, grouping similar codes into themes, and interpreting these themes to understand underlying meanings, experiences, or perspectives relevant to the research question. With its defined and systematic process, thematic analysis is one of the most widely used methods in qualitative research.

5. **(Constructivist) Grounded theory**

Grounded theory (Glaser & Strauss, 1967) is an inductive research method that develops theories directly from observed data rather than testing pre-existing theories. Initially, it emphasises the importance of researchers approaching their study with a 'tabula rasa' mindset to avoid biases, acknowledging the active role of both researchers and participants in shaping the data and analysis. Thus, it has evolved into a more constructive, flexible and heuristic approach rather than a rigid methodology.

6. **Discourse analysis**

Discourse analysis is a complex qualitative data analysis that applies various techniques for interpreting data, including interpretation on language use within social and cultural contexts. It draws on various analytical methods, such as conversation analysis and ethnomethodology, to offer a nuanced understanding of discourse. It also requires researchers to clearly define their analytical approach and consider studying published works to understand its practical application. Despite its complexity, it offers a comprehensive way to explore how meaning is constructed and linked to broader social structures.

The following chart (Dumitrica and Pridmore, 2021) will assist in determining the most appropriate approach for various research contexts. Each of these *'s represents the most common or useful methods of analysis and interpretation in relation to the different types of data collected:

	Words	Images	Moving images	Other symbols (open category)
Rhetorical analysis	***	**	**	*
Semiotic analysis	*	***	***	**
Narrative analysis	***	*	***	*
Thematic analysis	***	**	**	*
(Constructivist) Grounded theory	***	***	**	**
Discourse analysis	***	*	*	*

Figure 4. Type of data collected based on analysis method (Source: Dumitrica and Pridmore, 2021)

Given its deep attention to people's perspectives and lived realities, ethnographic approaches are essential for assessing human-centricity in real-world settings. Owing to its immersive nature, it is not only valuable for capturing social interaction and practices of people within organisation (Reeves et al., 2008) but also can investigate relationship between people and the infrastructures they are interacting with (Star, 1999). While evaluating human-centricity in diverse environment such SEISMEC requires understanding user's lived experiences within diverse industries and settings ethnography provides in-depth insights into social interactions, cultural practices, and how people make sense of their environments.

Related to SESMEC's objectives, Star (1999) presented the ethnography of infrastructure which provides in-depth insights of practices for multitude of interactions: among users, between user and system, and among the systems themselves. There are three trajectories of the ethnography of infrastructure (Star, 1999):

1. **Identifying Master Narratives**
   Systems often reflect master narratives that are presented by dominant assumptions and a single normative perspective, leading to marginalising diversity. Ethnographic analysis helps surface these hidden narratives by revealing what or who is rendered invisible or unnamed
2. **Surfacing Invisible Work**
   With any form of work, there are always overlooked labors involved in making systems function in practice. Ethnographic research surfaces these invisible works but requires careful observation and negotiation to make them visible without exposing it to misuse. Ethnography uncovers how visibility and invisibility are actively managed in socio-technical systems
3. **Paradoxes of Infrastructure**
   Seemingly minor obstacles in systems can disrupt workflows significantly because they disrupt the invisible, finely tuned articulation of work that users rely on to navigate complex tasks. Ethnographic insight shows that these 'tiny' barriers can either disrupt or improvise flow, showing why they are important to be examined.

4.1.2 Human-Factors for Human-centric Assessment

Human-centricity focuses on humans as the centre of technological, organizational, and design approaches (ISO 9241-210:2019). For assessment of whether the implications of technology are truly human-centric or not, it is essential to consider human-factors not only for end-user's feedback but also for stages such as the design, implementation, and evaluation process (Carayon, 2006). Therefore, there is a need to require a broader lens of human factors in assessment — which means our assessment not only captures individual experience and team dynamics, but also structural conditions at the workplace or organizational level.

Many of the studies, which are related to human-centric assessment, attempt to categorize assessments into intrinsic (human-internal) and extrinsic (contextual or systemic) factors (Carayon, 2006). However, because these factors constantly interact with one another in the real world, they are listed as critical elements that can be applied across different levels for assessment of human-centric systems, see **Table 1.** These factors can be applied across interface, team, and workplace levels, and are essential for ensuring systems are designed and evaluated in ways that align with human needs and capabilities.

	Definition	Assessment Rationale
Workload	The required mental and physical effort	Over workload increases fatigue and reduces performance and safety.
Physical/ Emotional Capability	The user's physical abilities and emotional state	Mismatch with workload can cause injury, or usability barriers
Situational Awareness	How well users notice what's happening around them	High situational awareness is important for decision-making
Error Susceptibility	The probability of making error	Effect productivity
Team/Collaboration Factors	Level of communication and Collaboration	Good teamwork reduces confusion and overload
Interpretive Clarity	The user's ability to understand symbols, labels, or messages	Clarity ensures correct action.
Trust in System	The user's confidence in the system's reliability and consistency	Trust influences user acceptance, reliance on automation, and safe decision-making.
Learning Curve	How fast users adapt to new technology	Shorter learning curves improve technology adoption

Table 1. A list of critical elements that can be applied across different levels for assessment of human-centric systems

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4.1.3 Humanistic Engineering: Human Value, Stakeholders Engagement, and Phases for a Holistic Assessment

Within Industry 5.0, technologies are critical elements to address underlying problems which may affect society and influence changes. However, in real-world practice, technologies often failed to address challenges due to lack of contextual understanding and alignment with human value (Bolton, 2022). **Humanistic Engineering** (Bolton, 2022) presents a vision of future where all of society benefits from technological advancement. It focuses on five main principles that require all engineering products to be: 1) human-centred, 2) accessible and inclusive, 3) sustainable, 4) democratic and 5) empowering. These principles correlate to SEISMEC's objectives which are to empower workers through human-centric solutions, understand and resolve tensions within organisation, define and test advanced technologies to enhance synergies between human and technology, as well as formulate evidence-based recommendation to relevant stakeholders, from line workers, companies, policy makers to EU innovation initiatives (DoA SEISMEC, 2024).

Based on humanistic engineering principles, assessing human-centricity requires a two-way engagement across all levels of stakeholders:

- Industrial level: include industrial econometric as one critical aspect to consider.
- Organizational level: focus on improving production efficiency, increasing profits, and expanding business.
- Employees level: provide a grounded understanding of on-field implementation and its implications for worker well-being and operational effectiveness.

Following the development of technology, responses from different stakeholders may also change over time. Therefore it is necessary to have assessment in three different phases of research:

- Preparation Phase,
- Action Research Phase,
- Evaluation Phase.

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The time frame of each phase is defined individually per pilot according to their context and stages of implementation.

In conclusion, to ensure a comprehensive assessment, it is recommended to apply ethnographic approaches combined with human-factors across multi-level stakeholders and throughout different phases of technology development. These approaches help reveal how technologies are integrated in daily practices, how workers interact with them, and how such interactions shape workers' behaviour, decision-making, and well-being. Incorporating these dimensions in an assessment framework ensures that evaluations capture both the technical performance and its broader impact on workers and organizational culture.

4.2 Human-centric Assessment Criteria within SEISMEC

SEISMEC adopts a human-centric assessment approach to ensure that technological innovations support worker well-being, autonomy, and productivity. In order to evaluate how well the technologies perform and interact with users, it is crucial to understand the criteria of human-centric assessments in a holistic approach, focusing on both the process and impact of implementation. It aims to evaluate how well technologies perform not only functionally but also in relation to human needs and organizational dynamics throughout the project. SEISMEC envisions the human-centric assessment criteria to be divided into:

1. Solution Direction Implementation process, done within a longitudinal period
2. Evaluation on Technological Implementation, done within a phased period

4.2.1 Solution Direction Implementation Process (Longitudinal Assessment)

The application of technology in an organisation may create tension between workers and organisations. T1.2 in SEISMEC identified 41 Solution Directions which represent a category of potential solutions to alleviate these tensions. Since Solution Directions are divided into six different categories (Ecosystem Level, Organisational Level, Workplace Level with end-user involvement, Workplace

Level without end-user involvement, Technological Level, and Ideation methods and others), their applications are diverse and complex. Therefore, their effectiveness can only be assessed over a period of time using longitudinal assessment. As such, the assessment on Solution Direction is guided by two criteria:

- **Relevance:** Was the chosen Solution Direction based on a clearly identified human-centric tension (i.e. whether worker's expectations and company demands are matched)?
- **Effectiveness:** Did the implementation of the Solution Direction alleviate that tension?

To answer these, there are three interconnected dimensions in assessing Solution Directions: procedural implementation, technical achievement, and alignment with pilot and SEISMEC Objectives.

4.2.1.1 Procedural Implementation

This component evaluates how closely the technology implementation process adhered to the planned approach outlined by the selected Solution Direction. Key questions include:

- Was the technology developed using the planned solution directions?
- Were sufficient resources available to support development?
- What unforeseen challenges, if any, impeded progress?

4.2.1.2 Technical Achievement

This component evaluates whether the implemented technology that is developed through the selected Solution Direction is achieving its intended functional goals. This dimension focuses on the effectiveness, reliability, and usability of the technology in real-world application. Key questions include:

- Did the technology perform as expected?
- Was it technically robust—such as providing accurate and interpretable AI outputs?
- Could end users operate the technology effectively in their daily tasks?

This assessment ensures that the solution is not only conceptually sound but also practically viable. Detailed criteria and their application are provided in section 4.2.2 Evaluation on Technology Implementation

4.2.1.3 Alignment with Pilot and SEISMEC Objectives

This component assesses whether the implemented solutions supported the broader goals of both pilot and the SEISMEC project as a whole. It examines whether the solution addressed key transversal themes such as cybersecurity, human trust, and system transparency. Key questions include:

- Were the Pilot and SEISMEC Objectives Met?
- Did the technology implementation meet the targets of the transversal themes?

The focus is on evaluating strategic impact beyond technical performance. Tools to support this evaluation are being developed under WP4 and Task 5.1.

4.2.1.4 Interdependency of Assessment Dimensions

It is important to note the cascading relationship between the three dimensions. If the procedural (A) is not executed effectively, it is likely to impact the technology achievement (B), which in turn may hinder the achievement of project-level goals (C). Therefore, a holistic assessment of Solution Direction shall be done in a longitudinal period to consider how shortcomings in one criterion may influence outcomes in others.

4.2.2 Evaluation on Technology Implementation (Phased Assessment)

To understand how well new technologies perform in real industrial settings, there is a need to evaluate them using clear criteria that reflect both technical implementation and user interaction. The goal is not just to assess whether a system works, but whether it works well for the people using it—in real environments, under real conditions. These criteria provide a conceptual foundation for evaluating the quality of new technologies across diverse industrial contexts and all pilot projects, ensuring consistency.

1. Interpretability and Clarity of System Behaviour

Interpretability is very important in environments where workers must interact with or act upon system outputs, particularly in AI-supported decision-making. Assessment focuses on whether the system provides sufficient transparency to enable users to understand its reasoning and limitations. Clear, consistent behaviour allows users to form accurate mental models of how the system functions, which is essential for effective and safe human-machine interaction. In AI-related implementations, interpretability supports accountability and user confidence, as demonstrated in empirical studies on explainable AI (Doshi-Velez & Kim, 2017). Systems that obscure internal logic or provide unintelligible outputs risk generating confusion, misuse, or resistance, especially in safety-critical or time-sensitive contexts. The assessment shall answer the concern:

- Can users understand the logic or reasoning behind the system's outputs?
- Are explanations provided in a format that is usable in real-time or field conditions?
- Do users rely more—or less—on the system after repeated exposure to its decisions?
- Are explanations matched to the user's role, experience level, and decision context?

2. Usability and Integration into Workflows

Usability is not only about interface design but also whether a tool supports the user's job without adding complexity. In real work industrial settings, users often work with different kinds of protective equipment, and under time pressure. Technology which requires multiple steps, difficult method of inputs, or constantly needs external instructions quickly become impractical, no matter how accurate it may be. Usability assessments should reflect the real pressures of the workplace—not just the technical performance under ideal conditions (Brooke, 1996). The assessment shall answer the concern:

- Can the system be used easily without disrupting the pace or sequence of work?

- Are the interface and physical design compatible with real-world conditions (e.g., PPE, noise, lighting)?
- Is training time minimal, and can users retain functionality with limited support?
- Does the system adapt to shift work, fatigue, and workspace?

3. User Trust and Confidence in System Performance

Trust is built—or lost—through everyday use. In real settings, workers form opinions about systems not by reading specifications but by seeing how systems behave under pressure, how they respond when something goes wrong, and whether they align with their own experience and judgment. It also may include confidence in the consistency of system outputs, the appropriateness of recommendations or alerts, and the system's ability to recover from or communicate failure. In the environment, where new technology plays a decision-support role, trust must be appropriately calibrated to system capabilities (Lee & See, 2004). Overtrust can lead to complacency or uncritical acceptance of outputs, while distrust may result in system rejection or non-compliance. The assessment shall answer the concern:

- Do users feel that the system supports rather than undermines their expertise?
- Are users able to predict how the system will behave across similar scenarios?
- Is trust damaged by false alarms, system failures, or lack of transparency?
- Can users intervene or override the system when appropriate?

4. Ethical Alignment and Data Privacy

Ethical alignment is a core assessment dimension, where technologies involve the collection of behavioural, physiological, or location data. Evaluation includes both compliance with applicable data protection regulations—such as the General Data Protection Regulation (GDPR)—and the degree to which users are informed and in control of how their data is collected, processed, and stored. Technology should demonstrate clear mechanisms for consent, data access, and withdrawal, especially in situations where user may be perceived as compulsory.

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Privacy protection should be embedded in the design of systems, not addressed post hoc (Gürses and Del Alamo (2016). The assessment shall answer the concern:

- Do users clearly understand what data is collected, and for what purpose?
- Can users access, manage, or withdraw their data if needed?
- Are mechanisms clear and continuous?
- Does the system reinforce or challenge the perception of workplace surveillance?

These criteria offer a solid starting point for assessing human-centric technology. But in practice, assessment isn't something fixed, it changes and develops as the project unfolds. As systems are prepared, implemented, tested, and gradually embedded in real industrial settings, both technical performance and impact on users can shift in different ways. To keep up with these changes, it's important to carry out assessments throughout all phases of the pilot project—Preparation, Action, Research, and Evaluation. The next chapter outlines a set of recommended assessment Instruments and explains how they can be used effectively at each stage.

4.3 Instruments for Human-centric Assessment of SEISMEC

4.3.1 Five (5) Umbrella Instruments of SEISMEC

Rohrer (2022) has listed 20 popular instruments for user research and categorised them into a three-dimensional framework, qualitative vs. quantitative but also attitudinal vs. behavioural and context of use.

1. Qualitative vs. Quantitative

Quantitative research focuses on numerical data collection and analysis, using predefined methods like surveys with closed questions and statistical techniques such as averages and regression analysis. In contrast, qualitative research emphasizes narrative data, using open-ended questions, interviews, and case studies to explore deeper meanings and individual cases. While quantitative research typically involves large, random samples and measurable indicators, qualitative research employs purposive sampling and broadly defined indicators to understand the "how" and "why" of phenomena. Data in quantitative research is processed automatically as numbers, while qualitative data is stored as words or reports and involves less automated processing.

2. Attitudinal vs. behavioural

Attitudinal and behavioural are framed by contrasting "what people say" (attitude) with "what people do" (behaviour). Attitudinal research generally focuses on understanding or measuring people's stated beliefs, but its limitations lie in the extent of people's self-awareness and their willingness to share. Attitudinal leads to self-reported information or responses regardless of whether the data is either qualitative or quantitative. For instance, surveys are useful for measuring and categorizing attitudes or identifying issues to address, and focus groups can provide immediate insights into people's perceptions of a product or brand in a group setting.

On the other hand, behavioural aims to understand "what people do" to see their natural response without any intervention within the environment or setting. For example, eye-tracking studies observe how users visually engage with a design or visual stimulus, offering insights into how they interact with the product in real-time. These methods prioritize actual user behaviour, providing a deeper understanding of how design choices affect interactions.

3. Context of use

The context of product use in user research can be categorized into four distinct types.

- **Natural or near-natural use:** involves observing participants as they engage with the product in their usual environment, with minimal interference from the researcher—this approach maximizes ecological validity but offers less control over specific variables.
- **Scripted use:** refers to studies where participants follow predefined tasks or flows, allowing researchers to focus on particular product features or usability issues; the level of scripting can vary depending on the study's goals.

- **Limited product use:** occurs when only parts or abstracted elements of the product are tested, often in early design phases—for example, participatory design exercises, concept testing, or card sorting, which help refine elements like structure and value propositions without requiring a full product.
- **Non-usage contexts:** involve studies where the product isn't used at all, such as brand perception research or visual design preference tests; these help uncover broader user attitudes disconnected from actual product interaction. Many research methods can shift across these categories depending on how they are designed and executed.

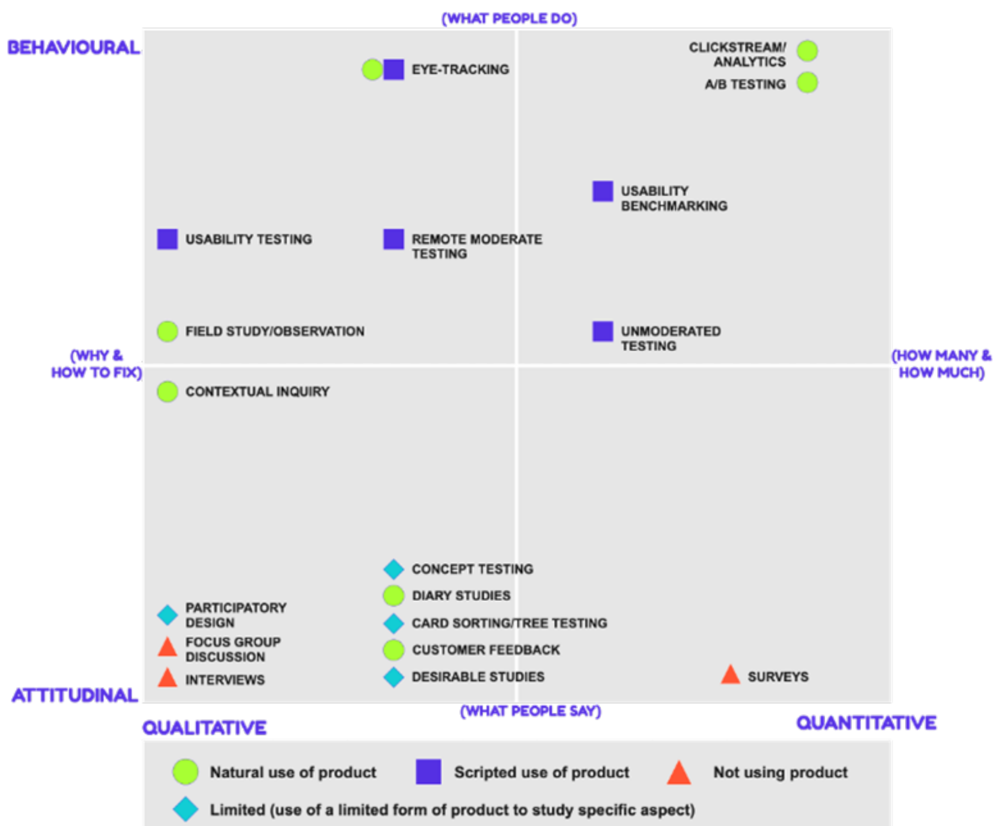

Figure 5. Assessment instruments quadrant (Source: Rohrer, 2022 with redesign)

SEISMEC project works on diverse nature of industries, countries, cultures, type of stakeholders, and regulations. Therefore, it is necessary for the assessment instruments to cover the diversity in more general and clustered approaches. Accordingly, there are 5 (five) umbrella instruments for assessment that are selected for SEISMEC: **(participant) observation, (ethnographic) interview, survey, participatory behavioural assessment and diary studies.** For a visual overview of these umbrella instruments, see **Figure 6**.

5 Umbrella Instruments of SEISMEC

	Type	Number of opt. active participants	Optimum time required	Suitable for gathering
Observation	Qualitative, behaviour	(n/a)	flexible	Activity / routines
Interviews	Qualitative, attitude	< 30 people	45 – 60 min/ session	Experience / phenomena / feelings
Surveys	Quantitative, attitude	> 100 people	< 20 min	Quantifiable responses
Participatory behavioural assessment	Quantitative, behaviour	Tbd per technology	Tbd per technology	Comparative study
Diary Studies For pilots	Qualitative, attitudinal	All Pilots	Throughout the project	Longitudinal study

Figure 6. A visualization of the 5 umbrella instruments of SEISMEC

4.3.1.1 (Participant) Observation

Observation involves systematically watching and recording user behaviour in real-world or simulated settings without direct interference. In human-centric assessments, this method allows researchers to identify unspoken needs, contextual limitations, or mismatches between design assumptions and actual user behaviour. It is especially effective in capturing extrinsic human factors (e.g., workflow patterns, environmental stressors, ergonomic issues) that may not be self-reported. Observational methods are particularly valuable in the exploratory or contextual inquiry phase, where the goal is to develop an in-depth understanding of how users interact with technology or processes in natural settings.

Gray et al. (2010) in the book "Game-storming" introduced 7Ps which can be used to structure important aspects during observation:

- Purpose: What are the problems? Why is it important?
- Product: What are the potential technologies to develop/research?
- People: Who will take important roles? (participants, decision makers, stakeholders)
- Process: What steps are needed to develop the research?
- Preparation: What materials are needed to be prepared for the research?
- Practical concerns: How to do the research? When to do it?
- Pitfalls: Are there any risks? How to prevent that?

Pillar	Key Focus	Example Questions or Prompts
Purpose	What are the problems? Why is it important?	• What behaviours or interactions are we trying to understand?
		• Why is this relevant to technology design or worker wellbeing?
Product	What are the potential technologies to develop/ research?	• Which tools, machines, or digital systems are being used?
		• How do workers interact with these technologies?
People	Who will take important roles? (participants, decision makers, stakeholders)	• Who is doing the work, and who is supporting/overseeing it?
		• How do roles and responsibilities affect observed behaviour?
Process	What steps are needed to develop the research?	• What are the sequences of actions?
		• What things that might cause delays, workarounds, or bottlenecks?
Preparation	What materials are needed to be prepared for the research?	• Consent forms, observation checklists, PPE, context briefing
		• Do you need translations or technical background knowledge?

Practical Concerns	How to do the research? When to do it?	• Duration of each session, time of day, number of observers
		• How many places / areas will be covered?
Pitfalls	Are there any risks? How to prevent that?	• What kind of risks might happen during research (i.e. misinterpretation, discomfort, distraction, bias, or data loss)? How to prevent it?

Table 2. Example of questions or prompts following on 7Ps Framework (Source: Gray, et al., 2022 with adjustments)

The full list of (participant) observation protocol is available in Appendix C

4.3.1.2 (Ethnographic) Interview

Interviews are important to capture in-depth experiences, values, concerns, and expectations of the participants in a dialogue form. It can involve from 1 participant to number of participants, depending on the scale of the studies. There is no maximum number of participants for interview, thus important to see the saturation of the data[7] to know whether goal of the research met. Some researchers generally aim for having at least 20 participants (Horsburgh, 2002), doctoral theses often involve around 30 people (Dumitrica & Pridmore, 2021), some can have hundreds (Horsburgh, 2002).

To understand diverse contexts, SEISMEC intend to apply ethnographic interview method (Spradley, 2011) within structured and semi-structured formats to help contextualize tensions and reveal ethical concerns that may not emerge through

[7] Saturation of data is achieved when there are no longer new insights or start hearing same reflections repetitively or have reached a point where answers, practices can be anticipated in different interviews (Boellstorf, 2024).

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quantitative tools. There are several elements critical and necessary to be considered prior doing the ethnographic interview (Spradley, 2011):

- **Context and culture:** The culture is derived into behavioural pattern and customs. It is important to do general research to get an idea of shared knowledge of the participants and their customs in the field prior to do interview. It also aims to synchronise the expectation and limitation of the interviews.
- **Language and Field work:** Language is more than a way to communicate, it is also tool to construct reality. A crucial question is *"What language shall I use for asking questions?"*. In this sense, it is not only about whether it uses English or other languages, but also about the diction, type of vocabulary and the verbal expression that can be understood to the participant and whether the participant has their own words to best express the answer.
- **Informants or Participants:** Informants are essentials to gather the right information. Therefore, it needs planning and sensitivity in identifying the suitable characteristic of participants in interviews. In understanding technology implementation, interview participants can differ from end users, supervisors, managers, designers, even high-rank such as directors, depending on type of questions and the type of information that want to be discovered

Interviews are relevant in every research phase from beginning to the end, which enable formative and summative insights into user experiences with technology or systems in different period of time.

Questions type

There is no rigid technique to form questions for interviews, and they are mostly contextually made. Nevertheless, these two types can be used to help structuring interview questions:

1. **Empathy map (Gray et al., 2010):**

Inteview questions are based on participants' sense (what they see, what they hear, what they say, what they think, what they feel, what they do). It aims to capture and understand the individual experiences, concerns, challenges, wishes of users or participants. Examples:

- [See]: Have you noticed any impact—positive or negative—on your team's mental or emotional workload when using (X)?
- [Hear]: When you and your peers talk about the (X), what are positive and negative things that you can describe?
- [Say]: How do you usually give feedback at work?
- [Think]: How do you think your participation has impacted the final product/technology?
- [Feel]: How do you feel when making decisions or solving problems during your interaction with (X)?
- [Do]: Are there any features or ways of interacting with the system that you now use more often? What made you start using them?

2. **SWOT analysis:**

Interview questions are based on strength, weakness, opportunity, threat of current and/or potential development. It is used to capture four aspects of new technologies that will be implemented. Examples:

- [Strength]: What support, tools or resources of your organisation that facilitate more effective and meaningful worker participation?
- [Weakness]: What are challenges in current technology and what risks do you foresee with integrating new technologies?
- [Opportunity]: What opportunities have you had to influence the design of the technology?
- [Threat]: How do you foresee the concerns about resistance or acceptance among your peers regarding (X)?

The full list of (ethnographic) interview protocol is available in Appendix C

4.3.1.3 Survey

Surveys are structured instruments that collect standardized responses from a large group of participants. The number of sampling participants will depend on how large the total of target population to represent. Martinez-Mesa, et al. (2014) presented the examples on calculating sample size in different scenarios. However, for a small population (100 or less), it may be useful to include everyone in the study, like in a census (Martinez-Mesa, et al., 2014). The used formula for calculating the sample size is available online[8].

The type of survey that may be used in SEISMEC:

- multiple choices: help to learn the top answer of respondents by forcing a clear decision on the question.
- Likert scale: psychometric rating scale to measure opinions, attitudes, or behaviours. Usually consist of 5-7 answer statements that best corresponds to the participants' feeling.
- Open-ended question: free-form survey that allows and encourages respondents to answer in open-text format

They are often used to quantify perceptions, experiences, or attitudes, and other variety of human factors. Several aspects that can be measured using survey are shown in **Table 3**.

Trust and Understanding	Human-Computer Trust Model (Gulati et al., 2019)
	Trust in Technology (McKnight et al., 2009)
	Trust in AI (Choung et al., 2022)
Understanding	TAM Perceived EoU (Davies, 1989)
	TOAST Scale (Wojton et al., 2020)

[8] https://www.calculator.net/sample-size-calculator.html

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Fairness	Outcome Fairness (Jiao & Zhao, 2014)
	Procedural Fairness (Jiao & Zhao, 2014)
	Implementation (Jiao & Zhao, 2014)
Co-design	Worker Co-Design (NWO Intrap, 2018)
Productivity	TAM Perceived Usefulness (Davies, 1989)

Table 3. Aspects to be measured in survey

Examples:

Scale:

1 – Strongly Disagree

2 – Disagree

3 – Neither Agree nor Disagree

4 – Agree

5 – Strongly Agree

- CAPS factor – Employee level:

Automation					
Item	**1**	**2**	**3**	**4**	**5**
I have the opportunity to choose which tasks in my work are automated.	☐	☐	☐	☐	☐
I am involved in evaluating the impact of automation on my daily tasks.	☐	☐	☐	☐	☐

- Transversal analysis – Trust and Understanding

Human(X)Computer Trust Model (Gulati et al., 2019)					
Item	**1**	**2**	**3**	**4**	**5**
I believe that there could be negative consequences when using (X)	☐	☐	☐	☐	☐
I feel I must be cautious when using (X)	☐	☐	☐	☐	☐
It is risky to interact with (X)	☐	☐	☐	☐	☐

In human-centric assessment, surveys are valued for their scalability and ability to identify patterns or correlations across populations. They are most relevant during the action research and evaluation phases, where quantifiable data is required to compare groups, interventions, or progress over time.

The full list of survey protocol is available on the link in Appendix C.

4.3.1.4 Participatory Behavioural Assessments

Participatory Behavioural Assessments are ways of learning how humans use new technologies in action during their normal work. These methods aim to uncover patterns of human behaviour that signal usability issues, cognitive stress, inefficiencies, or emotional responses (Darin et al., 2019; Vermeeren et al., 2010; Rohrer, 2022). An overview of the methods can be found in **Table 4**.

Method	Behavioural Focus	Data Collected	Implications
Task-Based Usability Testing	Observable interaction patterns (e.g., hesitation, trial-and-error, error correction)	Task completion time, error types, navigation behaviour, help requests	Identifies usability breakdowns
Eye-Tracking Studies	Visual attention, fatigue and cognitive effort during interaction	Fixation duration, gaze paths, attention heatmaps, re-fixations, blinks	Reveals attentional load, spatial confusion, and visual prioritization; informs layout, visual hierarchy, and perceptual ergonomics
Performance Metrics	Task execution behaviour (e.g., fluency, speed, consistency)	Success rate, time-on-task, error frequency, steps taken	Provides quantitative insight into workload, task complexity, and efficiency; supports evidence-based iteration of interaction design
NASA-TLX (Task Load Index)	Perceived behavioural demands and task strain	Ratings on mental, physical, and temporal demand, effort, frustration	Guides cognitive load calibration
Wearable Device Logging	Embodied behavioural signals related to stress, fatigue, or attention	Heart rate variability, skin conductance, motion/posture, gesture frequency	Enables affective state detection

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Table 4. Aspects to be measured by Participatory behavioural Assessments

The full list of participatory behavioural assessment protocol is available in Appendix C.

4.3.1.5 Diary Studies

Diary studies aim to document participants' urs, thoughts, and experiences relevant to a product or service using tools like journals, digital devices, as well as occupied with prompts or open-ended entries. These studies focus on capturing data over time in natural contexts (Bolger, 2003; Ohly, et al., 2010). There is no specific requirement for the study participants, but range is typically over 10 to 30, especially if it is combined with statistical analysis (Ohly, et al., 2010). Diary studies support human-centric assessment by providing a longitudinal lens on how technologies are affecting the participants. They are best suited for assessing the implementation and follow-up phases, help researchers evaluate ongoing human-technology interactions in dynamic contexts.

In the context of SEISMEC, diary studies may be used in two forms: Pilot Diary Log and Pilot Journey.

4.3.2 Research Phases

There are three key phases—Preparation, Action Research, and Evaluation—with each phase calling for different ways of assessing how technology is used and how users interact with it, see Figure 7. The instruments are not applied uniformly across all pilots; rather, their use is tailored to the complexity of the system, the type of user interaction involved, and the ethical context of each deployment. However, each phase includes a set of recommended instruments that support both qualitative and quantitative assessment of key human-centric dimensions.

Figure 7: Assessment phases in SEISMEC

4.3.2.1 Preparation phases

At this point, the technology hasn't been rolled out yet, so the focus is on getting a good understanding of the setting it's meant for. Before bringing any new technology into the workplace, it's important to look at how people do their jobs, what matters to them, how their workflows are set up, what the space is like, and what worries they might have, like being watched too closely or having to deal with something overly complicated. This phase support early ethical alignment and ensures the system fits within physical, cognitive, and social realities of the workplace (Suchman, 2007). These values and concerns must be considered at all levels of the organization.

Instruments recommendation:

- **Observation**: Identify workflow constraints, space limitations, informal routines, team dynamics and organization culture
- **Interview**: Reveals expectations, worries, and past experiences with technology
- **Survey**: Gathers baseline data on trust, digital literacy, and openness to new tools.

4.3.2.2 Action research phases

In the next phase, the aim is to capture real-time user behaviour, adaptation, and emerging challenges during live use in real work environments. This is very

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important to observe how a new technology interacts with human behaviour under operational conditions. This is very important to understand what's working and what's not.

Instruments recommendation:

- **Participatory Behavioural Assessments**: Track attention, mental- physical load, and performance through eye-tracking, task-time logging, or wearable devices
- **Post-Task Interviews**: Clarify reasons behind behavioural patterns (e.g., "Why did you skip this step?").
- **Micro-Surveys**: Capture short-form feedback during or after system use without interrupting workflow.

4.3.2.3 Evaluation Phase

After users have spent some time using new technology, this is very important to asset a long-time effect of technology. This phase looks at the bigger picture—was the technology adopted, or did the user do not want to use it anymore? Understanding what technology means to users in the long run is the main key of the project. It's not just about whether the technology works as expected or not, but how it's felt over time and what kind of impact it's had (Rogers, 2003).

Instruments recommendation:

- **Observation**: Documentation of how users use the technology in practice (e.g., avoidance of alerts, unacknowledged prompts).
- **End-of-Pilot Interview**: assess perceived long-term impact (e.g. "Looking back, how did the system affect your work and confidence over time?")
- **End-of-Pilot Survey:** supports summative evaluation across time (e.g. "Would you use it again?").
- **Diary Studies**: Capture long-term effectiveness, emotional or behavioural shifts during using technology in pilots (e.g., weekly logs from pilot showing increased or decreased reliance on the system).

The structured assessment of human-centric technology relies on the deliberate combination of evaluation criteria, methodological instruments, and project phases. Each criterion—such as interpretability, usability, trust, and ethical alignment—must be examined through instruments suited to the specific context and stage of implementation. Observation, interviews, surveys, and behavioural assessments and diary study could provide important insights into new technology when applied at different stages of the project. By aligning these instruments with the three key research phases—Preparation, Action Research, and Evaluation—it can capture both immediate and longer-term impacts. However, the selection of instruments and primary criteria depends a lot on the unique goals and context of each pilot. It's important to have these discussions on early communication, so everyone is aligned before technology is introduced in the field. An example of how this alignment could be achieved in practice is presented as a use-case example in section 4.4.1.

4.4 Application Example of Human-centric Assessment

4.4.1 Case study

A pilot works in logistics wants to improve the productivity of workers in shopfloor as well as empower the workers. They are using AI-generated voice-command device to support their work-flow in the warehouse and wonder how their goals can be reached within their current system.

- Aim: to explore the current user journey and user experience, including challenges and benefits of the current system as well as expected improvements from users for new technologies.

Phase 1: Preparation Phase

1. **Observation (Table 5):**

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Pillar	Example Questions or Prompts
Purpose	• What interactions between workers and voice-command that are needed to be improved? • In which way productivity can be improved?
Problem	• What are gaps in the system usability? • How is the workers' critical experience when using the voice-command?
Product	• What tools and digital systems are being used for voice-command device? • How do workers interact with these technologies?
People	• Who are the stakeholders? • How do roles and responsibilities affect the observed behaviour of workers? • How many participants are realistically involved?
Process	• What are the sequences of work-flow and user-journey? • Which methods will be used? (ex. Interviews)
Preparation	• Context briefing with the company • administrative files (i.e. consent forms, NDA), voice recorder, camera, interpreter (if necessary), list of questions
Practical Concerns	• Schedule/itinerary • duration of each research session
Pitfalls	• Could the observation cause discomfort or distraction? • Are there risks of misinterpretation, bias, or data loss?

Table 5. Example questions for initial observation

2. **Interview**

Example Questions:

- Could you walk us through your current interaction with voice-command device at your workplace?

- What are important concerning factors that affect how you work when using voice-command device?
- What improvements / benefits do you expect (X) to bring to daily work (e.g., tasks, safety, or wellbeing)?

Example conclusion of Preparation Phase:

The preparation phase revealed usability gaps in the current voice-command system, such as unclear prompts, slow responses, and limited adaptability to user needs. These issues affect both productivity and user experience. Workers expressed the need for more responsive, intuitive, and supportive interactions that align with their tasks and working styles. To achieve pilot's goals, user journey and workflow integration of the voice-command device must be improved, with a focus on adaptability, usability, and worker empowerment.

Phase 2: Action Research Phase

1. **Participatory Behavioural Assessments:** Use wearable devices to track:
    - GPS location and movement: evaluate task coverage and efficiency
    - Heart rate: detect signs of physical or cognitive load
    - Stress indicators: detect stress while using a system
2. **Post-Task Interviews:**

    Example question:

    - Usability & Workflow Integration
        - Can you walk me through how you used the system during your task?
        - Were there any moments where it felt difficult or unnatural to interact with the system? Can you describe what was happening?
        - How did the system fit into your usual way of working? Has anything disrupted your workflow?
    - Trust & Confidence
        - How did it feel to use voice commands during your tasks? How is your confidence and comfort when interacting with the system?

  - Can you share an example of a moment that made you trust the system more—or less?
  - What made you feel confident (or not confident) in relying on the system during your work?
- Interpretability
  - How did the system communicate back to you? Can you describe how you understood its responses?
  - Were there any moments when you were unsure what the system was doing or what it meant? What did you do in those situations?
- Cognitive & Emotional Load
  - How did it feel to use voice commands during your tasks—mentally, emotionally, or physically?
  - Were there parts of the interaction that made you feel stressed, tired, or frustrated? Can you describe what was happening?
- Improvements
  - If you could change one thing about the system, what would it be—and why?
  - What would help the system work better for you?

The action research phase provided a critical window into how workers interact with the new version of AI-generated voice-command system under real operational conditions. By combining wearable device data with post-task interviews, the assessment captured both objective behavioural indicators and subjective user experiences of new version.

Phase 3: Evaluation Phase

1. **Observation:**

- Are there some commands being ignored?
- Do workers show signs of trust in the system's decisions?
- Has the frequency of repeated commands decreased compared to old version?
- Does the upgraded version lead to increased productivity among workers

2. **End-of-Pilot Interview/Survey**

The goal of interview was to determine whether the upgrades—such as better voice recognition, faster response times, and clearer prompts—led to sustained improvements in trust, workflow efficiency, and user satisfaction on long-term changes. Example questions:

- Improvements:
  - Since the new version was introduced, how has your experience with the system changed?
  - Can you describe any differences you've noticed—positive or negative—while using it in your daily tasks?
  - Thinking back to problems (i.e. misrecognition or slow responses), how have those issues changed for you?
- Usage Behaviour
  - Are there any features or ways of interacting with the system that you now use more often? What made you start using them?
  - Was there anything you avoided before that feels more comfortable now? Can you explain why?
- Workflow
  - How has the system affected the way you do your tasks now compared to before?
  - Can you describe a time when the new version helped you finish something faster, or maybe slowed you down?
- Trust and Emotional

        - How has your sense of trust in the system changed over time? Can you share an example of when you felt more or less confident using it?
        - How does using the system make you feel emotionally—less stressed, more frustrated, more supported? Has that changed with the new version?
    - Remaining Issues
        - Have you noticed any new challenges or issues with the system since the update?
        - Is there still any part of the system that doesn't work well for you? Can you describe a time that happened?
    - Willingness to Continue
        - How do you feel about continuing to use the newer version in the future?
        - If you could improve the system further, what would you like to see changed or added?
- **Diary entries**: user showed clear signs of with the upgraded system over weekly log
    - Growing confidence
    - Drop in frustration and negative emotional

In the evaluation phase, the main goal of assessment is the long-term impact of the new version of AI-generated voice-command, which was made in response to insights from the Action Research Phase.

4.4.2 An Actionable Result and Intersubjectivity for Human-centric Technology

Human-centric assessments aim to uncover what is embedded in people's lived experiences and whether the technologies being developed address their real concerns. The instruments and criteria used — whether in a different context of use, qualitative or quantitative methods, and behavioural or attitudinal approaches— are tools to help achieve this understanding. Regardless of the method, the key objective is to produce actionable results and foster

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intersubjectivity (J. Pridmore in expert interview, April 9, 2025). Intersubjectivity refers to the shared understanding among individuals performing similar roles or working in similar contexts. While individual experiences may vary, common patterns often emerge, especially in workplaces where people use the same technologies under similar conditions.

Ethnography plays a critical role in this process by capturing both the shared experiences of the majority and the unique perspectives of minorities whose voices might be overlooked. It also enables researchers to grasp these nuances in ways that quantitative methods may miss, helping ensure that technological solutions are inclusive and contextually adaptable. An assessment phase is considered complete when data saturation is reached, which is when enough meaningful, consistent data is collected. At this point, the findings can be synthesized to form strong, evidence-based conclusions and a robust foundation for human-centric technological improvements.

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5 Conclusions

D2.1 offers descriptions, guidelines and a practical roadmap for organisations aiming to implement and assess novel technologies in a way that empowers human-centric work in the industry. D2.1 can be used in the SEISMEC project to support pilots with selecting the proper solution direction, implementing the solution direction, and assessing the effectivity of the solution direction. The full descriptions of the solution directions and their guidelines can be found in the separate appendix, Appendix B. On the other hand, the full list of prompts and questions for Research Protocol in order to assist the assessment can be found in the Appendix C.

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7 Appendices

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7.1 Appendix A – Interview protocol

SEISMEC WP 1.2 and 2.1 – Expert Interviews

Introduction

Thank you for your willingness to participate in the SEISMEC interview about solution directions and design guidelines for a human-centric application of new technologies. Within SEISMEC, we define human-centricity as making people's needs the most important priority in the design of jobs and organisations, management decisions and problem-solving strategies.

We will conduct interviews with multiple experts. In this interview we're specifically interested in the knowledge from your field of work. Together with the response from other participants we will build a comprehensive set of solution directions and design guidelines for human-centric application for (digital) technology.

With this writing we would like to inform you about the interview procedure and share the interview questions. We would appreciate it very much if you reviewed the questions before the interview.

First, we would like to know more about the kind of work that you do and where your focus is on. Second, we will discuss the role of human-centricity in your work. Third, we would talk more in detail about the potential solution directions that ensure an effective and sustainable implementation of a new technology. Solution directions are methods and best practises that aid the human-centric implementation of a new technology. Then, we will try to find out what critical factors someone needs to take into consideration when implementing a new technology. Finally, we will ask about other important work areas to consider and to interview experts about.

In total, this will take about 1 hour.

Questions

1. Tell me about your job: what are the key things that you do and how do your support your organisation?

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2. What role does human-centricity play in the work that you do?

In the following questions, we use the term “implementing” as a combined term for the process of selecting, implementing and adopting a new technology within an organisation.

3. Can you think of solution directions which help to implement a technology in a human-centric manner? Can you recommend literature on these solution directions?
4. Regarding these solution directions: what are the critical factors (do’s and don’ts) to aid a human-centric implementation of new technologies in organisations? How do these affect the success of the implementation?
5. Are you aware of other solution directions that exist or experts that we should contact for our research?

End

That is all for now, thank you very much for your participation. We would like to let you know when we have implemented your input into the design guidelines, and would come back for a quick feedback on whether we have integrated this correctly. Are you okay with that?

7.2 Appendix B – Extended descriptions of solution directions and design guidelines (TNO)

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1 Ecosystem level (work-life balance)

1.1 Settings-based approach

General description

A settings-based approach to healthcare focuses on the various environments where people live, work, and play, making these contexts the primary targets for health promotion and intervention (Poland, Krupa, and McCall, 2009). All the components that make up a whole system are considered in a settings-based approach and integrating them could minimize risk factors and conditions that contribute to disease (Neufeld & Kettner, 2014). By addressing the specific needs and capacities of individuals within these different settings, this approach can enhance the effectiveness of health initiatives (Poland *et al.*, 2009). Interventions should not only focus on influencing the people within the setting but also on how the setting itself can become more health-promoting. This involves making changes to the physical, organisational, and social environments to create conditions that support health and well-being (Poland *et al.*, 2009). As the real-life (social) contexts are considered, as opposed to patients in isolation, the solutions are better aligned with their needs, thereby enhancing human-centricity.

Application

The settings-based approach is a paradigm designed for health promotion and is thus applicable to health-related contexts. An example application is health promotion at the workplace for individuals with an intellectual disability, which is extensively described in Joyce (2024). By adopting a settings-based approach the focus shifts from interventions aimed at individuals to creating an inclusive and supportive environment that enhances socialisation and mental health. This can include implementing accessible wellness programs, introducing clear communication channels and policies, or supporting peer support networks to empower workers with varying cognitive abilities.

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Referral to transversal themes

Trust and understanding: using a settings-based approach for intervention development increases the chances of a successful implementation. Through stakeholder involvement, the intervention could be more tailored to the target group and thereby enhancing the success of the intervention.

Design guidelines

- **Take differences and similarities across types of settings into account.** Understanding the differences and similarities across various types of settings is crucial for tailoring interventions. For example, schools, workplaces, and hospitals each have unique characteristics and standardized structures. Recognizing these differences helps practitioners initially orient themselves to a setting and appreciate the diversity within it. This understanding allows for more effective and context-specific interventions. Look into physical, built, and psychosocial environments within a setting helps identify health risks and potential targets for intervention. Key stakeholders from different settings, such as school administrators, workplace managers, and hospital staff, should be involved in this analysis. Recognize the impact of race, gender, class, and age differences of participants. These differences can significantly impact the dynamics within a setting. A health promotion specialist can guide the process, ensuring that all relevant factors are considered (Poland *et al.*, 2009).
- **Account for the temporal patterning of behaviour.** When designing interventions, it is essential to consider the temporal patterns of behaviour within the setting. Different seasons of activity, seasonal deadlines, production cycles, and the distinction between business and after-hours uses of the space can all impact the effectiveness of an intervention. By accounting for these temporal variations, practitioners can better align their strategies with the natural rhythms of the setting, ensuring that interventions are timely and relevant. This approach helps in maximizing the impact of

health promotion activities by synchronizing them with the setting's operational cycles (Poland *et al.*, 2009).

- **Look for unanticipated effects and unintended consequences.** Interventions can have both positive and negative unintended consequences. It is crucial to anticipate and monitor these effects to adjust strategies as needed. This involves being vigilant and responsive to changes that occur as a result of the intervention, ensuring that any negative impacts are mitigated and positive outcomes are maximized. Regular evaluation and feedback mechanisms are essential to identify these unintended consequences early and make necessary adjustments to the intervention plan (Poland *et al.*, 2009).
- **Be reflexive regarding ethics associated with actions, assumptions, and use of power.** Ethical considerations are paramount in any intervention. Practitioners should be reflexive about their own actions, assumptions, and use of power, and expand this reflexivity to include others involved in the intervention. This involves critically examining the ethical implications of decisions and actions, ensuring that interventions are conducted with integrity and respect for all participants. By fostering an ethical practice, practitioners can build trust and credibility, which are essential for the success of health promotion initiatives (Poland *et al.*, 2009).
- **Develop a coherent, but nonlinear, ecological logic model.** Creating such a model helps summarise how an intervention addresses the determinants of health in a setting. This model links specific intervention strategies to intermediate and longer-term outcomes, as well as to the stability and ongoing core functions of the setting. It provides a comprehensive framework for understanding the complex interactions within the setting and guiding the intervention process. This approach ensures that all aspects of the setting are considered, leading to more holistic and sustainable health promotion strategies (Poland *et al.*, 2009).
- **Engage participants in the process and address a variation of topics to deepen the social analysis of root causes that affect their health.** Moving from personal and individual perspectives to organisational, community, and

societal contexts ensures that interventions are grounded in the lived experiences of participants and address broader determinants of health. This participatory approach fosters ownership and empowerment among participants, enhancing the likelihood of success (Poland *et al.*, 2009).

- **Link across and beyond settings.** Interventions should consider the broader context and link across different settings. This involves identifying relevant stakeholders and influences outside the immediate setting and understanding the role of the broader sociopolitical context. Higher-level policy change and advocacy work may be necessary to support and sustain interventions. By linking across settings, practitioners can create more comprehensive and impactful interventions. This approach ensures that health promotion efforts are not isolated but are part of a larger, coordinated strategy to improve health outcomes.

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1.2 Value sensitive design

General description

Value sensitive design (VSD) is a design philosophy similar to the other human-centric design disciplines like humanistic engineering. Similarly, it follows the latest developments of design approaches in which ethics play an important role.

VSD is a theoretically based approach to designing technology that systematically and comprehensively considers human values (Friedman, 1996). It is about the creation of technologies that are not only functional but are also ethically sound and in line with the values of all stakeholders. The primary goal of VSD is to influence the design of technology by paying explicit attention to which human values are considered and integrated into and throughout the design process (Friedman, Hendry and Borning, 2017). The term "value" is broadly defined here as "what a person or group of people consider important in life" (Borning and Muller, 2012). VSD highlights how technology shapes society and is shaped by social factors (Cummings, 2006). Thus, socio-technical systems involve complex interactions between people and technology that cannot be designed in a value vacuum. VSD approaches this with a formalized methodology consisting of a tripartite methodology, consisting of iteratively applied conceptual, empirical, and technical investigations.

The *conceptual investigation* is the more theoretical aspect of VSD and consists of an analysis informed by the philosophy of the values constructs relevant to the design in question (Cummings, 2006; Umbrello and Bellis, 2018). During the development of the VSD, twelve specific human values were selected: human welfare, ownership and property, privacy, freedom from bias, universal usability, trust, autonomy, informed consent, accountability, calmness, identity, and environmental sustainability (Cummings, 2006). These values were chosen because they represent the broad values commonly discussed in the literature on technology and ethics, as well as those that have become more important as computer technologies have become more prevalent in everyday life (Friedman and Kahn, 2003).

The second investigation is *empirical*. As the name suggests, it focuses on quantitative and qualitative measurements to evaluate the design from both a technical and value approach (Friedman, 1996; Cummings, 2006; Umbrello and Bellis, 2018). The quantified variables could be statistical data that describe patterns of human behaviour, assessments that measure users' needs and wants, and the dichotomy between what people say they want in a design and what they care about in practice (Friedman, Jr and Borning, 2006).

The last investigation is *technical*, namely, investigating and analysing how technical designs support particular values, and how the values identified in the conceptual investigation might best be supported by different design possibilities (Cummings, 2006). While the technical and empirical investigations may seem similar, they differ in focus: the technical phase focuses on the technology itself, and the empirical phase examines how people interact with that technology.

Overall, the theoretical approach of VSD and its tripartite investigations distinguish it from other design approaches because it is self-reflexive, fallible, and continually improving. Other different design methodologies could be used in order to safely design advanced technologies such as participatory design, universal design, user-centred design, and inclusive design (Umbrello and Bellis, 2018). However, VSD is a potential and undeniable candidate for a careful and uninhibited approach to the design of advanced technologies as it has the potential to embed stakeholder values and incorporate current design methods. In addition, the three investigations lend themselves to the proactive nature of design, which means that each of the three carries the other along (Umbrello and Bellis, 2018). For example, if one investigation fails, it is likely that all other investigations will need some attention as well. All three need to be considered when taking a VSD approach. Thus, armed with the knowledge of what VSD is and what it does differently to overcome the shortcomings of certain responsibility ascriptions, such as issues involved when determining methods for protecting humans from unintended consequences impost by new technologies, it is important to understand how the three investigations each contribute to the combined, all-encompassing nature of the approach.

Application

The application of value-based design covers a wide range of fields such as healthcare and engineering. Consider the creation of a care robot that assists an elderly person with daily tasks. If designers initially believe that an assistant must ask the user for permission to help them with each micro task, they may soon learn that such requests hinder the actual assistance of the system and end up frustrating rather than helping the user (Wynsberghe, 2017). Therefore, it is important to conduct further empirical investigation to tabulate the behaviour of both the care robot and the elderly people using it. In addition, further conceptual research is needed to gather more information about what the technology can and should do. Another application of VSD is demonstrated through an engineering design case study involving the development of a supervisory command and control system for the U.S. Navy's Tactical Tomahawk cruise missile (Cummings, 2006). This case study highlights the first fundamental canon of engineering ethics: engineers should put the health, safety, and welfare of the public first. When considering this canon and the design of weapons, the question arises: "Is it ethical for an engineer to design a weapon?" Therefore, the application of the VSD methodology, which focuses on values of ethical importance, can inform the design process in both technical and ethical areas.

Referral to transversal themes

If the design process is truly and thoroughly carried out in a value sensitive way, then both process and end-result should warrant positive outcomes on the transversal themes, since “Value sensitive design” is the creation of technologies that are not only functional but are also ethically sound and in line with the values of all stakeholders. That means worker’s values (and needs) in terms of privacy (theme 1), trust in and, understanding of technology (theme 2) and learning (theme 4) are most likely to be addressed in VSD. Whereas theme 1, 2 and 4 directly focus on worker’s needs, theme 3 has its focus more on technology: the effects of worker co-design. Nevertheless, here too, it should become visible that by involving workers in the design process, new technology should mirror their values and needs, and where it doesn’t this should be made explicit.

Design guidelines

Here are important guidelines to consider that distinguish a VSD approach from human-centric design approaches with less focus on values. More information on these guidelines can be found in for example Friedman *et al.* (2013). In general, for large and sensitive projects it is recommended to seek support from experts in this field. Other than that, the following guidelines should be considered.

- **Identify and engage stakeholders.** Expand the scope of stakeholder identification to include indirect stakeholders and those affected by the broader impact of the design. Engage them through interviews, surveys, and workshops. Ensure transparent communication with stakeholders throughout the design process. Regular updates and feedback sessions are crucial. Consider all of the diverse perspectives of the stakeholders and ensure that marginalized voices are heard and respected to make sure the design process is inclusive.
- **Conduct empirical investigations to understand and prioritize the values of stakeholders.** Use methods such as value-sensitive interviews and participatory design sessions. Identify potential conflicts between stakeholders' values and address them through negotiation and compromise. This may involve iterative discussions and value trade-offs.
- **Implement an iterative design process that incorporates continuous feedback from stakeholders.** This ensures that the design evolves in alignment with stakeholder values.
- **Conduct conceptual investigations.** These are to articulate the values and ethical considerations relevant to the design. Contrary to the empirical and technical investigations (see above), conceptual investigations are more theoretical analyses and reflections on ethical considerations. They help in understanding the broader impact of the changes.
- **Incorporate sustainability into the design process,** ensuring that changes are environmentally responsible and promote long-term well-being.
- **Continuously evaluate the ethical implications of the design choices.** This includes considering privacy, autonomy, and fairness.

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1.3 Quadruple helix model

General description

The investigation of changing knowledge production and innovation development has roots in the early 90s, as a means of moving towards a different dynamic than the public-private relations that modelled economic development. The "Quadruple" (or n-tuple) Helix Model is an innovation framework that prioritises the integration of stakeholder input into innovative problem solving. The helix symbolises the dynamic interactions among various stakeholders, with each strand representing one: the State, Industry/Business, Academia, and Citizens, where citizens embody the role of end-users.

The helix model was developed as a heuristic that explains multi-faceted relations between different actors in a system and symbolizes a departure from the linear and/or hierarchical models of knowledge production. Leydesdorff (2011) explains that systems are constantly in flux and cannot be expected to exist as fixed entities, hence this move from Schumpeter's creative destruction to the integration of more moving parts with a role to play in knowledge production.

The description and understanding of the model is based on the two items that create the concept, namely the helix and the n-tuple characteristic. Firstly, the helix model originated in simultaneous work done by Etzkowitz (1992) and Leydesdorff (1994) on new ways to look at knowledge production and innovation. The helix model is a departure from the previous thinking because it integrates academia within the traditional industry-government relation and reimagines their interactions as being more complex with both top-down and bottom-up initiatives (Cai and Lattu 2022).

Secondly, the n-tuple characteristic of the model leans into this complexity of stakeholder interactions and the possible integration of further entities. While it initially started with the industry-academia-government triad, the helix model was extended to the quadruple helix model to fit the new realities of the 21st century (Cai and Lattu, 2022). Cai and Lattu (2022) performed a literature review and identified different perceptions of the relationship between the triple and the quadruple helix models. On the one hand, some in the literature view them as competing concepts (Nordberg et al.2020), while on the other hand, others see them as parts of an evolutionary pathways that explains the introduction of the n-tuple characteristic to this model.

Carayannis and Campbell (2009) developed the quadruple helix model by adding a fourth significant stakeholder involved in knowledge production, namely the civil society defined in a broad sense to include citizens, NGOs, media etc. The inclusion of multiple actors acknowledges their voices and inputs as valuable to the production of innovation. Indeed, Carayannis and Campbell explain in subsequent

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works that democracy is a condition for the proper functioning of the quadruple helix model.

Application

The quadruple helix model has been used to explain the development of innovative clusters in regional contexts. One application is the development of European Digital Innovation Hubs (EDIHs), which represent a sophisticated application of the quadruple helix model, where academic institutions collaborate closely with innovative tech companies and startups to develop cutting-edge digital solutions. The public sector supports the development and implementation of these hubs, with funding from structural funds and directly from the European Commission.

In Romania, the public sector provides strategic support and funding mechanisms, while civil society organisations ensure that these technological innovations address genuine societal needs and promote digital inclusion. This collaborative ecosystem enables Romanian EDIHs to focus on key digital transformation areas like artificial intelligence, cybersecurity, advanced manufacturing, and cloud computing, with each helix contributing unique perspectives: universities generating advanced research, companies developing market-ready technologies, government creating supportive policy frameworks, and stakeholders, such as clusters and community organisations, guiding user-centric design and ensuring that digital innovations align with broader social objectives. The European Digital Innovation Hub in Transilvania is the EDIH coordinated by Transilvania IT Cluster.

The European Digital Innovation Hub in Transylvania (EDIH Transilvania) emerges as a strategic collaborative ecosystem centred in Cluj-Napoca, leveraging the region's strong technological infrastructure and innovation potential. Its primary focus encompasses digital transformation services for small and medium enterprises, offering advanced technological support in areas including artificial intelligence and advanced manufacturing technologies. By providing testing facilities, skills development programs, and innovation support, EDIH Transilvania aims to enhance the digital capabilities of regional businesses and contribute to the broader digital transformation of Romania's economic landscape.

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Referral to transversal theme

The Quadruple Helix Model is way to configure an ecosystem, e.g. a region. It implies collaboration in a system to improve innovation. As such it can support all transversal themes. Worker or end-user involvement is a central factor in the model, but the helix model has been used before to facilitate learning and skills development, improve cybersecurity and enhances technology acceptance.

Design guidelines

- **Select a venue that is accessible, comfortable, and conducive to collaboration.** This was found of great importance in a project examining and developing the Quadruple Helix Model (The Värmland County Administrative Board, 2019)). Physical attendance is preferred and shown to be more effective. Facilitate a pleasant environment to encourage open communication and active participation among all stakeholders. Providing refreshments can help maintain energy levels, foster a relaxed atmosphere, and encourage informal interactions. Arrange the space with round tables or flexible seating. Ensure the venue is equipped with necessary technical facilities such as projectors, whiteboards, and internet access to support presentations and collaborative activities. Additionally, pay attention to the ambiance, ensuring good lighting and ventilation to positively impact the mood and productivity of participants (The Värmland County Administrative Board, 2019).
- **Involve representatives from all sectors of society: public authorities, industry, academia, and citizens.** In the In For Care project, the involvement of citizens ideally includes two or three different representatives to ensure diverse perspectives. The specific actors may vary by region, as formal health care providers can be public, private, or a mix of both (The Värmland County Administrative Board, 2019).
- **Use instruments, methods and approached in the Quadruple Helix Model design as suits best with your goal and the actors you aim to include.** See the sections

- Workplace level with end user involvement, Workplace level not necessarily with end user involvement, and Instruments for methods you can use. The most suitable instruments could differ whether you already have an idea you want to test or want to discover new ideas. In all cases, it is of great importance to facilitate good communication and collaboration between all actors. Not all stakeholders have to be involved from the beginning of the process, but all should be involved in the approach. Overcome language barriers by using technology or other solutions and facilitate physical sessions, as face-to-face meetings are reported as more effective (The Värmland County Administrative Board, 2019).
- **Find a purpose or goal that all partners rate as an important investment** (The Värmland County Administrative Board, 2019).

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1.4 Innovation camp

General description

The interaction among various stakeholders within an innovation ecosystem, marked by the triple and quadruple helix models, requires a clear methodology to create more structure and clear results. The Innovation Camp methodology is an example of such a structured interaction among stakeholders from the quadruple helix model. The innovation camp methodology is an intensive, time-bounded collaborative approach designed to generate creative solutions to complex challenges through structured yet dynamic participatory processes based in co-creation and problem-solving. The root of the methodology is the entrepreneurial discovery process, which is an inclusive, interactive process uniting diverse stakeholders to identify opportunities and co-create solutions for regional development challenges in general, with policymakers facilitating their realisation (Aranguren *et al.*, 2018; Rissola, Kune, & Martinez, 2017). It has been used also for facilitating learning and community building.

Given that it is a structured event with a clear methodology, it takes place in several steps, detailed in (Rissola, Kune, & Martinez, 2017):

- **Before the camp** - conception of the camp experience, including the identification of the meta-goals, shared vision and direction, including a regional focus and a clear conceptual framework
- **Preparation phase** - development of the challenge description, designation of the challenge owners and facilitators, as well as gathering participants

- **Camp phases** - exploring the challenge, explore the opportunities developed by the insights of the participants, generating ideas, prototyping ideas and thinking forward
- **After the camp** - testing the camp results, prototyping the results, deciding on a Go/No-go strategy for the implementation of the ideas

The innovation camp is a human-centric solution direction, as it is problem driven and it is focused on co-creation and co-design of solutions to societal challenges. In general, the challenge owners are directly involved in the activity that posed the challenge in the first place. Additionally, innovation camp solutions aim to bring societal value.

In conclusion, the Innovation Camp methodology offers a structured yet flexible framework for fostering collaboration among stakeholders within the quadruple helix model. By integrating principles of co-creation, problem-solving, and the entrepreneurial discovery process, this approach facilitates the generation and implementation of innovative solutions tailored to regional needs. Its step-by-step methodology ensures clarity, direction, and measurable outcomes, making it an effective tool for addressing complex challenges. Whether used as a learning tool, an idea generation platform, or a solution-oriented camp, its adaptability underscores its value in driving innovation and stakeholder engagement across diverse contexts.

Application

The camp methodology exists under different facets, depending on its focus. The literature shows several examples of using the camp as learning tools, for instance in Svennevig and Thorstensen (2019). It has been used extensively at the European level to help in the development and implementation of innovative solutions at the regional level. A practical example of this is the Cluj Innovation Camp, held in 2023. This event brought together 80 specialists from 11 countries to discuss and develop solutions for key challenges in technology and sustainability. Organised by Transilvania IT Cluster, the camp focused on four main topics: accelerating digital innovation with data, interregional collaboration for smart manufacturing and green energy, digital skills, and sustainable living.

The primary outcomes included practical solutions for these challenges, enhanced collaboration between diverse stakeholders, and significant contributions to regional and international innovation strategies. Notably, the camp's discussions and outcomes helped Cluj-Napoca gain visibility at the European level (Transilvania IT, 2023). At the same time, some camps are focused on idea generation and are labelled as Innovation Camps, while others are considered Solution Camps, focusing on the implementation of certain solutions (Bager, 2008).

Referral to transversal themes

An innovation camp is used to involve not only the employee, but the entire ecosystem around it, divided over the four quadruple helix factors, therefore going beyond addressing the theme Worker Inclusion.

Design guidelines

- **Assign a Camp Convener to take responsibility for the process.** This should preferably be someone with experience in organising innovation camps and who has responsibility, influence, and credibility. Often, this person works for a public institution (municipality or government). The Camp Convener is in charge of organising and hosting the camp, scheduling dates, location, duration, facilitators, and participants (Rissola, Kune, & Martinez, 2017).
- **Use an Innovation Camp to address societal and site-specific issues that require a holistic approach.** Innovation camps are not suitable for solely technological, economic, social, or organisational issues. They are ideally used for co-designing policies and strategies (Rissola *et al.*, 2017).
- **Allocate at least a year to execute the entire innovation camp process.** Preparations for the event can take several months due to scheduling appropriate dates that work for all and the extensive preparations needed. The camp itself can last about 3 days, resulting in a prototype. In addition to preparations and the camp event itself, about 6 weeks are necessary to test the (paper) prototype created during the camp, followed by another 6 months

to further improve the prototypes and disseminate the findings (Rissola *et al.*, 2017).

- **Include a diverse range of stakeholders with varying expertise, backgrounds, and nationalities.** Here, heterogeneity is more important than the number of stakeholders. Include stakeholders who are directly or indirectly involved in the challenge discussed in the innovation camp. Additionally, people with relevant expertise, although not directly involved in the challenge, could be included, as well as people with relevant expertise from another sector. It is essential that the group is diverse, has participants from all parts of the quadruple helix, and can bring novel ideas to the discussions that others might not have considered. Camp participants can range between 40 and 80 persons, yet the groups that work on the challenges are smaller, ideally between 8 and 12 individuals (Rissola *et al.*, 2017).

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1.5 ELSA-lab

General description

An ELSA Lab (Ethical, Legal, and Societal Aspects Lab) operates through a structured process to ensure that ethical, legal, and societal aspects are integrated into the development of technology in complex societal issues, involving ethical, legal, and public values (Van Veenstra, Van Zoonen and Helberger, 2021). While the full ELSA Lab approach is especially suited for complex issues, its principles can also inspire smaller-scale projects. Even in these cases, applying elements such as early reflection, stakeholder dialogue, or ethical framing can enhance the quality and responsibility of the outcomes (Van Veenstra, interview). Research has been done to examine the benefits of using an ELSA Lab for the development and embedding of AI into society. Van Veenstra *et al.*, 2021 found several benefits and summarized this in their paper. First, AI systems technology are more aligned with societal needs as the technology is designed with both human and public values in mind. In addition, by embedding fundamental rights and public values into the design process, ELSA Labs ensure that these aspects are considered from the start, leading to more ethical and responsible AI systems. Also, ELSA Labs promote ongoing learning and adaptation, rather than assuming a straight path of growth and impact. This helps in keeping the technology relevant and effective. Last, they support a more iterative and less linear approach to technology development, which means continuous improvement based on feedback and real-world use and thereby ensuring to meet user needs and expectations (Van Veenstra *et al.*, 2021).

The process begins with identifying and engaging relevant stakeholders. Among others, these could include citizens, civil society organisations, industry representatives, policymakers, and researchers. Doing so, several and diverse perspectives are collected and taken into account during the development process. Next, ethical, legal, and societal impact assessments are conducted to identify potential issues related to the technology, such as impacts on human rights, privacy, security, and societal values. Then, workshops or other gatherings (see chapter on ideation methods) are organised to facilitate discussions among stakeholders. This allows for the collection of input, feedback, and suggestions for addressing identified issues. An iterative development and refinement process follows, where the technology is continuously improved based on stakeholder feedback and impact assessments. Parallel, ELSA Labs develop and provide guidelines and methods for organising societal engagement and conducting impact assessments. Finally, continuous monitoring and evaluation are carried out to ensure that ethical, legal, and societal considerations are being addressed, with further adjustments made as needed (TRANSCEND Project, 2024).

Application

The Dutch AI Coalition (NL AIC) has initiated several ELSA Labs ensure responsible AI development and application in the Netherlands. To date, the NL AIC Label has been awarded to 20 ELSA Labs, which address various topics and foster collaboration among helix actors, including government, industry, academia, and citizens. The coalition plans to expand its portfolio with new labs in the future. For more information on their goals and approach, you can view the details on their website[1]. A practical example of one of these ELSA Labs is given here, in the context of healthcare. The ELSA AI Lab Northern Netherlands (ELSA-NN) used the ELSA Lab framework to develop an online tool that integrates ethical, legal, and societal considerations into AI systems used in healthcare. This tool helps to ensure that AI technologies are designed and implemented in a way that aligns with societal values and needs. The researchers did so by working with a consortium of knowledge institutions, societal partners, business partners, and patient and public organisations. By involving these diverse stakeholders and addressing health disparities, the lab created a dynamic learning process that continuously improves AI systems, making them more inclusive and equitable. As a result, the tool developed by ELSA-NN embodies the principles and practices of

[1] https://nlaic.com/en/bouwsteen/human-centric-ai/elsa-concept/

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the ELSA Lab, promoting trustworthy and responsible AI in healthcare (ELSA AI Lab Northern Netherlands, 2025).

Referral to transversal themes

An important theme within ELSA Labs is Learning and Skills development. ELSA Labs aim to foster learning by creating an ecosystem of individuals that could learn from each others expertise and creating responsible AI. Doing so, stakeholders, among which the end-users or workers, are involved, so the theme Worker Inclusion is addressed as well.

Design guidelines

- **Take time to understand and define the complexity of the challenge you aim to address.** Before implementing technology within an ELSA Lab, it is essential to invest time in understanding the societal challenge you intend to tackle. Many issues are multi-layered, involving ethical, legal, organisational, and societal dimensions. Begin by collaboratively exploring the question with relevant stakeholders to determine whether technology is the appropriate solution. This helps to avoid premature or misaligned technological interventions. Consider the scale and complexity of the issue: is it a small, well-defined problem or a systemic challenge requiring long-term engagement?
- **Include ethical, legal and societal aspect into the process.** To embed *ethical* principles into the technology development process, combine ethical frameworks (see Van Veenstra, & Tilman, 2021) with practical design approaches like Value sensitive design. Address concerns such as lack of consensus on norms, unclear handling of conflicting values, and responsibility. Establish clear guidelines, manage conflicting values, and foster discussions to build consensus. Take *legal* considerations into account by addressing AI laws and regulations, such as the GDPR and the Digital Services Act to ensure that risks are mitigated and fundamental rights are protected, including privacy, non-discrimination, autonomy, and freedom of expression. Consult an expert when addressing this topic. Lastly, take *societal* factors into account by adopting a perspective that acknowledges and accommodates conflict

and contestation rather than assuming progressing pluralism. Recognize the importance of addressing inequality and power structures in society (Van Veenstra *et al.*, 2021).

- **Collaborate with all actors from the quadruple helix.** Collaboration in the AI ecosystem involves fostering partnerships between public and private entities, actively engaging SMEs, government, knowledge institutions, societal organisations, and citizens. This inclusive approach facilitates a rich exchange of knowledge and drives new innovations, ensuring that AI development is both responsible and aligned with collective needs and goals (NL AIC, 2024). All four helix dimensions should be equally responsible for the development and coordination of activities that are performed within the ELSA Lab.
- **Organise regular reflection sessions with multidisciplinary experts.** To ensure that the development and implementation of technology remains aligned with ethical, legal, and societal values, it is essential to organise regular reflection sessions throughout the project lifecycle. These sessions provide structured opportunities to reassess the challenge, evaluate the role of technology, and incorporate diverse perspectives. The frequency of these sessions should be tailored to the complexity of the project. For smaller initiatives, a single session during development may suffice. For more complex or long-term projects, sessions should be held periodically—such as every three months—or at key decision points. Include multidisciplinary experts in these sessions, such as ethicists, legal scholars, technologists, policymakers, and citizen representatives. Ensure that all quadruple helix actors are represented. Document the outcomes of each session and use them to inform project decisions and future reflections. For ongoing guidance, consider establishing an advisory committee that meets multiple times per year to provide strategic input and ensure continuity.
- **Use structured tools such as the DEDA framework (Utrecht University) and Aanpak Begeleidingsethiek (ECP) to guide discussions.** These tools help identify ethical dilemmas, clarify responsibilities, and surface conflicting

values. Sessions should focus on reassessing the original problem definition, evaluating the societal impact of the technology, and identifying emerging risks.

- **Use an ELSA Lab if you want to develop and use advanced technologies in a responsible way, or if you want others to learn how to do so.** AI-technologies such as machine learning, deep learning and generative AI are often addressed in ELSA Labs. If you want to develop or use responsible AI technologies, create tools and methods that take ethical, legal and social aspects into account in the analysis, design and evaluation of these AI tools. This could help direct future AI applications in setting up requirements, product specifications, purchasing and the use of equipment. If your goal is to educate others, develop educative programmes in the Lab to facilitate education and the transfer of relevant information (NL AIC, 2022).
- **Use methodologies as described in the section**

- **Workplace level with end user** involvement **and in the Instruments chapter to co-design and collect ideas.** ELSA Labs do not necessarily have to take the form of actual 'labs', but also have a wide variety of other forms like reflections, evaluations or end user research. It reflects around the inclusion of quadruple helix actors in the development of responsible AI technologies. Facilitate a collaborative and dynamic learning process (Van Veenstra *et al.*, 2021).

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2 Organisational level

The Organisational level consists of three solution directions, namely 'integral organisational (re)design, 'workplace innovation', and 'semi-autonomous teams'. They have in common that each of them can be applied to a wide range of technological innovation, at different parts of the organisation, affecting different actors and stakeholders. Each approach looks at such innovations from an aggregated level. 'Organisational level' can refer to the organisation as a whole from a systemic perspective. This applies that such approaches take into account multiple variables simultaneously. An intervention, for example, can have consequences for the production process, the structuring of work activities, the skills of employees, the flow of information, and many more. Applying each of the three approaches, therefore, is not a 'one-size-fits-all' activity, but needs to be designed in accordance with the specific requirements of each technological innovation at organisational level. For this reason an 'overall guideline' (at the end of section 6) is suggested for an organisational level solution direction based on modern sociotechnics (MST) and similar human-centric approaches to designing work. For the simplicity we will further refer to this approach as MST.
First, brief descriptions are given of the separate solution directions. Where applicable, some guidelines are provided. After this, the overall guideline is given.

2.1 Integral organisational (re)design

General description

The organisational (re)design approach "Integral Organisational Renewal" (Gronouwe *et al.*, 2021; Van Eijnatten, 1993; Van Eijnatten & Fitzgerald, 1997; Van Eijnatten & Van der Zwaan, 1998), is a specific development of the Dutch variant of modern sociotechnical design theory. The origin of the sociotechnical tradition lies in studies executed in the British coal mines in the 1950s, where the relation between the social and technical aspects of organisations (hence "socio-technical") was investigated, in the light of more humane ways of organising (Trist

& Bamforth, 1951; Van Amelsvoort, 2000; Kuipers *et al.*, 2020). Up until today, the sociotechnical approach has been further developed with insights from both system theory, providing it with a strong theoretical foundation, and practical experiences in organisational consulting and practice (De Sitter *et al.*, 1997; Achterbergh and Vriens, 2010; Kuipers *et al.*, 2020). The main goal of IOR is the improvement of an organisations' ability to simultaneously achieve excellent organisational performance in terms of efficiency and effectiveness, as well as good quality of jobs (i.e. human-centric work), that result for example, into excellent employee-related outcomes such as commitment (De Sitter *et al.*, 1997; Achterbergh and Vriens, 2010; Kuipers *et al.*, 2020). An integral organisational redesign approach (IOR) views an organisation as a social interaction network. These interactions are substantially influenced by the organisational structure, which refers to the grouping and coupling of activities to subsystems (De Sitter *et al.*, 1997; Kuipers *et al.*, 2020). IOR uses structural parameters to characterize such organisational structures, of which "functional concentration" is often considered to be the most important one, describing the degree to which similar activities are concentrated within specialised departments (Kuipers *et al.*, 2020). Such concentration should be avoided. A (bureaucratic) functionally concentrated organisation structure, in which specific activities are grouped at separate subsystems, is thought to contribute to crippling complexity of the social interaction network (i.e. structural complexity) and a decrease of autonomy at specific departments. According to IOR, this is likely to result in a variety of problems for organisational members, such as stress, a lack of involvement and a lack of opportunities to learn and develop. Functional ways of organising are still dominant within many organisations (Van Amelsvoort and Van Hootegem, 2017; Kuipers *et al.*, 2020). To change these structures, IOR proposes to reduce the complexity of the social interaction network and to increase worker autonomy by lowering functional concentration. Subsequently, IOR advocates integral and organisation-level participative organisational (re)design to achieve such de-concentration. This transformation should result in flexible and humane organisations, with a low level of complexity: "simple organisations with complex jobs" (De Sitter *et al.*, 1997). These jobs are considered to be of better quality with limited stress risks and abundant learning opportunities (Karasek, 1979).

Application

IOR, in its form of modern sociotechnical design of organisations and jobs, has a set of design rules, which are based on a number of principles. One of these principles is to minimize the need for coordination between organisational parts to limit disruptions and faults. Another principle is to minimize the division of labour to ensure jobs with 'complete task' with both executing and decision-making tasks. The results of organisational design are 1] better business performance through more effectiveness, efficiency, flexibility and innovativeness at organisational level, and 2] better quality of work at the level of employees. In the organisational design it is taken into account that choices about developing, designing and implementing (digital) technologies are augmenting and supporting the work of employees (i.e. improving human-centricity), instead of controlling, monitoring and steering employees.

Referral to transversal themes

IOR has a direct link with human trust and understanding via the participative role of employees (as one of the prominent stakeholders) whose work may be affected by the implementation of the new technology. The participative role ranges from being informed (one-sidedly), being consulted (co-creating role) to being allowed to (co-)decide (decision latitude) with regard to the development, (investment) choice, implementation and / or evaluation of the new technology.
IOR has an indirect link with cyber security and privacy (depends on how the new technology is applied), inclusiveness (IOR supports workplace democracy), and in-work learning (IOR supports the fact that employees must be enabled learning to work with the new technology).

Design guidelines

The purpose of IOR is to help companies align the sales / delivery of their products / services ('results') with their process of production, in terms of requirements such as efficiency, effectiveness, flexibility and innovativeness. That is a 'big

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order', because several of the aspects of an organisation are affected during the process (that's why it is 'integral'). It is assumed that the organisation has 'a problem' which needs to be assessed in relation to underperformance in achieving the 'results'. In our pilots (non-)digital renewals are (to be) implemented, and the question is in what way they (are expected to) help alleviating the 'problem'. This requires an analysis of the problem and its relation to the renewal ('intervention'), and how this intervention can improve the results. In such an analysis one usually involves the strategy, the environment and the design of the primary process.

The following analyses should be made:

- **Assess what products do / will you sell to which markets / customers (grouping of product families and markets / regions), and what are your targets.**
- **Assess the requirements to improve efficiency, effectiveness, flexibility and innovativeness** (select first any of the criteria that need to be included). It is assumed that improving the results depends on any of those four criteria, which now fail short.
- **It is important not to jump to conclusions by pointing out what causes the problem.** The IOR, therefore, follows a sequence in (re)designing organisations and addresses problems (issues) in the correct order. It is nonetheless very useful to make an inventory of all issues that may have a relation with the problem (resulting in underperforming in achieving the desired results / targets). For this purpose, one can use the TOP model as a concept to search for issues: technology, organisation, and people / personnel. Be aware that the (to be) implemented (non-)digital renewals in each of the pilots are possibly premature solutions to the problem (at least from the perspective of the IOR guideline). Not seldomly it occurs that solutions are chosen for the wrong problem!
- **Define the systems and their borders of what needs to be (re)designed: organisation, department, team.** Be aware that, in the case a production department is selected, there are several relationships from a systems

perspective, such as logistics / distribution, assembly, work planning, human resources, finance, and so on. In our cases it is helpful to look at the (to be) implemented renewal (i.e. technology), and then assess its boundaries. In your own words: define the (part of the) organisation that you have under review, its strategy, targets, mission and environment.

- **Define output requirements or 'functional specifications'.** If your organisation needs to become more efficient, effective, innovative, flexible or your outputs should meet requirements in terms of quality and quantity, try to pin these down as clear as possible and in a measurable manner.
- **Often it is helpful to describe and lay-out the primary process.** To understand what this process is about, one can assess the orders that are being processed. Orders can be grouped as orders for specific markets, regions, customers or else. Orders can also be grouped as sequential steps that must be processed in the production process. For example, an automobile is produced and assembled in a certain sequence of tooling and assembling materials and parts along various workstations and subdepartments. For each step one can decide to become more efficient, effective, innovative, flexible and so on, and design their desired functional specifications. The new to be implemented technology may play a crucial role in improving the primary process and in meeting improved functional specifications. These need to be assessed or estimated. Our assumption is that the new technology should address 'the problem' and improve the result of the primary process in terms of its outputs. The output requirements should meet market demands, customer demands, environmental demands, and quality of work demands in a way that corresponds with the need for human-centricity of the employees.
- **Design the structure of the organisation.** First, one needs to design the 'production structure' (top down). How to produce the orders in a most efficient, effective, innovative, flexible manner is a matter of dividing the organisation into relative independent units. This process of 'functional allocation of tasks' takes place at the level of the unit, (autonomous) teams,

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and team members, and between humans and technology. A rule of IOR is to minimize the division of labour, limit the number of coordination nodes ('junctions'), reduce complexity and combine executing and managing tasks into the level of jobs and teams while ensuring that technology is enabling, augmenting and empowering humans-in-the-loop. Second, one needs to design the management structure (bottom up). A rule of IOR is that a maximum of decision latitude to solve problems and disturbances should be present at the lowest organisational level. This decision latitude should be built up from job level, to team level to unit level, taking into account that control should be allocated to humans and not to machines, unless machines function more efficient, effective, innovative, and flexible *and* if control allocation to machines does not harm the quality of work of the human (i.e. the human-centric values, norms and characteristics). This keeps the organisation 'simple' but ensures that jobs are 'complex' (rich).

- **Design of support systems.** Systems and information flows should support the work done in the production process and the managing tasks of employees, that is decision making and coordination. Too often systems are designed to monitor and control people, instead of putting humans-in-the-loop based on human-centric points of departure.

The former design steps are based on the modern sociotechnical design rules (De Sitter *et al.*, 1997; Kuipers *et al.*, 2020)[1]. Consultant organisations that can support in MST are rare[2].

- **The process of change and implementation of new technology, and the application of IOR, should cover the points of departure of human-centricity.** This means at least that all persons who are affected by the implemented new technology should be involved in the change process. Unless their relation with the organisation is too indirect, such as anonymous customers.

Tips:

[2] Experts in MST: https://st-groep.nl/ ; https://www.workitects.be/ ; https://www.torgo.be/nl/team ; and https://www.ulbodesitterkennisinstituut.nl/ (comprises experts from KU Leuven, Radboud Universiteit, Hanze Hogeschool, TNO and other knowledge institutes).

- **Realise that applying this solution direction is not easy.** It is complex, time consuming, and gives no guarantee for desired outcomes: but a forewarned user is doubly alert!
- IOR embraces human-centricity, but you still must **pay attention to a human-centric application of implementing new technology** with the IOR approach because there are so many (economic) reasons to deviate from this aspect,
- **Involvement and commitment are crucial.** Assess the internal and external people who have an interest at stake (stakeholders), and give them a place in the process;
- **Critically assess the possible Inputs of employees and co-workers.** IOR states to not only inform and consult them, but let them co-decide as well. See what is possible;
- **Make a project with a project teams and a project planning based on human-centric values to apply this guideline.**
- **Consider calling in external experts** (see footnote 2).

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2.2 Workplace innovation

General description

Workplace innovation (WPI) is an organisational level intervention to simultaneously improve the business performance and the quality of work (good jobs). The working definition of WPI is "human-centric innovations with regard to TOP (Technology, Organisation, Personnel) in order to simultaneously enhance business performance and human performance" (Oeij & Dhondt, 2023), and is in line with another related definition: Workplace innovation is an integral set of participative mechanisms for interventions relating to structural aspects (e.g., organisational design) and cultural aspects (e.g., leadership, coordination and organisational behaviour) of the organisation and its people with the objective of simultaneously improving the conditions for performance and quality of working life (Oeij & Dhondt, 2017, p. 66; Parker & Boeing, 2023: 92). The structural aspects in this definition correspond with the design of the production process, jobs and technology (the T and the O of TOP), see **Figure 1**, which overlaps with the production structure and control structure in modern sociotechnical systems design (Kuipers *et al.*, 2020); and the cultural aspects are a consequence of these structural aspects, in the sense that they enable and disable particular organisational behaviours and leadership styles (Karanika-Murray & Oeij, 2017). This corresponds with strategic choices and labour supply and HR policies (the P in TOP). The definition includes participative mechanisms, pointing to the distinction between the content of WPI (what) and the process of designing and implementing WPI (how). Participation and engagement are not only a hallmark of WPI but also of a human-centric approach (Breque *et al.*, 2021).

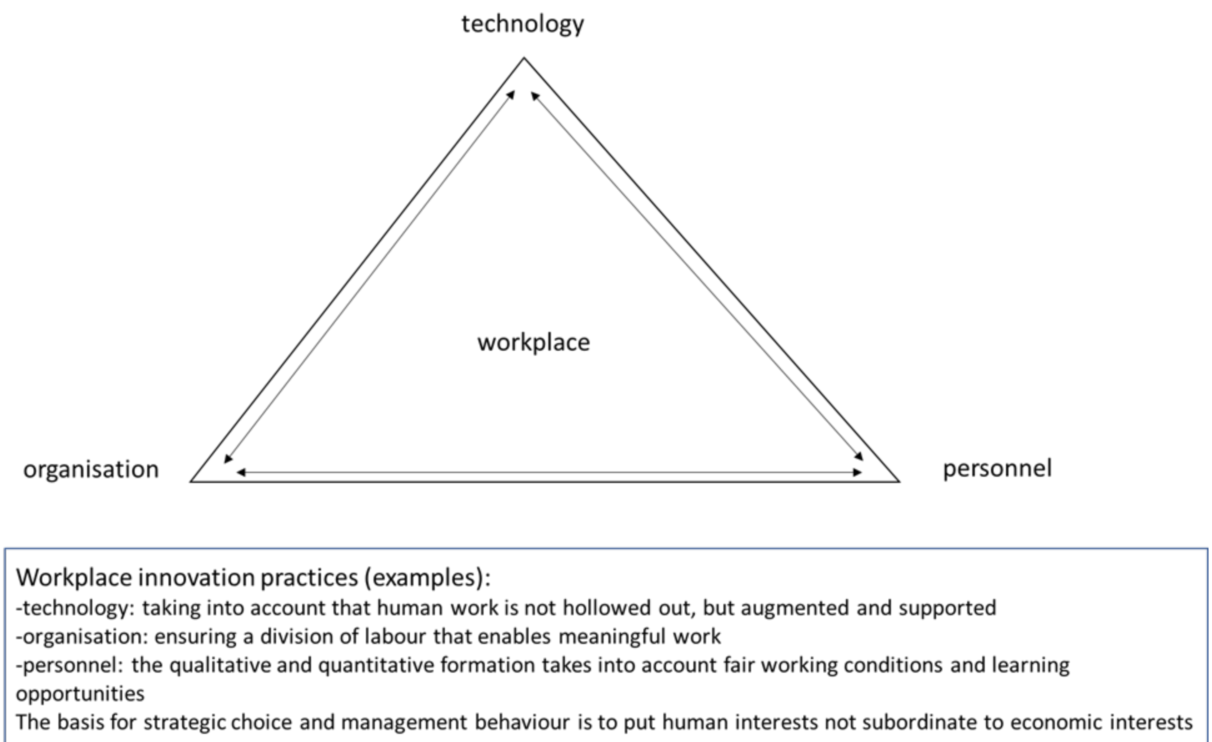

Figure 1. Workplace innovation practices related to the TOP-model (Source: Oeij & Dhondt, 2024)

WPI is connected to sociotechnical thinking and integral organisational renewal (see paragraph 2.1 on IOR). There is also a relationship with the SMART work design model (Parker & Boeing, 2023), which deals with the design of jobs from

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the viewpoint of psychological human needs in work. While the SMART work design model delivers criteria to include human needs in job design, sociotechnical thinking provides the design rules for organisational design that includes these human needs criteria implicitly. Combining both approaches within WPI fosters a human-centric approach to enable Industry5.0 characteristics.

A remark should be made about the relation between WPI and social innovation (Howaldt & Oeij, 2016). In the Dutch context the term 'social innovation of work and employment' is used as a synonym for WPI. But social innovation has a broader meaning, referring to the improvement of societal and social issues in more general terms, like housing, energy, education, mobility, environment, employment.

Application

The hallmark of WPI is that the number of possible interventions of TOP-elements are endless, even if the purpose is to enhance both the business performance and the quality of work. Criteria that look at both these outcomes are therefore essential, which requires that responsible change agents – the persons involved in the change process - are susceptible to both goals simultaneously. A humanistic management philosophy is demanded to be prepared to accept participation and involvement of employees in the change of organisations and the implementation of new (digital) technology (Karanika-Murray & Oeij, 2017; Totterdill & Exton, 2014) which is not self-evident, especially for enterprises that depend on capitalist shareholders or that have troubles to keep their head above water in competitive environments. Managing seemingly contradictory goals (economic and human-centric) may be too big an order in dire times. Examples of workplace innovation interventions can be found in a study by Eurofound (2015) and on the Workplace Innovation Knowledge Bank[3]. Apart from being a concept with content, WPI is also a process of change and innovation (see **Figure 2**). The

[3] Cases can be found here: Workplace innovation in European companies - Case studies | European Foundation for the Improvement of Living and Working Conditions

TOP-model from **Figure 1** is here part of the 'structural design' quadrant, which concerns the design of the primary process.

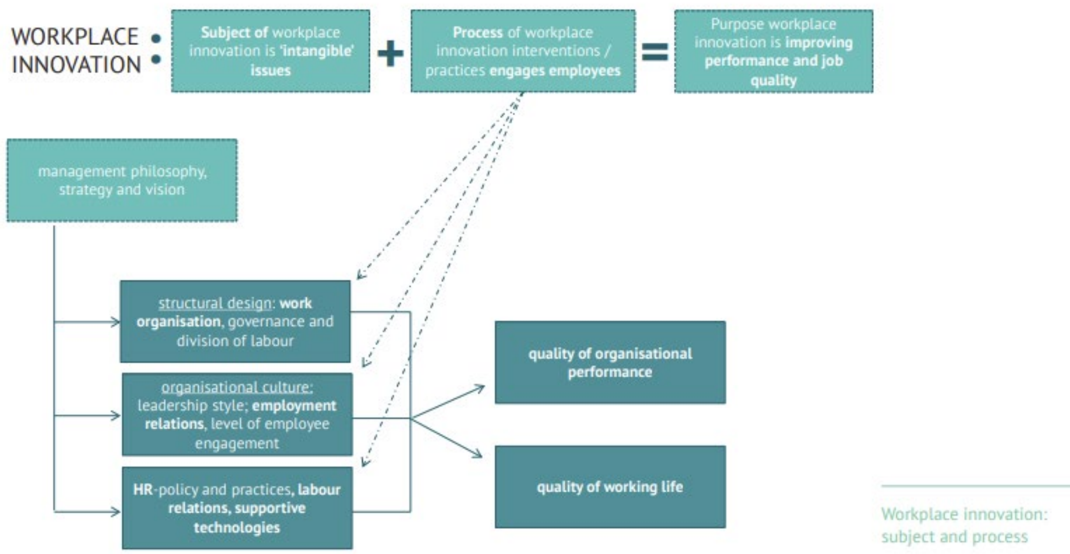

Figure 2. WPI as a process of change and innovation (Source: Oeij, Dhondt, Pot & Totterdill, 2018).

Referral to transversal themes

WPI has a direct link with human trust and understanding via the participative role of employees (as one of the prominent stakeholders) whose work may be affected by the implementation of the new technology. The participative role ranges from being informed (one-sidedly), being consulted (co-creating role) to being allowed to (co-)decide (decision latitude) with regard to the development, (investment) choice, implementation and / or evaluation of the new technology. WPI has an indirect link with cyber security and privacy (depends on how the new technology is applied), inclusiveness (WPI supports workplace democracy), and in-work learning (WPI supports the fact that employees must be enabled learning to work with the new technology).

Design guidelines

The guidelines for this solution direction partly overlap with the 'overall guidelines for organisational level' approaches and with the solution direction of IOR (see above). The starting point in the case of SEISMEC is the implementation of new technology in the light of human-centricity at work, which implies meeting the requirement of good job quality and, at the same time, ensure good organisational / business performance.

- Asses the reason(s) why the new technology will be implemented, what will be its intended effect(s) on organisational performance and quality of work, and what will not be achieved if the new technology is not implemented. **Use the TOP model (Figure 1) to arrange your arguments.**
- **From a human-centric stance make an inventory of the effects of the new technology on jobs, tasks and employees**. Make a distinction between positive and negative effects for employees. Apply a task-allocation method that helps to assess, as a consequence of the new technology, which tasks have been allocated to humans and which to technology. Apply a method to evaluate the quality of work, such as the Well-being at work method or the SMART work design method. This demands to produce a description of the jobs affected, their tasks, and their needed competencies / skills.
- **For the negative outcomes for the quality of work, determine the relationship with the newly implemented technology**. Design alternative solutions for the implementation of the technology in which the quality of work can be improved, such as through re-allocation of tasks between humans and technology whereby the goal is to put / keep humans-in-the-loop.
- **Implement the alternative solutions whenever possible.**

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2.3 (Semi-) autonomous teams

General description

(Semi-)autonomous teams (SATs) are teams of workers who have partial control over a complete unit of work or a specific task (Kuipers *et al.*, 2020; Van Amelsvoort *et al.*, 2005). The team has partial control over decision making skills, development and process improvements within a project or a part of the production process, while the management team retains the other part (e.g. strategy, business, investment and financial decisions). The team is responsible for a number of tasks, in which supervision is not constant and the members have partial autonomy to perform both technically and administratively. Semi-autonomous team design is a logical consequence of organisational design that is grounded in integral organisational design and sociotechnical design (see Integral Organisational Re-design in this document).

Autonomy can be understood as limited and instrumental, but also far-reaching and overarching (Ravn *et al.*, 2022). In organisation and management theory, understandings of autonomy seem to regard "influence on the task at hand" more than overall organisational strategy or governance. For instance, Hackman and Oldham (1980) state that "autonomy refers to control over conducting the task." In original sociotechnical theories, the concept of autonomy was also used as similarly instrumental, enabling better organisational performance. However, autonomy at work was also seen as a cornerstone in societal theory, as Gustavsen paraphrased Emery's key insight, "…the core significance of autonomy in work, its anchoring in democracy, and the need to see workplace development as an issue on the level of society…." (Gustavsen 2017:118). One way to examine autonomy is to relate it to participation. Abrahamsson (1977) used the concepts of "political participation" and "sociotechnical participation" to distinguish between overarching strategic influence and instrumental autonomy at work. Political participation means involvement in high-level goal setting and long-term planning (1977:186). Sociotechnical participation means "involvement in the

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organisation's production"— it is about implementing decisions made at a higher level. Such involvement will include changes in the production organisation, mode of operation and various job enhancements. The autonomy concepts in the team literature relate to sociotechnical participation. Nevertheless, in empirical cases in organisations, the distinction is blurrier. Political/strategic and sociotechnical participation blend into each other. Understanding how autonomy works in organisations requires us to examine structures of sociotechnical participation around tasks and how they relate to overall decision-making.

Several researchers point out that semi-autonomous teams can contribute to better organisational performance and to higher job satisfaction (Kuipers *et al.*, 2020). This notion resonates with human-centricity.

Application

Autonomy – as one of the CAPS factors - is relational: the autonomy of one actor (A) will always meet the autonomy of other actors (B and C) who are in a relationship with the actor (Ravn *et al.*, 2022). If A is granted increased autonomy, it could mean that B and C's autonomy will be restricted. To the extent that a team is to act autonomously, the organisation around it must relinquish some of its governing authority, and the team's individuals must be submissive and conform to what the team as a unit chooses to do. The autonomy aspect produces a challenge when the horizon widens. The freedom of individual teams cannot be created simply by tearing down organisational hierarchies or ignoring individuals. To function autonomously, a team needs to develop and learn. However, putting engineers, designers, and sales and business representatives together in cross-functional teams, encouraging them to cooperate, and expecting them to work properly and integrate does not necessarily mean they succeed. Possible barriers are communication problems caused by transdisciplinarity (Bernstein, 2015; Ravn, 2004), interaction problems caused by different working practices and goals (Mikalsen *et al.*, 2018), social loafing (Liden *et al.*, 2004) and group thinking (Janis, 1972). Additionally, not all teams have the time, space and resources to develop as teams, and may not succeed in becoming excellent in collaboration and cooperation – they remain a group of loosely coupled operators.

Referral to transversal themes

SAT has a direct link with human trust and understanding via the participative role of employees (as one of the prominent stakeholders) whose work may be affected by the implementation of the new technology. The participative role ranges from being informed (one-sidedly), being consulted (co-creating role) to being allowed to (co-)decide (decision latitude) with regard to the development, (investment) choice, implementation and / or evaluation of the new technology. SAT has an indirect link with cyber security and privacy (depends on how the new technology is applied), inclusiveness (SAT supports workplace democracy), and in-work learning (SAT supports the fact that employees must be enabled learning to work with the new technology).

Design guidelines

The implementation of SAT requires an alignment with how the organisation as a whole is designed. The essence of a SAT is to be responsible for a complete task. For example, the assembly of a complete automobile. This implies the SAT has full control over the operational tasks at that organisational level (The fact that a SAT has (full) control over operational tasks does not imply that it has (any) control over managerial tasks at higher level(s)); higher-level tasks, like strategy and marketing, may not be part of the SAT (and adjacent SATs if these are present). The design of an SAT is dependent on the design of the whole organisation. The design strategy is for SATs to meet the required flexibility, effectiveness, efficiency, and innovativeness. For that purpose, the dependencies and nodal links with other parts of the organisation are minimised to reduce complexity and thus reduce the risks of disturbances. SATs can be made responsible for their personnel policy, maintenance tasks, quality control.

As a consequence, the application of SATs is part of an integral organisational re-design. At least one should make an integral analysis of the whole organisation and its linkages, even if one only intends to imply changes at parts of the organisation. The integral analysis identifies what products are made for which markets, customers, regions. In one of the next steps one determines what part of the production is divided across the present SATs. This should be a part of the production that can be executed by the team rather independently and autonomously.

- **To define the boundaries of an SAT, one can first follow the steps of the solution direction of IOR.** The next step is to design the team composition and the division of team tasks. To produce, manufacture or assembly the whole team task must be decomposed into all separate subtasks/actions, and these tasks must be allocated to humans and machines.
- **It is needed to create a competencies matrix, of tasks to be executed by humans and qualifications required.** The fit of tasks and qualifications with the selected team members can be assessed in a next step; qualification deficiencies can be assessed as well. It is in particular important to assess the newly required skills that come with the implementation of the new technology.
- **The compositions of team members can be such that all team members together have the required skills and qualifications at their disposal.** It is not necessary that each individual team member is qualified to carry out all tasks. Team members can have different roles within the team. They can also rotate across work stations within the team. This is up to the SAT to decide. Apart from the fact that the team members have craftmanship skills, they must have social and communicative skills to ensure good collaboration. Teams can also divide star tasks, general tasks that must be carried out to support the work, such as planning, finance, administrative work, personnel policy, quality control, etcetera.
- **Each SAT has a link with the rest of the organisation, must render account for its performance to higher levels, and needs to manage internal leadership.** This leadership role can be divided among team members, it can be decided that members take this role in turn. This is also up to the SAT.

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- **One of the pitfalls of designing SATs is to make them responsible for a team task without providing the appropriate authority or decision latitude and resources.** Teams like these prove to be confronted with higher risks of work overload and work stress, and personnel turnover. It is therefore crucial that (likely) team members are involved in the design process.

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Overarching guideline human-centric organisational (re)design

Overarching guideline for an organisational level solution direction based on modern sociotechnics (MST) and similar human-centric approaches to designing work.

Human-centricity, according to the EU (Breque *et al.*), puts human well-being central to the production environment in the context of Industry 5.0. Industry 5.0 implies making maximum use of new technologies (competitiveness, innovativeness) while taking into account human-centricity, sustainability, and resilience.

Human-centric values in the working environment are related to human needs (see the SMART work design model of Parker). Modern sociotechnical systems design translates human needs as meaningful work, in the sense that humans at work possess the decision latitude to make meaningful selections in carrying out their tasks (De Sitter, 1993). The design of the production process and its management structure are such that organisational nodes and division of labour are minimised (to reduce complexity and enhance flexibility) leading to the transition of ‘complex organisations with simple jobs’ to ‘simple organisations with complex jobs’. They should be so-called active jobs (Karasek, 1979), characterised by high demands (learning opportunities) and high autonomy (control capacity to solve problems), thus human-centric. Organisations function best when organisation members collaborate and cooperate to achieve best quality and quantity. Organisations go beyond individual employees and are social by nature, hence socio-centric, and must not only meet individual goals but also societal goals (Oeij *et al.*, 2024).

Although Sociotechnical systems design (STSD) has a strong organisational focus and (organisational) psychology background, other human needs (cognitive, physiological, biomechanical) are equally part of the design approach. The latter is generally the main focus of the human factors and ergonomics professional (see further).

There are different approaches and variants of sociotechnical systems design. What they have in common is to optimise or balance the technological with the social factor (people and organisation). The variant called ‘modern sociotechnical systems design’ (developed in the Lowlands) has specific design rules for the production structure, management structure and information structure that result in a task allocation (between humans and machines) that keep humans-in-the-loop through designing meaningful jobs. In that sense, it is more principal, rigorous, and accurate than other variants.

- The main requirement to apply MST is the presence of appropriate knowledge among the users. Apart from the manpower and financial means to run an MST-based organisation (re)design project, interdisciplinary knowledge from human-resources mobilisation, sociotechnical systems design, operational management, quality of work and human factors and ergonomics (HFE) are needed, to guarantee the desired outcome of achieving both overall system performance (technical and human) and wellbeing.
- The organisation must function in balance with its environment. Each pilot is implementing a new (digital) technology. Where in the organisation and in

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which process is this technology applied? Is it in the product, in the production process (primary process), in supporting processes (secondary processes), in the information structure?

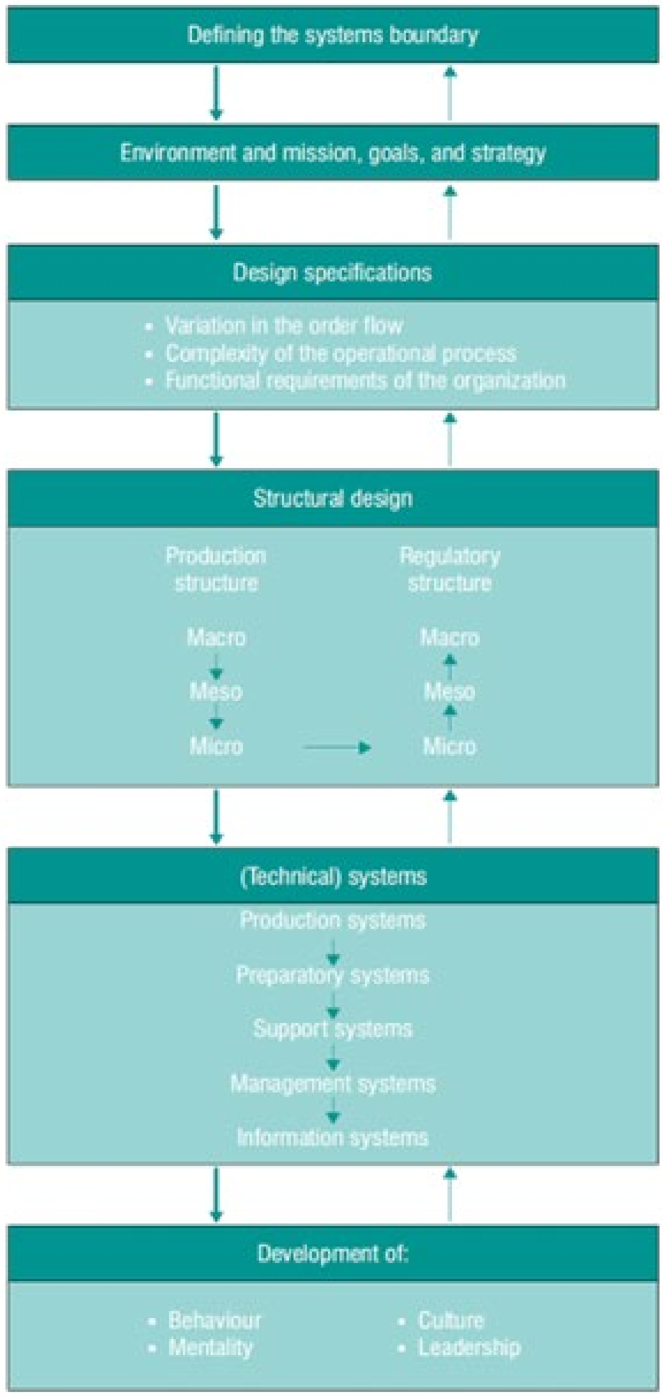

Figure 3. Integral design chain (Kuiper et al., 2020: 222)

Figure 3 shows the integral design chain of modern sociotechnical systems design. It consists of the following steps:

Step 1: Strategy

This strategic step deals with a number of topics. The systems boundary of the organisation or the part of the organisation that is going to be affected by the technology implementation needs to be defined. Based on requirements from the environment of the organisation, one needs to assess the mission, vision, goals and strategy. This includes the organisational and management philosophy and also the norms and values of the organisation.

A critical and fundamental activity is to define the design specifications, which are related to variations in the order flow, the complexity of the operational process, and the functional requirements of the organisation (such as efficiency, effectiveness, flexibility and innovativeness – which SEISMEC adds with human-centricity, (and to a much lesser extent) resilience and sustainability). Guiding questions are for example:

- What is the product / service this organisation / company is producing / manufacturing? How is the primary process laid out?
- Can orders be grouped into clusters, such as customers, markets, regions, and grouping technology? How are activities coupled with each other that cause interdependencies?
- What part of the organisation is affected by the new technology? What is the boundary of the (sub)system that will de (re)designed? What are the consequences for interdependencies and functional task allocation?

Based on the gathered information the structural design is the next topic, which consists of designing the production structure (step 2), followed by the design of the management structure (also control structure or regulatory structure) (step 3), and the information structure (also called technical systems) (step 4). In practice, most organisations redesign an existing structure. Less often a 'green meadow' approach is present where a completely new organisation is built from scratch.

Step 2 Production structure

The production structure must be able to deal with variety and turbulence in the environment (like market demands) in order to operate in a way that meets such demands. This is the resilience that is one of the Industry 5.0 goals. Key performance indicators help to assess whether the primary process of an organisation is on track. The production structure consists of grouping and coupling all (preparatory, supporting, implementation and operational) activities of the primary process to execute the orders. The design results in simplified logical work flows (parallel streams, interrelated segments), first at macro level (entire system), second at meso level (units), and third at micro level (teams). Guiding principles are:

- Design the production structure top down (see also 2.1)
- Minimise the division of labour, by preventing functional concentration, preventing the splitting up of preparatory, support, implementation, operational and management activities into separate units, and preventing a further division of preparation and support into aspects such as sales, purchasing, work planning, quality control, personnel, maintenance (too far uncoupling of primary and secondary processes).

Step 3 Management structure

The management (regulatory) structure is the grouping and coupling of all managing / managerial and administrative activities required to control the primary process. Here, the order of design is in the opposite direction, starting at the micro level (jobs within teams), followed by the meso and macro levels. The rule is to maximise and allocate control at the level where issues / problems / disturbances in the primary process need to be solved. This implies the integration of control cycles (control loops), which is the integration of preparatory, supporting, operations and managing tasks at the same level, for example, by designing maximum decision latitude within teams. In teams, the jobs are ‘rich’ (active jobs). The design makes clear that, for example, operational decisions are allocated to micro-levels as much as possible, whereas strategic policy and investment decisions are allocated at macro-levels (under the condition that lower levels have participatory influence in design making). This translates to the following guidelines:

- Design the management structure (see also 5.1). Design the task allocation between humans and machines.
- Ensure that technology implementation does not deteriorate the autonomy of humans unnecessarily. Ensure transparency of technology (hardware and software).

Step 4 Information structure

(Technological) systems should support the organisational structure and culture of constructive collaboration. Systems are, for example, production systems, planning systems, support systems and information systems. Their sequence of design should result in an information structure that supports and augments humans in carrying out their tasks and local decision-making (minimal critical specifications reduce unwanted control and monitoring).

- Define minimal critical specifications for systems that process and produce information (all technical systems). Design the (technological) systems.
- Ensure that the control capacity/decision latitude of humans is supported and augmented. Critically evaluate the adaptability of off-the-shelf technologies to human-centric needs.

Step 5 Teams and job structure

SEISMEC requires the incorporation of human needs as an essential part of the design and implementation of new technology. The sociotechnical design chain (**Figure 3**) points to the development of behaviour, mentality, culture and leadership but is less strict and specific in this regard. Sociotechnology sees an organisation as an interaction network, a network of nodal points, and a network regime. Via division of labour, that network can grow in complexity and become less effective ('bureaucratic'). Therefore, the number of nodal points can be reduced by making the organisation simple and making jobs complex: the organisation becomes less bureaucratic, and the quality of work more complex. This meets the requirements of human-centricity as long as there is a balance between job demands and job control ('active jobs'). This network regime approach implies that at the level of teams not only tasks are allocated to the team, but also that team members dispose of the appropriate mix of competencies to carry out the tasks. Not every team member has to be skilled to carry out all tasks, but all members together should be competent to carry out all team tasks. These guidelines apply:

- Ensure a team composition that includes persons who together dispose of all needed competencies;
- Allow space for self-management and self-organising at the team level so that teams can continuously adapt to changing situations and requirements. Team composition can change among teams depending on how the teams deal with complex environments;
- Teams have a certain responsibility to dispose of craftmanship, professional, commercial and management, and leadership competencies and accountability for targets.

Step 6 Task, man-machine interface and workstation design

SEISMEC's human-centric point of departure demands human well-being at work with regard to psychosocial and physical job demands. This can be partly ensured by creating active jobs (Karasek). However, the presence of means and resources to deal with possible health and safety risks is also crucial. This requires the application of psychological and physiological principles to the engineering and design of products, processes, and systems, not only to reduce human error and increase productivity and system availability but also to enhance safety, health and comfort with a specific focus on the interaction between the human and technology, machines and software algorithms.

- Ensure the application of HFE principles at all design levels (tool to organisation)
- Ensure stakeholder participation of human stakeholders in the design process.

There are a few pitfalls when one wishes to apply MST as a solution:

- There is not enough stamina to apply this solution in-depth, as it may be time-consuming and labour-intensive.
- Organisations and management with traditional and bureaucratic management and leadership styles may be reluctant to apply this solution direction as it may contradict their views on the autonomy and participative role of their employees.
- The order of design steps is directional and not a law in practice. But doing design activities in the wrong order is doing fundamental harm to a human-centric design result.

3 Workplace level with end user involvement

3.1 Collaborative design

General description

To create solution that match the needs, preferences and expectations of end-user, different approaches were developed that prioritize the end-users and possible other stakeholders. The approaches are based on the principle that end-users, being key stakeholders, possess unique and valuable knowledge that can significantly improve the relevance and applicability of design solutions. In these approaches the effort to emphasize, collaborate, and respond with and to end users. The three main branches of these approaches are: **co-creation, participatory design, and user centred design (UCD).** All methods might make use of specific tools and methods that facilitate the research and involvement of end-users in the design process. In itself the methods are abstract and focus on the added value of involving the end-user in the development process. More specific methods on how to involve end-users and other stake holders in the development process are described in sections 3.3 to 3.7. Collaborative design approaches are particularly useful for design processes where the fit to the end-user plays an important role. The approaches might be less suitable for applications where system stability and consistency are fundamental. For example, in fields where outcomes must be replicable regardless of user input, for instance with financial or cyber-security applications.

Co-creation is defined as a collaborative process where various stakeholders, including companies, customers, and end-users, work together in various stages of the development process to develop solutions, products, or ideas (Prahalad, & Ramaswamy, 2000). This approach places end-users at the heart of the development process, ensuring that their needs and perspectives are integral from the outset (Simpson, 2012). The co-creation environment fosters effective communication, collaboration, and engagement among participants. This collaborative atmosphere not only enhances the quality of the outcomes but also makes the process more enjoyable and productive for everyone involved. McCaffrey *et al.* (2025) found several positive effects for the users participating in co-creation processes, such as, the establishment of interpersonal relationships and positive group dynamics as addition benefits of the co-creation process. On the other side, participants might also have negative experiences, most frequently project related, but also for example, workload pressure and stress, lack of clarity about roles (McCaffrey *et al.*, 2025).

Applying co-creation comes along with the complexities and potential downsides of collaborative efforts (Steen, Brandsen, and Verschuere, 2018). These complexities include different levels of commitment and involvement (TU Delft, n.d.), planning and management to ensuring equal contributions and dominance within the group (Steen, Brandsen, and Verschuere, 2018), and fair distribution of responsibilities and accountability among stakeholders (TU Delft, n.d.). Lastly, established structures provide stability, but co-creation can disrupt these systems. The temporary and experimental solutions from co-creation may be seen as unstable, leading to a lack of trust and resistance from stakeholders who prefer existing structures (Steen, Brandsen, and Verschuere, 2018).

Participatory design originates from Scandinavian practices in the 1970's. The primary goal of this design method democratises the design process. In this method, users actively contribute to the design process and thereby enhancing the contextual suitability and user-focused nature of the end product or service (Robertson & Simonsen, 2012). It is also a useful approach in addressing workplace controversies by fostering collaboration (Björgvinsson *et al.*, 2010).

Key principles of participatory design, such as inclusiveness, transparency and empowerment, guide each phase of the process. These principles create a collaborative environment in which participants are encouraged to openly express their needs, preferences, and concerns. As a result, participatory design fosters a sense of ownership among stakeholders, its iterative nature allows for

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continuous feedback, refining solutions to be more responsive to real-world needs (Marois *et al.*, 2010).

Participatory design aims to make the design process more democratic, but it faces some criticisms. Björgvinsson *et al.* (2010) suggest that participatory design practices can sometimes be influenced by management or research agendas, which might dilute its original focus on workplace democracy. Additionally, tensions can emerge when balancing economic and social objectives. Cozza *et al.* (2019) highlight how these competing goals can shape the environment for collaboration, sometimes challenging the alignment of values within participatory design projects.

User Centred Design (UCD) is a multidisciplinary approach to designing and implementing advanced technologies. It focuses on designing products and services to satisfy user needs rather than starting from a technological perspective (Mao *et al.*, 2005; Schleyer *et al.*, 2007). Unlike approaches that balance various stakeholder demands, UCD exclusively focuses on the user perspective. It puts the user at the heart of processes, and that makes it human-centric: its main goal is to optimise the experience for specific end-users by prioritising their needs, preferences and limitations above all.

The UCD process is an iterative method with that goes through the following phased: investigation (understanding who the users are, what their needs are, what the context of use is), ideation, prototyping, evaluation, refinement, and validation (Graham *et al.*, 2019). Throughout the iterations designers actively incorporate user insights to identify potential issues early and develop solutions that align with user behaviours and routines. (Mao *et al.*, 2005; Or *et al.*, 2022; Harrison *et al.*, 2018). The main difference between UCD and co-creation and participatory design is the way the end-user is involved. Users might be understood through other methods than direct participation in the design process, as is the case with participatory design and co-creation. Techniques like field studies, needs analysis, usability testing, cognitive walkthroughs, heuristic evaluation and think-aloud protocols help reveal how users interact with technology in their daily practice (Or *et al.*, 2022).

Ultimately, UCD is an approach for improving the fit between technology and its intended users, enhancing efficiency, user satisfaction and engagement (Or *et al.*, 2022). As technology continues to evolve, ongoing research and cross-disciplinary collaboration will be crucial for advancing UCD methodologies and their application across diverse domains (Dopp *et al.*, 2018; Lu & O'Reilly, 2024).

Application

User participation can be applied to different types of technology, including web applications and wearable devices, and is widely used in a variety of fields, including health care, education, technology-enabled services, software development and enterprise systems. Its principles enable the development of products that align with user behaviours, preferences, and environments.

Examples of UCD and participatory design can, for example be found in healthcare projects. Using UCD can improve the usability and acceptability of systems such as medical tele-consultation tools (Nathanael & Marmaras, 2000), healthcare planning applications (Carr *et al.*, 2017), and mobile apps for STI diagnosis (Gkatzidou *et al.*, 2013). These systems improve workflows and address the specific requirements of patients and professionals (Lennox-Chhugani, 2018; Dabbs *et al.*, 2009; Reale *et al.*, 2018). Additionally, UCD's adaptability to remote collaboration has also been shown: for instance, the Chronic Pain project applied digital co-creation workshops during the COVID-19 pandemic, allowing continuous user engagement despite physical restrictions (Smaradottir *et al.*, 2020).

Similarly, PD is highly effective as it enables patients, healthcare providers, and administrators to collaboratively shape systems that meet complex health service requirements. By involving stakeholders in the co-design process, PD enhances the relevance and usability of solutions, such as critical care information systems that benefit from the direct insights and experiences of end users (Rothmann *et al.*, 2016). Similarly, in the development of assistive technologies, PD methods allow users with specific needs, such as those with visual impairments, to guide the creation of applications that respond precisely to their requirements, thereby improving user satisfaction and overall accessibility (Hakobyan *et al.*, 2013).

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Referral to transversal themes

Two transversal themes are relevant. First, 'Trust and understanding': Involving end-users in early stages of the design process helps identifying potential issues related to trust and understanding and addressing these issues in the final product. 'Inclusion': Including the worker in the design process helps addressing their specific needs, preferences and expectations. However, this requires that end-users involved in the approaches come from a representative group.

Design guidelines

- **Involve end-users from diverse user groups and with distinct abilities.** It helps capture a comprehensive understanding of user needs (Marti & Bannon, 2009). PD is particularly effective in settings where users differ significantly in their experiences, expectations, and roles. In educational contexts, for instance, PD methodologies enable teachers and students to co-create learning tools that cater to varied engagement levels, learning preferences, and goals. This allows for personalized learning experiences that enhance both student motivation and educational outcomes (Xu *et al.*, 2023; Holstein *et al.*, 2019).
- **Ensure a fair distribution of responsibilities and accountability among stakeholders.** This can be challenging due to the diversity of expertise levels, social identities, and historical backgrounds but is required because of the high participation of multiple stakeholders.
- **Integrating participation of end-users into traditional development methodologies can also pose difficulties.** The iterative nature of UCD can be resource-intensive and time-consuming, which may conflict with fast-paced development environments. Combining UCD with agile methodologies can exploit skills and experiences in a multidisciplinary environment to address complex design challenges (Vilcapoma & Paz, 2018). Balancing UCD activities with agile implementation can be challenging, as human-centred activities often require substantial time before and during implementation (Minge & Föhl, 2018). Additionally, the high risk of failure when development phases are

rigid and linear and do not accommodate revisions of the initial UCD processes is a significant concern (Wulan, 2024).

- Engaging user groups can be complex, especially when working with individuals with limited capacities or specific needs, such as children or those with cognitive impairments (Case, 2013; Marti & Bannon, 2009). **Tailored strategies may be required to ensure meaningful participation from such groups.**

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3.2 Value-co-creation

General description

Value co-creation (VCC) is closely related to the approaches with end user participation in 3.1. However, it differs from there approach in its aim of creating, delivering, and exchanging value to craft products, services, and experiences with customers and businesses involved in a symbiotic relationship (Saxena 2021; Fawcett *et al.*, 2014). Key actors can include companies (employees, management), customers, partners, and communities (Liu *et al.*, 2018). In addition to conventional co-creation, VCC emphasizes the joint creation of value through interactions during the design process. Moreover, VCC goes beyond simply producing value and delivering it to customers, as it emphasises the active participation of customers and other key contributors in the creation process. This is done through direct and indirect collaboration across multiple stages of production and consumption (Ranjan, & Read, 2016). This approach recognises that value is not just embedded in the product or service itself but is co-created through the experiences and interactions between the stakeholders (Vargo and Lusch, 2004, 2008). In essence, a shift from a Goods-Dominant logic towards a Service-Dominant logic is being made, emphasizing the value of skills and knowledge instead of materials and machines (Saha *et al.*, 2020).

Using VCC, organisations can foster innovation, encourage customer participation, and enhance customer services (Galvagno, & Dalli, 2014). VCC could result in higher customer satisfaction and engagement (Ranjan & Read, 2016), and better business- and economic-related outcomes (Wu *et al.*, 2023). Yet, using VCC successfully does not happen automatically, it is of importance to focus on a few key areas. Challenges such as organisational resistance to change, the lack of proper tools to measure progress, potential legal and regulatory issues (Das *et al.*, 2021), and varying levels of participant commitment can hinder the process (Danielsson, & Stenman, 2021). The depth and nature of customers' involvement in a service system are crucial factors influencing their participation in VCC activities. This participation, in turn, leads to various beneficial outcomes for both the customers and the organisation (Laud & Karpen, 2017), such as customer's brand passion and brand connection, and as a result also in brand satisfaction and willingness to pay a higher price (Chen, Lu, and Gong, 2022).

Application

A practical example is LEGO Ideas, which is a pioneer in the field of value co-creation. Here, value co-creation was successfully implemented in LEGO Ideas Portal, an online community where fans can submit, iterate, and vote on new product ideas. This platform allows LEGO to access the creativity and preferences of the LEGO customer base, ensuring that new products are both highly anticipated and well-received. By transforming customer suggestions into novel kits, LEGO has significantly reduced its time to market from two years to just six months. This approach not only enhances customer engagement and satisfaction but also drives continuous innovation and commercial success. All of these kits were best-sellers with a high selling-out rate of 90% within the first release. A great success factor in this example is the dedicated customer base of LEGO (Ramaswamy, & Gouillart, 2010).

Another example given is from the Dutch bank ING, who planned to launch a low-end life insurance product with an investment feature. Instead of a traditional approach, where no attention would have been drawn to the overall experience of the bank's employees, ING adopted a value co-creation approach, involving various stakeholders in the development of the novel product. Workshops including employees from different departments (insurance product managers, actuaries, IT people, bank insurance specialists, branch managers, senior branch advisers, and junior branch advisers) were organised with each other and subsequently with target customers to discuss their experiences with past product launches. Through these sessions, it was found that junior advisers shared similar needs and concerns with the target customers, whereas a strategy was developed where junior advisers and customers learned about the new product together through informal sessions and online platforms. This approach not only enhanced the advisers' skills and career prospects but also improved customer engagement and satisfaction. The result was a successful product launch, accompanied with significant revenue generation, reduced training and distribution costs, increased customer loyalty, and lower employee turnover. This example illustrates how value co-creation can lead to better outcomes for both the company and its employees by fostering collaboration and mutual understanding (Ramaswamy, & Gouillart, 2010).

Referral to transversal themes

VCC enhances employee and customer engagement and satisfaction, thereby increasing value of a brand, product or service. Both employee and customer learn to understand each other during the collaborative sessions, thereby enhancing Trust and Understanding of the process and product. Moreover, Workers Inclusion is a requirement for the use of VCC. End-users have an important role in expressing needs, giving input and feedback, and designing the technology.

Design guidelines

- **Arrange sessions with stakeholders, following the guidelines on collaborative sessions, workshops and brainstorming sessions as described in other sections.** For general guidelines on how to include workers and users into the design process, see Collaborative design. For guidelines on how to organise a collaborative workshop, see the section on Co-creation workshops or look for a suitable method in the Instruments chapter. For other guidelines on VCC specifically, see below.
- **Facilitate an environment for open interaction.** Encourage dialogue by creating platforms for regular interaction between all stakeholders, including customers, employees, and partners. This can be through forums, social media, or dedicated communication channels. Additionally, ensure that all relevant information is accessible to everyone involved. Transparency builds trust and facilitates better decision-making (Das *et al.*, 2021).
- **Clarify roles and expectations by clearly defining what is expected from customers in terms of their involvement.** Ensure they understand how their contributions will be used. Empower customers by providing them with the tools and resources they need to contribute effectively, including training, access to information, and support (Galvagno, & Dalli, 2014).
- **Ensure to have a strong brand and create a loyal customer base**. Build brand trust by delivering consistent value and maintaining a positive reputation. A strong, trustworthy brand attracts loyal customers who are more likely to engage in co-creation. Engage with your loyal customers regularly and recognize their contributions through loyalty programs, exclusive previews, and personalized communication (Das *et al.*, 2021).

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3.3 Co-creation workshops

General description

Co-creation aims for actively involving users in brainstorming, prototyping, and testing phases. Co-design fosters a deeper understanding of user needs and encourages innovative solutions that might not emerge from a more isolated design process. It emphasizes the importance of creating shared experiences and leveraging the collective creativity of all participants to generate breakthrough insights.

A common way of involving different stakeholders is through co-creation workshops. These workshops are collaborative sessions designed to bring together diverse stakeholders to achieve shared goals. As such these workshops can be organised within different development trajectories that include end-users in the design process. The workshops can be used to better understand the design problem from different perspectives, identify opportunities and the ideate different solutions.

To maximize the output of the workshops there are several attention points for the format, listed under the design guidelines.

Referral to transversal themes

Co-creation has a direct link with human trust and understanding via the participative role of employees (as one of the prominent stakeholders) whose work may be affected by the implementation of the new technology. Co-creation has an indirect link with cyber security and privacy (depends on how the new technology is applied), inclusiveness (Co-creation supports participation and workplace democracy), and in-work learning (Co-creation supports the fact that employees must understand the new technology).

Design guidelines

The following design guidelines are applicable to all three forms of co-creation. Additionally, the co-creation design guidelines as reported in section 3.1 are of great importance when using a co-creation workshop.

- **Schedule enough time to perform the session.** A co-creation workshop should last at least three to four hours if you aim to do more than just inform participants. This duration allows enough time for meaningful engagement, discussion, and collaboration. Shorter workshops may not provide sufficient time for participants to fully immerse themselves in the topic and contribute effectively. If necessary, multiple sessions could take place over the course of the development process (Kuhn, Konrad. Wist, & Witzel, 2021)
- **Limit the group size to no more than 15 participants to ensure a productive and effective session.** If you wish to include more participants, consider dividing them into smaller groups and designing the process to switch between plenary and workgroup sessions. This approach ensures that each participant can contribute meaningfully without the session becoming unpractical. Additionally, limit the number of observers/leaders to no more than two to maintain focus and engagement (Kuhn *et al.*, 2021).
- **Preferably consult an expert in designing and organising co-creation workshops.** Experts bring valuable experience and knowledge in designing and facilitating these sessions, ensuring that objectives are met, and participants are engaged. However, it's also possible to organise a co-creation session without an expert. If you have a good understanding of the principles and techniques involved, you can still create a productive environment for collaboration. Ultimately, the decision depends on your familiarity with co-creation processes and the complexity of the session you plan to organise.

- **Structure the session in phases, typically four.** 1) Warm-Up: This initial phase allows participants to tune into the topic, understand the workshop agenda, and get to know each other. It fosters curiosity and creates a good working atmosphere. Elements can include welcoming words and participant introductions. We refer to the Workshop section for ideas on participant introduction. 2) Orientation: In this phase, the topic is presented in depth, covering all its various aspects. This sets the stage for the main activities. 3) Working: The core phase where participants dive into the topic and work collaboratively on it. This is where the "real work" happens. 4) Conclusion: The final phase involves reflecting on the workshop, gathering feedback from participants, and summarising the outcomes (Kuhn *et al.*, 2021).
- **Document everything extensively and report this back to the participants.** Write down points of action and keep participants posted on the progress.
- **Prepare one or two questions you aim to address in the session.** Answer these questions by using various instruments or design methods. In Chapter 6 of this document, you can find some of these instruments and how to execute them. Other ideas can be found in the Delft Design Guide from Van Boeijen, A., Daalhuizen, J., and Zijlstra, J. (2020). Important here is to choose a method that suits your goal and matches the participants, resulting in involved participants with significant contributions and input.
- **Adjust the level of difficulty and challenges to the participants and make the session more immersive than instructional.** Unexpected barriers that may arise during the co-creation process could result in perceived stress and pressure of the participants. To reduce stress and pressure on participants, ensure that workloads are manageable and provide support when needed. Design the session to be immersive and interactive rather than purely instructional to keep participants engaged and prevent boredom. Regularly check in with participants to address any concerns and adjust the process as necessary to maintain a positive and productive environment (McCaffrey *et al.*, 2025).

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- **Prepare materials that belong to the design approach you choose.** If you aim to use technology during this approach, make sure it is appropriate for the co-creation process and ensure it works smoothly. Provide clear instructions and support to participants and consider their prior experience with the technology. When technology functions well, it can facilitate the process, spark interest, and strengthen feelings of co-ownership among participants. Regularly test and troubleshoot technology to maintain its effectiveness throughout the session (McCaffrey *et al.*, 2025).

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3.4 Living lab

General description

A Living Lab is a research concept and methodology that involves the active participation of users and stakeholders in real-world settings to develop, test, and refine innovations (Higgins, & Klein, 2011). It is used as a methodology to foster implementation of technological innovations in a human-centric manner (Dell'Era & Landoni, 2014). The primary goal is to study the implications of designed solutions in the environment where the innovation will be implemented. This could be organisations, workplaces, public spaces, and broader communities. Within this approach, requirements can be solicited, and feedback can be integrated into the ongoing innovation process (Higgins, & Klein, 2011). Users are considered co-innovators – they are actively involved in the process of developing, testing and implementing innovations in real-life settings (Zipfel *et al.*, 2022). Doing so, ensures that innovations are practical, effective, and aligned with the needs and experiences of the people who will use them. Due to the involvement of users in not only the development phase, but also the testing phase, the likelihood of successful and sustainable implementation is increased (Zipfel *et al.*, 2022). Feedback of the users tailors the innovation on real-life use, which may additionally speed up the lifecycle of the innovation's realisation (Värmland County Administrative Board., 2019). Using a Living Lab approach, issues such as testing assumptions of the set-up and infrastructure, and unforeseen consequences of action could be exposed and taking into account in further developing the technology (Higgns, & Klein, 2011).

A recent literature review of Zipfel *et al.* (2022) examined which factors contributed to the success of the living lab approach, and found six components:

leadership, involvement, timing, openness, organisational support and **ownership**. Senior leadership or participants with prior knowledge of the intervention could contribute to better leadership and is shown to enhance involvement of the end users. This involvement of end users early during the process and during the entire implementation process is also determined to be a success factor. Moreover, it is of great importance to establish a realistic yet concise timeframe for the implementation to maintain the end-users' motivation. Openness to change can also support better implementation, as well as received support in terms of staff and funding from the organisation. Last, a sense of ownership could determine the success of a healthcare implementation. Ensuring the programme meets the needs of end-users and is essential for it to be perceived as valuable, as well as shared responsibility among the end-users (Zipfel *et al.*, 2022).

Application

Living labs are commonly applied to implement innovations, in the healthcare domain in particular, concerning a various range of topics such as ageing, technological innovations, and healthy living (Zipfel *et al.*, 2022). An example of a healthcare application is the eLabEL-project. This project aimed at integrating e-health in primary care, to improve patient care and streamline healthcare processes. A wide range of participants, including healthcare providers, technology developers, and policymakers were included as stakeholders in this project. The collaboration was intended to ensure that the solutions were practical, effective, and widely accepted. The integration of the novel solutions into the vast IT infrastructure, conflicting priorities among stakeholders, and inadequate business cases were the main challenges faced in the project. Although the project itself failed, important lessons were learned during the project, giving better understanding of the complexities involved in implementing e-health solutions and applying a living lab approach. The project underscored the importance of having a clear, shared vision and strong alignment among all stakeholders. Effective collaboration requires not just participation but also a unified direction and purpose (Huygens, & Swinkels, 2018).

Referral to transversal themes

The Trust and Understanding and Worker Inclusion are two transversal themes that are relevant for the Living Lab. A Living lab contributes to user acceptance as end-users must be included in an experimental living lab setting. It can also enhance diversity, as a form of inclusiveness, as a diversity of users can be selected in doing so.

Design guidelines

- **Explore and define clear objectives and scope of the living lab.** Establish the purpose of the living lab, aligned with real-world challenges and AI-driven innovations. Specify the problems to be addressed, identify the key sectors (e.g., healthcare, education, food market etc.) and the desired outcomes. The focus is on deeply understanding the challenges and needs of stakeholders. Different stakeholders have different meanings and goals (Wagner, no date). It is important to make room for different opinions, goals and solutions. Most important is to search for common ground and respect the differences in meanings, goals and solutions. Look into various qualitative methods that you can use to gather information on this, such as an Interview, Co-creation workshops, and a Customer journey / journey map (Labs *et al.*, 2025).
- **Involve all relevant stakeholders and aim to include end-users in every stage of the process** (Malmberg *et al.*, 2017). Stakeholder could be all quadruple helix actors: representatives of public and private sector and academia (see the description of the Quadruple helix model for more information). It is important to explore which organisations, professionals and informal networks are familiar or willing to work on the defined challenges and goals (Wagner, no date). It is important to create an equal relation between all stakeholders involved (Kareborn and Stahlbrost, 2009). Representations of all users' needs should be integrated so that the living lab could ensure benefit for all relevant stakeholders and the society as a whole (Postmes, no date).
- **Define the real-life setting in which you want to implement the technology.** Co-create, implement and test the results in the users' perceived real-life setting,

validating their feasibility and assessing their problem-solution fit (Labs *et al.*, 2025; Postmes, no date). To do so, gain a thorough overview of the context and work on a specific challenge together with different institutions (Malmberg *et al.*, 2017; Wagner, no date).

- **Use various methods to gather ideas and opinions on the living lab.** There is no one size fits all living lab approach. All living labs combine and customize different human-centred co-creation methodologies to best fit their goals. A possible set of methods that you might want to consider using: participative observation, informal talks, interviews, and focus groups. Determine which tools and instruments to use based on your users, stakeholders, setting, time and type of input needed. For more elaborate information on how to use these methods, we refer to the descriptions in the Instruments chapter.
- **Perform an impact assessment to examine effectivity.** This could done in two ways, top-down or bottom up. For a Top-Down impact assessment, define Key Performance Indicators (KPIs) at the outset of the project (Labs *et al.*, 2025). The KPIs are then measurable and influenced by the living lab. A baseline measurement of the KPIs is taken before the intervention, and they are measured again after the execution. For a bottom-up impact assessment, the focus is on a dynamic, iterative process of measuring impact (Labs *et al.*, 2025). The process follows a sequence: inputs à activities à outputs à outcomes à impact. Stakeholders involved in the living lab define their own assumptions about change and these assumptions are validated and iterated throughout the intervention.

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3.5 Lead user innovation

General description

Lead users are defined as members of a user population who 1) expect to derive relatively high value from obtaining a solution to their needs and thus may innovate, and 2) are at the forefront of important trends in a market under study and thus are currently experiencing needs that will later be experienced by many users in that market (Franke, Von Hippel and Schreier, 2006). They are early adapters of existing technology and early adopters of new technology

(Sedghipour, 2017). Lead user innovation refers to the process by which lead users not only identify unmet needs but also create and develop new products or solutions to address those needs. This innovation process involves leveraging the creativity and expertise of lead users to co-create solutions that can later be adopted by the broader market. Lead user analysis has been shown to have a high potential for generating attractive innovation ideas, but what characteristics of lead users are important (Schuhmacher and Kuester, 2012; Venesz, Dőry and Raišienė, 2022)? It is important for service companies to focus on the following characteristics when inviting individuals to participate in idea competitions: ahead-of-the-trend, dissatisfaction, usage experience. The first characteristic, ahead-of-the-trend, is about lead users showing needs that are not covered by existing services, as these needs will become common in the future (Franke and Shah, 2003). The unmet needs of lead users provide the motivation to develop products and services that meet their vision. The second characteristic dissatisfaction, also known as "high value from innovation," is related to a deeply felt need for a better solution. As a result, lead users who are ahead-of-the-trend feel a deep need for better solutions and innovation, and therefore have a high level of dissatisfaction with existing offerings. The third characteristic use experience refers to knowledge and learning based on repeated usage (Lüthje, Herstatt and Von Hippel, 2005). Use experience helps in understanding how the service works. In addition, highly experienced users are able to differentiate which attributes are relevant to them. Moreover, the researchers emphasized that companies should focus on lead users, who are particularly capable of coming up with creative ideas (Schuhmacher and Kuester, 2012).

In conclusion, lead user innovation is an important method to contribute to the high-quality success of an open innovation process. It is essential to consider the characteristics of lead users as they play a crucial role in the co-creation process.

Application

Lead user innovation has continued to evolve, and several applications show that it can generate innovative ideas and concepts that can even lead to new

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products and services (Brem, Bilgram and Gutstein, 2018). When you apply lead user innovation, it is useful to keep the validated process in mind (see **Figure 4**).

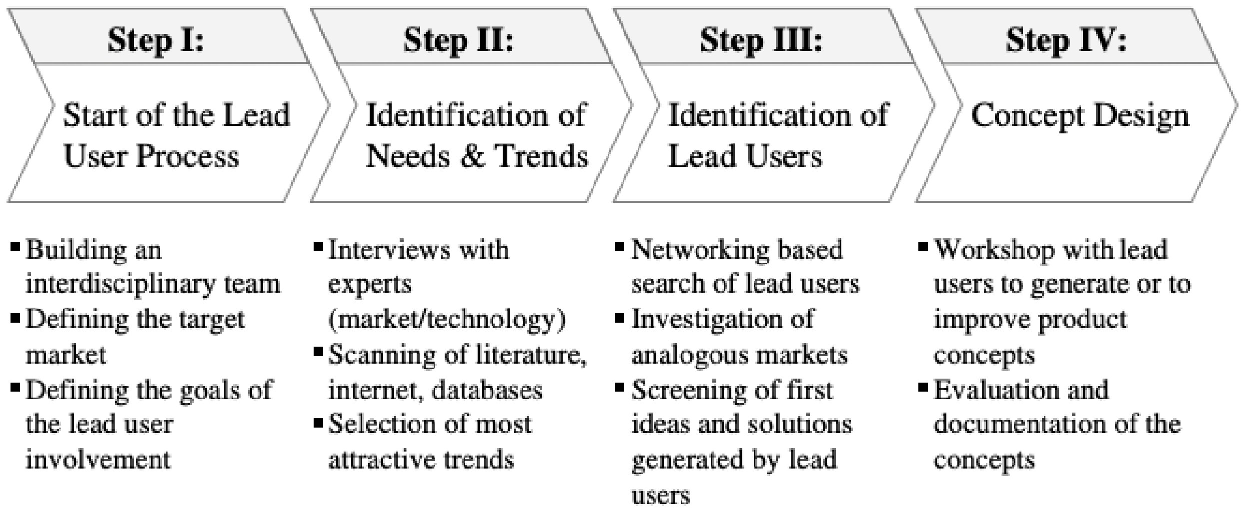

Figure 4. Lead User Method Process (Brem, Bilgram and Gutstein, 2018).

The first step is to define the search of field, which can be a market, product field, or service area for which innovative ideas or concepts should be developed (Lüthje, Herstatt and Von Hippel, 2005). Next, the goal of the project should be specified, considering constraints such as budget and time. The second step is to identify and understand critical market and technology trends in the area under study. Identifying needs is also important because trends illustrate general and long-term developments and form the basis for determining potential needs. In addition, this step also includes scanning literature, reports, academic publications, databases (e.g., complaint management database to invite dissatisfied users to participate). The third step is the identification of lead users. Here, the characteristics of lead users are very important to distinguish them from ordinary users. The last step is to, e.g., invite the lead users to a workshop, where preliminary concepts are further elaborated, or completely new solution concepts are developed to meet the previously defined trends and needs.
The application of this method covers a wide range of areas. For example, a case study involving a leading American manufacturer of semiconductor chips

(Kakatkar, Bilgram and Füller, 2020). The company recognized the need to address the needs of end users, ranging from consumers to professionals, and lead users of chip-based products. These lead users are active online, act as social media influencers, and shape end-user opinions about semiconductor chips. By looking at the issues affecting the lead user group, the company believed it could target high-impact issues related to the chips. So, the company created a cross-functional innovation team that included data scientists to analyse end-user data to identify potential lead users and develop a shortlist of high-impact issues.

In summary, the lead user method follows a systematic process that provides access to knowledge and innovative ideas. Several applications have been conducted, ranging from improving teamwork to creating entirely new products or services.

Referral to transversal themes

Trust and understanding: technology acceptance is enhanced by making sure to have the early adopters included in the design process.

Worker inclusion: Within lead user innovation the aim is to include adapters of existing technology and early adopters of new technology of the targeted worker population.

Design guidelines

- **Use Lead user innovation to create new products and/or services.** However, involving lead users in business optimisation processes, e.g. in implementing new technology in a human-centric way, can also be very beneficial. The term ‘users’ refers to all staff who ‘use’ certain processes, tools, machinery etc. Here are some examples of when it is better to involve lead users over average users in participatory design processes.
    - Lead users form a subgroup of the users that are generally more critical of the processes they are involved in and tools they work with. They place higher demands on them and are therefore more likely to

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provide insights into practical improvements if current tools, processes, or technologies fail to meet evolving job demands.
  - Lead users often tend to develop their own solutions, offering tested and refined ideas. Regular users typically identify issues but may not have devised solutions.
  - Industries undergoing digital transformation (e.g., AI-driven workplaces) can benefit from lead users to test and integrate new technologies before company-wide implementation.

- Follow the process steps of **Figure 4**. **Figure 4** shows a typical innovation process involving lead users, this process is similar to other participatory design processes (see also Collaborative design).
- **Identify lead users.** After having decided that lead users need to be involved in the design process, step III in **Figure 4** is most important. Identifying lead users inside a company may be a lot easier than externally as internal lead users are closely connected to the processes or tools involved in the innovation/design process. Co-workers and team leaders should generally be able to identify workers that qualify as 'lead user'.

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3.6 Learning community

General description

In a learning community, various parties are brought together to work together on structured activities aimed at solving urgent, complex and critical societal issues (Zamiri, & Esmaeili, 2024). This collaborative setting encourages sharing ideas and best practices, using the diverse skills of all parties to tackle multidimensional challenges effectively. Typically, a learning community includes 10-15 people who collaborate to solve problems, innovate, and participate in research (Hord, 1997). Also, they can learn with and from each other and develop novel skills and networking connections (Wildeman, & Pannebakker, 2023; Zamiri, & Esmaeili, 2024). Learning communities promote collective thinking and problem-solving from various perspectives, including policy, education, practice, research, and the target audience (Zamiri, & Esmaeili, 2024). Learning communities are seen as an effective way to solve these complex societal issues, because of their characteristics of working beyond the usual boundaries to achieve common goals. Unlike occasional meetings, learning communities use a systematic approach that ensures continuous, structured learning while addressing complex issues (Visscher *et al.*, 2024). Their structured nature makes them effective in preparing individuals for ongoing changes, significantly contributing to sustainable employability, personal development, and professional growth (Zamiri, & Esmaeili, 2024).

Engaging in learning communities offers many benefits, including developing solutions for complex issues, fostering innovation, and contributing to research (Zamiri, & Esmaeili, 2024). Learning communities are ultimately suited to bring all kinds of expertise together and foster in sharing knowledge and needs from diverse perspectives, enhancing both individual and collective expertise and learning (Wildeman, & Pannebakker, 2023). Learning communities function at best if there is enough openness for all perspectives to be brought in there is a focus on learning (and forms of learning) and if implicit knowledge is made explicit (Wildeman, & Pannebakker, 2023).

Learning communities are a frequently applied method to help enhancing teaching and learning processes, as well as evaluating the progress of teachers and students (Prenger *et al.*, 2018). Moreover, it is used in the social domain, where stakeholders come together to solve their complex, societal challenges (Schipper, Vos, & Wallner, 2022). Although the broad application of learning communities within various domains, the method lacks a solid theoretical support base. Therefore, the 'social domain networks' ("Leernetwerken in het social domein" in Dutch, Wildeman, & Pannebakker, 2023)" as a framework has been developed to support and evaluate (novel) learning communities. This framework is based on existing literature and evaluated and complemented by experts in the field. This framework consists of eight core elements, where working elements are identified for each core element to assist in successfully setting up and maintaining a learning community (Wildeman, & Pannebakker, 2023). By doing so, factors that contribute to the success of a learning community were identified. These include: 1) implementing it within a well-functioning collaborative framework; 2) achieving consensus on strategic ambitions between the learning community and consortium partners; 3) allowing room for taking risks; 4) setting clear goals, and, in case of multiple learning communities, 5) having a responsible coordinator over all communities who encourages learning.

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Application

Learning communities could be used for AI knowledge development purposes. Netherlands AI Coalition (De Nederlandse AI Coalitie) is committed to the development and application of responsible AI in the Netherlands, and used learning communities when doing so. These communities involve businesses, educational institutions, and innovation labs working together to develop new educational programs and training modules. By leveraging regional collaboration structures and focusing on practical AI applications, these learning communities produce tangible outcomes such as research, training programs, and skilled professionals. This approach not only accelerates the integration of new knowledge into education but also addresses the mismatch between AI talent supply and demand, ultimately fostering innovation and development in the AI sector (Nederlandse AI Coalitie, 2022).

Referral to transversal themes

Learning and skills: Learning communities ensure continuous learning and skill development (social learning as it brings diverse parties together). End-users are involved as well and acceptance of the technology is intended to be enhanced, yet the primary goals is to set up a learning environment. There are indirect links with human trust and understanding, and inclusion of stakeholders.

Design guidelines

- **Involve representatives from policy, education, practice, research and the target group to ensure diverse perspectives** (Zamiri & Esmaeili, 2024). Keep the network size manageable (10-15 members) to ensure active participation and effective coordination (Hord, 1997). Develop a support network that includes a wide range of platforms (e.g. advisory groups, expert mentorship programmes, peer-learning forums). It can be ensured that input from different sectors is well-rounded, and that community goals and organisational needs are aligned. Workers and participants need to have positive attitudes towards collaborative learning and be willing to engage in knowledge sharing (Lloyd *et al.*, 2014; Nesheim & Hunskaar, 2015).

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- **Appoint a learning community leader to coordinate multiple activities and maintain engagement.** Additional coordinator(s) can be further employed for administration and planning in case the community expands.
- **Allow community members to allocate dedicated work hours for community activities and support a positive learning culture within the organisation.** It can be done by creating a safe learning environment where members can take risks and learn from mistakes. Management plays an important role in fostering a culture of learning. They need to be committed to providing resources, protected learning time, supportive management practices, and create a positive environment for learning (Lloyd *et al.*, 2014). It is also beneficial to have clear discussion guidelines, anonymous idea submissions and regular diversity audits to ensure that all voices are heard.
- **Define the expected duration of the learning community**: short term (6-12 months) or long-term (multi-year initiatives). Having periodic evaluations is beneficial to track progress. Meetings should be regular but not excessive, ensuring a balance between discussions and action (Wildeman & Pannebakker, 2023). This can be done by monthly feedback surveys, quarterly reflection meetings and by documenting lessons learned, successes, best practices and challenges. This way, there is a clear orientation towards knowledge transfer, hence innovations can be effectively implemented.
- **Encourage synergy and collaboration by pooling resources.** Funding needs to be transparent to manage resources efficiently. Financial resources can cover a wide range of costs: technological tools, learning materials, logistics, expert involvement, research and development activities etc.
- **Use interactive formats** such as workshops, breakout groups, interdisciplinary panels, knowledge exchange session, case studies and co-creation sessions etc. It is important to ensure that members 'own' the group which fosters trust-building (Wilson & Lowe, 2019). For more information on how to organise a collaborative workshop, see the section on Co-creation

workshops or look for a suitable method in the Instruments chapter**Error! Reference source not found.**.

- **Allocate physical or digital spaces that facilitate collaboration** (e.g., meeting rooms, online platforms). A wide range of technologies are available to rely on, such as: digital communication platforms and collaboration tools (e.g. MS Teams, Miro, Slack, Google Workspace, etc.); Knowledge repository for shared resources; Learning Management System (LMS); Technical support and training to enhance digital literacy; Surveys or analytics tools to integrate feedback mechanisms.
- **Develop a structured learning framework** (such as the LISO framework or Kolb's experiential learning cycle) to guide activities, facilitate continuous learning, evaluate and support community effectiveness (Wildeman & Pannebakker, 2023). In addition, accommodating some flexibility can be useful for spontaneous discussions, informal open forums etc.
- **Sustain the learning community** by focusing on some significant phases of development (Wildeman & Pannebakker, 2023):
    - Formation: establishing the network, define goals, set up collaboration structures
    - Maintenance: ensuring active participation, refine processes and strengthen relationships
    - Institutionalisation: embedding successful practices into organisations for long-term impact

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3.7 Intervention mapping

General description

Intervention Mapping (IM) is a planning approach used to develop behaviour change interventions. IM is facilitating a human-centric approach, and results in an intervention that is tailored to the needs and contexts of the target population (Bartholomew-Eldredge *et al.*, 2016). It is primarily used to develop, implement, and evaluate health promotion and public health programs and has proven its effectiveness accordingly. Recently, IM is being applied for other purposes as well, for example to develop an intervention in the occupational safety domain (van der Beek, Steijn, & Groeneweg, 2023), or in the development digital health interventions (Marcos *et al.*, 2024). IM shares several principles with human-centred design (HCD), such as understanding people, user involvement, and iterative development. Both approaches prioritise understanding and addressing the needs of end-users (Melles, Albayrak, & Goossens, 2021). IM consists of six steps (see **Error! Reference source not found.**), each designed to guide the development process from problem identification to evaluation. The first step in the IM process involves conducting a needs assessment or problem analysis to identify what needs to be changed and for whom. Secondly, matrices of change objectives are created by combining (sub-)behaviours (performance objectives) with behavioural determinants, thus identifying which beliefs should be targeted by the intervention. Thirdly, theory-based intervention methods are selected to match the determinants, and these are translated into practical applications that meet the effectiveness criteria. The fourth step integrates these methods and practical applications into an organised programme. Fifthly, plans are made for the adoption, implementation, and sustainability of the programme in real-life contexts. Finally, an evaluation plan is generated to conduct both effect and process evaluations (Bartholomew-Eldredge *et al.*, 2016).

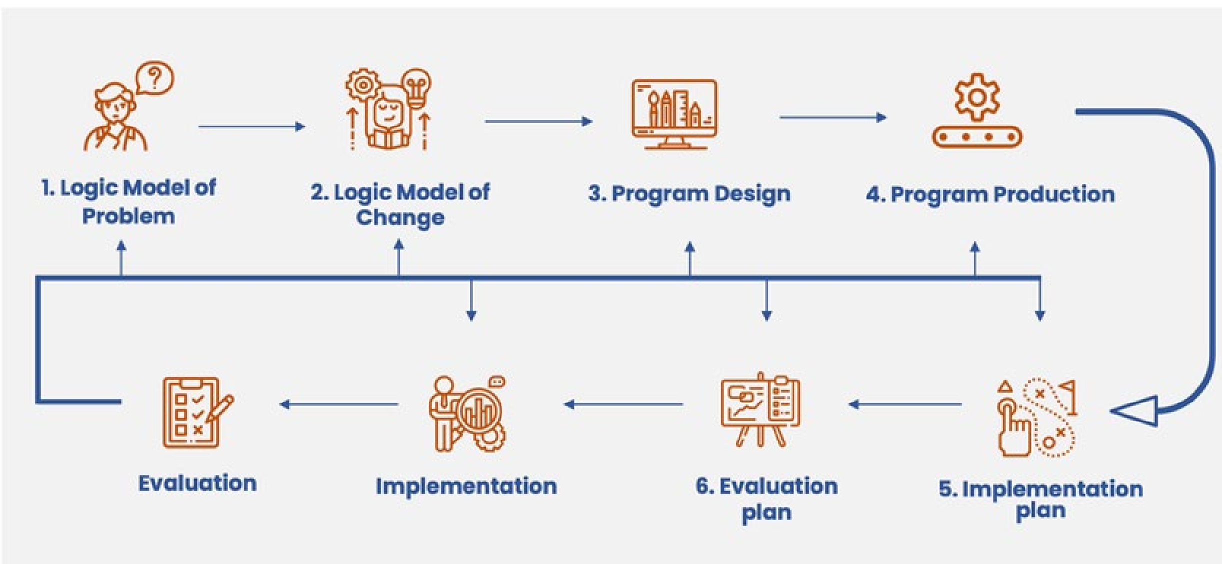

Figure 5. The six steps of Intervention Mapping (Marcos *et al.*, 2024).

One of the main benefits of IM is its structured approach. It provides a clear, step-by-step, yet iterative, process that ensures that all aspects of intervention development are considered. This sometimes requires going back to earlier steps to improve or adjust the programme. Another significant benefit is that IM emphasises stakeholder involvement throughout the process, ensuring that interventions are relevant and acceptable to the target population. Additionally, the framework is flexible and can be adapted to various contexts and types of interventions, making it versatile and widely applicable (Fernandez, Ruiter, Markham, & Kok, 2019b). Last, the focus on sustainability ensures that the interventions are designed for long-term impact and maintenance (Highfield, Valerio, Fernandez, and Eldridge-Bartholomew, 2018).

Several factors contribute to the success of interventions developed using IM, which were mentioned in a study of Highfield, *et al.* (2018). They highlighted the importance of a systematic and structured approach, which ensured that all critical aspects of the intervention were addressed. The integration of various theories and frameworks in the planning process was also mentioned as a success factor, making the intervention robust and context-specific. Furthermore, the use of these theory-based methods increases the likelihood of achieving actual behaviour change (Fernandez *et al.*, 2019b). The involvement of relevant stakeholders is suggested to help tailor the intervention to the specific needs and context of the target population, facilitating a successful implementation.

However, there are also factors that can lead to the failure of interventions. An inadequate needs assessment can result in interventions that do not address the actual needs of the target population. Poor implementation planning can hinder the adoption and sustainability of even well-designed interventions. Additionally, a lack of evaluation makes it difficult to determine the effectiveness of the intervention and make necessary adjustments (Fernandez *et al.*, 2019a).

Application

IM has been used in various contexts to develop effective interventions. For example, it has been applied to health promotion programmes aimed at increasing physical activity and improving body composition in adolescents. By conducting a thorough needs assessment and involving stakeholders such as schools and parents, effective strategies were designed to encourage regular physical exercise (ten Hoor, Plasqui, Schols, & Kok, 2017). In the context of healthcare, IM has been used to design mental health interventions (Agteren *et*

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al., 2021) and digital health interventions, such as mobile apps for chronic disease management (see Fernandez *et al.* (2019a) for more examples). An example of the application of Intervention Mapping is the study by Wong *et al.* (2023). Here, the six stages of Intervention Mapping (IM) were utilised to create the interactive Self-Management Augmented by Rehabilitation Technologies (iSMART) program. This programme is a digital intervention designed to help stroke survivors manage chronic symptoms and support daily life participation. It includes tools for effective activity scheduling, symptom management techniques, and cognitive enhancement exercises. Developed using the Intervention Mapping (IM) framework, the programme was designed with stakeholder input to ensure it is practical, acceptable, and feasible for users. Overall, iSMART aims to enhance the self-management capabilities of stroke survivors and improve their quality of life and daily functioning. Stakeholder feedback indicated that the intervention was acceptable, appropriate, and feasible, demonstrating that IM was successful in creating a practical and well-received tool for stroke self-management (Wong *et al.*, 2023).

Other examples of IM are given in the papers of Anraad *et al.* (2024), van Keulen *et al.* (2022), and Spook *et al.* (2015).

Referral to transversal themes

Trust and understanding: IM facilitates a step-by-step approach for a successful and user-centric implementation of a (digital) intervention. Due to the involvement of stakeholders, the excessive needs assessment and taking personal and environmental factors into account, the intervention is tailored to the user and its needs. If properly addressed in the programme and setting it as a goal, this step-by-step approach could contribute to trust, safety and understanding of technology, explainable AI and worker feedback in relation to the specific human-centric interfaces, and the fairness and usability of the technologies.

Inclusion: Using an IM approach, workers are required in the design process of the intervention.

Learning and skills: Similar to trust and understanding, the IM approach could be used to achieve the goal of learning and developing skills. Evaluation of the

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programme and its outcomes and objective is a required part of IM, which lines up with this transversal theme.

Design guidelines

- **Involve an expert.** Intervention Mapping (IM) requires a deep understanding of behavioural science and intervention design. The process involves complex steps, such as creating matrices of changes, which are challenging to perform without prior experience. Therefore, it is crucial to include an expert who can guide the process. This expert in behavioural interventions should be familiar with the IM framework. Their expertise will ensure that the intervention is designed and implemented effectively, increasing the likelihood of achieving the desired outcomes. Additionally, the expert can provide valuable insights and feedback throughout the process, helping to refine and improve the intervention.
- **Target a wide population.** IM is most effective when applied to large populations with similar characteristics. The process is time-consuming and resource-intensive, making it impractical for small groups, such as those in small companies. When implementing IM in larger organisations, it is essential to consider the diverse needs of different groups, such as operators, managers, and HR staff. Each group may have unique behaviours and determinants that need to be addressed through tailored interventions. By targeting a wide population of equivalent individuals, the intervention can achieve a broader impact and be more cost-effective. It is also important to ensure that the intervention is scalable and adaptable to different contexts within the organisation. Consider that this method can take 1 to 4 years to implement.
- **Use IM primarily for achieving behavioural change in large populations.** The main objective of IM is to facilitate specific behavioural changes rather than merely implementing technology. For technology implementation, a design thinking approach might be more suitable. This approach also involves a thorough needs assessment to identify the problem, relevant factors, and existing interventions, but without the need to create matrices of change. IM

is ideal for lifestyle and behavioural interventions but is often too intensive and focused on behaviour to be effective for organisational changes or technology implementation. These latter scenarios involve additional complexities, such as the intricate dynamics of organisations and the Technological Readiness Level (TRL) of the technology. Yet, if you want to realise a large-scale behavioural change within your organisation, for example the way they use a certain technology, or for applying an e-health intervention, with all the other factors controlled for and well arranged, IM can almost guarantee a successful development of your intervention.

- **Continuously improve and monitor the process and keep doing so even after the intervention is implemented.** IM is an iterative process that requires continuous adaptation. It is essential to evaluate the impact and relevance of the intervention regularly. Continuous monitoring helps identify any issues or challenges that may arise during implementation. Adjust the intervention based on the feedback and changing conditions to ensure its effectiveness. Always consider the practical implications and the difference between theory and practice. By adopting an iterative approach, you can ensure that the intervention remains relevant and effective over time, resulting in a sustainable intervention.
- **Thoroughly document the entire process.** This includes recording the factors influencing the intervention, the steps taken, and the outcomes achieved. Regular evaluation helps identify success and failure factors, providing insights for future interventions. Documentation also ensures transparency and accountability, making it easier to replicate the intervention in other contexts. By evaluating the intervention regularly, you can identify areas for improvement and make necessary adjustments. This continuous evaluation process helps ensure that the intervention remains effective and achieves the desired outcomes.

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4 Workplace level not necessarily with end user involvement

4.1 Design thinking

General description

Design thinking (DT), is an established process used in organisations, which aims to solve problems and promote innovation (Brown, 2008). DT is a human-centred approach to problem-solving that emphasises **empathy, creativity, and iteration**. It aims to develop new products, services, and processes while prioritising the needs and viewpoints of users and other stakeholders. (Brown, 2008; Carlgren and Ben Mahmoud-Jouini, 2021; Carlgren *et al.*, 2016).

While different models use varying numbers of stages—ranging from three to six or more—they share a similar core process focused on **understanding user needs**, generating ideas, and testing solutions. The common elements across different models include the following:

- **Empathise** – with your users
- **Define** – your users' needs, their problem, and your insight
- **Ideate** – by challenging assumptions and creating ideas for innovative solutions
- **Prototype** – to start creating solutions
- **Test** – solutions

These elements should be viewed as an overview of the modes or phases that contribute to an innovative project, rather than as a series of sequential steps. Iterating or returning to previous phases, is an important element of design thinking. In that way it is different from traditional engineering approaches.
It is further important to note that feedback plays an important role in all of DT's modes or phases.
What does it consist of? DT seeks to understand the potential user and their problems to come up with innovative ideas to overcome these problems. It involves immersing in the solution through five phases, building a user profile by understanding the problem and the environment, and validating the solution through interviews and an initial prototype.

Application

Recent advancements in technology have greatly impacted user preferences and behaviour, speeding up the evolution of user needs and increasing competition in the market (Wang, 2021). As a result, many companies have come to understand the shortcomings of traditional, product-focused approaches to technology development and the limitations of a product-centric mindset (Mortati *et al.*, 2023). This awareness has highlighted the urgent need for innovative methods and strategies to foster creativity (Lievens and Blažević, 2021). DT has emerged as a key framework in this regard, particularly appreciated for its role in problem-solving and promoting innovation (Dell'Era *et al.*, 2020). By providing organisations with structured methodologies and guiding principles, DT helps in identifying needs, generating ideas, and developing solutions throughout the innovation journey (Auernhammer and Roth, 2021; Magistretti *et al.*, 2021a; Randhawa *et al.*, 2021). With a focus on human-centred design – i.e. by taking into account the interests of users, DT prioritises users and stakeholders, utilising iterative processes to address complex challenges and create innovative products, services, and processes.

DT is a methodology that can be applied across various sectors. While there may be differing opinions on the most suitable stage for its application, it is clear that there are success stories at every stage.

Some real examples are:

Public sector: Government of Singapore

Singapore implemented Design Thinking in government services by focusing on empathy, collaboration, and iterative testing. The National Council of Social Services (NCSS), with support from Design Singapore Council, first identified the challenges faced by people with disabilities through direct engagement, shadowing 25 individuals instead of relying solely on surveys.

This deep understanding informed a collaborative ideation phase, where stakeholders—including caregivers, public servants, and healthcare professionals—co-created 30 potential solutions, selecting four for pilot testing. One initiative, the Box of Joy (It involves delivering personalised packages containing a variety of items and kits that are meaningful, useful, educational, or interesting) was deployed in communities, allowing partners to adapt and refine it based on real-world use. This iterative approach ensured that the final solutions were truly user-centric, inclusive, and impactful.

Technology: Telstra

Design Thinking has been widely adopted to enhance organisational processes, particularly in improving employee onboarding experiences. A notable example is Telstra, Australia's leading telecommunications company, which applied Design Thinking to develop a new 90-day onboarding program. By conducting discovery interviews with leadership, engaging in ethnographic research with employees, and synthesising insights with HR data, Telstra identified key transition points and challenges in the onboarding journey. Through rapid prototyping and persona-based visualisation, the company created a structured, user-centric onboarding experience that increased employee engagement and retention. This approach highlights how Design Thinking can drive innovation in workforce management, ensuring a smoother transition for new hires while improving overall organisational efficiency, bringing diverse teams together to discuss each project phase with a razor focus on what is the intended benefit for the end user. (Deloitte, 2016)

Design Thinking in Health Care

Design Thinking has demonstrated success in the healthcare sector by fostering patient-centred innovations, such as improving nurse communication systems and developing digital tools for managing chronic conditions, leading to enhanced usability, patient satisfaction, and clinical outcomes (Altman *et al.*, 2018). Thinking has therefore proven to be an effective methodology in the healthcare sector, enabling the design of user-centred solutions that enhance patient experience and optimise medical services. A notable example is GE Healthcare's Adventure Series, where MRI machines were redesigned with a focus on the experience of young patients. By transforming hospital environments into immersive adventure settings, this initiative not only reduced children's anxiety but also improved hospital efficiency by decreasing the need for sedation and repeat scans. *Design Thinking* was implemented by observing children in a daycare, consulting child life specialists, and collaborating with experts from GE, a children's museum, and hospitals. This process led to the development of the first *Adventure Series* scanner prototype, which was piloted at the University of Pittsburgh Medical Center. (Köppen, 2021 Changing Experiences through Empathy – The Adventure Series, 2021). This case demonstrates how an empathetic, user-centred approach can drive innovative and effective solutions in healthcare.

In conclusion, case studies highlight that, over the long term, adopting DT practices can foster competitive advantages (Appleyard *et al.*, 2020). Moreover, these examples underscore the versatility of DT in tackling a wide range of challenges across various industries.

Referral to transversal themes

DT has a direct link with human trust and understanding via the participative role of employees (as one of the prominent stakeholders) whose work may be affected by the implementation of the new technology. DT has an indirect link with cyber security and privacy (depends on how the new technology is applied), inclusiveness (DT supports participation and workplace democracy), and in-work learning (DT supports the fact that employees must understand the new technology).

Design guidelines

Below are guidelines for applying design thinking in work settings. In addition to these guidelines, an important general guideline is that one should keep in mind that design thinking is also about going back to a previous phase, if the basis for the actual phase is insufficient.

1. Empathise

- **Engage with end-users.** Interact directly with employees, customers, or other stakeholders to understand their experiences and challenges. This engagement fosters a deep understanding of their needs and contexts.
- **Observe in context.** Spend time observing users in their work environment to gain insights into their tasks, interactions, and pain points. This real-world observation is crucial for identifying genuine needs.
- **Conduct interviews and surveys.** Use qualitative methods like interviews and surveys to gather detailed information about worker experiences, preferences, and expectations.

2. Define

- **Synthesize findings.** Analyse the information gathered during the Empathize phase to identify common themes and insights. This synthesis helps in understanding the core issues.
- **Formulate problem statements.** Develop clear and concise problem statements that reflect the worker needs. A well-defined problem guides the ideation process effectively.
- **Prioritize challenges.** Identify and prioritize the most pressing challenges to address, ensuring that efforts are focused on areas with the highest impact.

- **Align with organisational goals.** Ensure that the defined problems align with the organisation's strategic objectives and values, promoting coherence and support for the initiatives.

3. Ideate

- **Encourage diverse participation.** Involve team members from various backgrounds, and if relevant for the project, departments to generate a wide range of ideas and perspectives. This diversity enhances creativity and innovation.
- **Facilitate brainstorming sessions.** Conduct structured brainstorming sessions to encourage free thinking and the generation of numerous ideas without judgment.
- **Use creative techniques.** Apply methods like mind mapping, sketching, or role-playing to explore different aspects of the problem and potential solutions.
- **Promote a safe environment.** Create a culture where team members feel comfortable sharing unconventional or risky ideas without fear of criticism.

4. Prototype

- **Develop low-fidelity prototypes.** Start with simple and cost-effective prototypes, such as sketches or mock-ups, to quickly visualize and test ideas. Developing prototypes may not always be possible. Especially for non-tangible redesign projects such as organisational redesigns, the challenge lies in creating something that can be tangible to everyone so that it can be evaluated.
- **Iterate rapidly.** Use feedback from initial prototypes to make quick adjustments and improvements, fostering an iterative development process.
- **Engage users in testing.** Involve end-users in the prototype testing phase to gather authentic feedback and ensure the solution meets their needs.
- **Document learnings.** Keep detailed records of what works and what doesn't during prototyping to inform future iterations and avoid repeating mistakes.

5. Test

- **Conduct user testing.** Implement the prototypes in real-world scenarios to observe how they perform and gather user feedback. See also under: Living Labs
- **Analyse results.** Evaluate the outcomes of testing to determine the effectiveness of the solution and identify areas for improvement.
- **Refine solutions.** Use the insights gained from testing to make necessary adjustments, ensuring the solution evolves to better meet user needs.
- **Plan for implementation.** Develop a strategy for scaling the solution, including training, resource allocation, and integration into existing systems.

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4.2 Customer journey / journey map

General description

The customer journey describes the complete "journey" of a user and their interaction with a wide range of services, which is technology in the current context (European Union, n.d.). It provides a visual overview of the specific incidents that occur, the agencies and people the user interacts with, and the user's experience. This allows us to see what parts of the technology are working for the end user and what parts may need improvement. It also identifies hidden or emerging user needs. The primary goal of a customer journey is to provide a helicopter view of a given service. The customer journey starts with the consumer's past experience, which includes previous purchases and external factors that will affect the customer's experience (e.g., pre-purchase, purchase, and post-purchase) (Moura, Reis and Rodrigues, 2021). In the context of SEISMEC, we will use "pre-use, use, and post-use". Customer experiences are all the elements and aspects associated with selling to the customer, such as product quality, ease of use, trust, advertising, and others (Moura, Reis and Rodrigues, 2021). It results from the relationship between the customer and the company or organisation, as each exchange of goods and services results in an experience perceived by the consumer. Customer journey and customer experience are

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different concepts, but they work together and overlap. **Figure 6** shows that the customer journey is the path that customers take through the touch points, while the customer experience is the experience that the consumer perceives along the customer journey. This process can serve as a guide for empirically examining customer experiences over time (t) during the customer journey, as well as for empirically modelling the impact of different touchpoints on the customer experience.

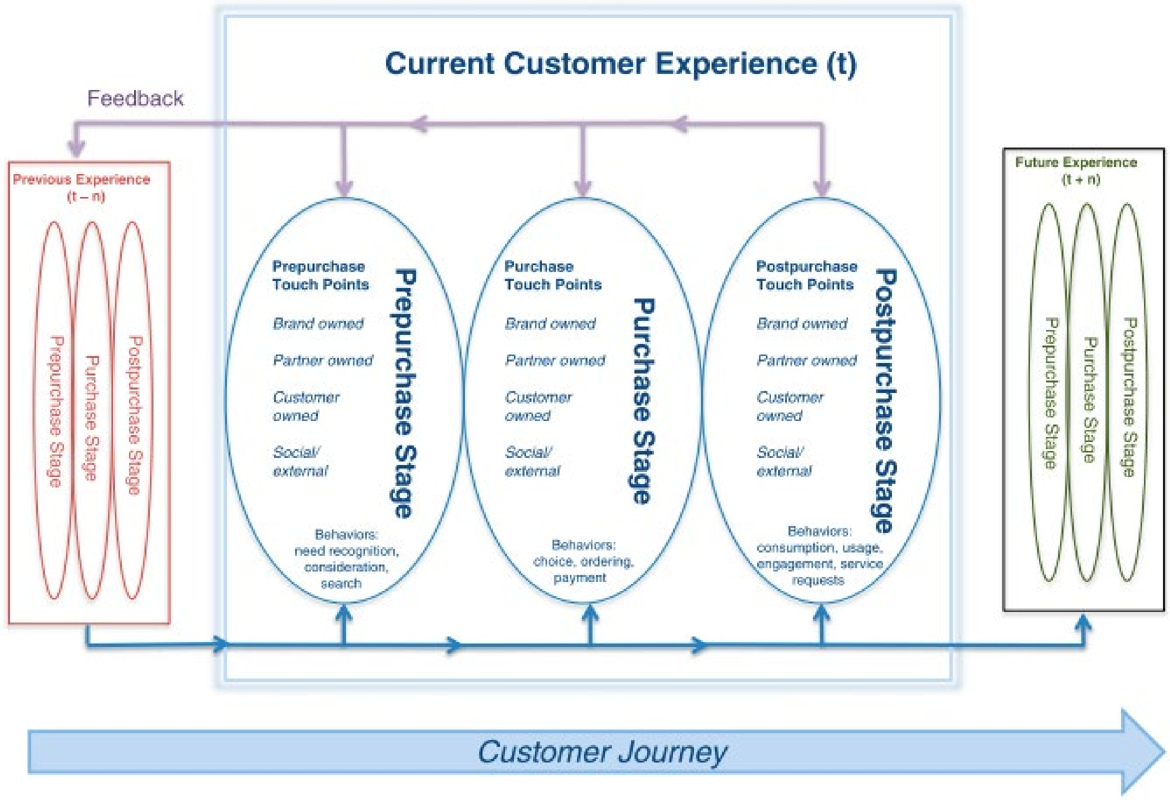

Figure 6. Customer Journey and Customer Experience

As mentioned earlier, the customer journey helps understanding user needs which is a very important first step. It is one of the benefits of the customer journey as, unfortunately, many organisations start with the technology and then back into customer understanding and their needs (Leachman and Scheibenreif, 2023). Thus, the customer journey is beneficial for developing customer understanding in order to create technology experiences that help customers develop a greater sense of control and self-confidence.

The customer journey is conceptualised as the movement of a customer along a purchase cycle (Grewal *et al.*, 2022). First, in the pre-purchase stage, the customer is engaged in identifying needs, searching, and defining a consideration set (Lemon and Verhoef, 2016). The second stage, the purchase, adds all the relationships and interactivity with the type of technology or service during the purchase and its environment: behaviours of selection, ordering, and payment. The post-purchase stage involves the use and consumption of the technology or service, post-purchase engagement, and support services.

In summary, the customer journey is essential to create a map or representation that visualizes the process and the consumer's path to achieve the goal of the product or service (Moura, Reis and Rodrigues, 2021). It helps professionals understand and identify customer motivations and needs, key events and touchpoints, and how the user interacts with services. In addition, the customer journey creates a better understanding of technology and enhance a greater sense of engagement, sense of control, and self-confidence.

Application

The customer journey is an example of a method used when applying a Quadruple Helix approach (European Union, n.d.). A Quadruple Helix is an innovative approach with an emphasis on the integration of end-user outcomes, needs and preferences (see Quadruple helix model). This approach is useful in innovation processes where citizens' needs are central. In the context of SEISMEC, Artificial Intelligence (AI) is an example of advanced technology where citizen and user needs are central. AI tools such as chatbots, voice assistants, and image recognition systems can impact different stages of the customer journey AI drives the customer experience for organisations in three categories: customer insights, customer interaction, and automation (Moura, Reis and Rodrigues, 2021). First, it allows to gain insight into customer needs, identify the most advantageous channels to attract them, and support target audience strategies. It also improves interaction with consumers by developing experiences and service quality. In addition, the automation of tasks and processes ensures the efficiency and effectiveness of the organisation. During the customer journey, AI can bring several benefits. For instance, Levy (2020) investigated the use of well-being applications, applying the customer journey to understand how a specific application can be used in everyday life, enabling users to become attached and engaged. Levy (2020) found that this approach helped users cope with a challenge of creating applications for reducing stress. Thus, applying the customer journey is beneficial in engaging end users with the technology provided.

Referral to transversal themes

Using a Customer Journey map could contribute to Trust and Understanding, as it helps professionals understand and identify customer motivations and needs, key events and touchpoints, and how the user interacts with services. In addition, if end-users are included in the process, the customer journey ensures a better understanding of technology and enhance a greater sense of engagement, sense of control, and self-confidence. Then, it also contributed to the Worker Inclusion theme.

Design guidelines

- **Set clear objectives for the map.** Ask yourself why you want to use a customer journey map, what kind of information you want to know and why. Are you looking to optimize certain touchpoints (e.g., moments in the customer journey when the user interacts or engages with the technology)? Are you looking to see why user retention is low? Do you want to determine why users decide against your product? Identify why you are building a customer journey map. (*What is a Customer Journey Map? Tips & Examples | Miro*, no date).
- **Identify profiles and personas.** You need to focus on a specific persona (see section 4.5 for more information) when examining the customer journey. It is important to remember that <u>a customer journey map should focus on one specific audience at a time.</u> This will help you figure out who your target user base is and gain an in-depth understanding of the needs that your

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organisation is attempting to fulfil (Tincher, 2023; TOPdesk, no date; *What is a Customer Journey Map? Tips & Examples | Miro*, no date).

- **Define the customer journey touchpoints.** Once you know who you target users are and what they need, you can start plotting the touchpoints they have with your technology. These points in the process will tell you which areas of the journey you need to streamline and optimize to improve the customer experience (TOPdesk, no date; *What is a Customer Journey Map? Tips & Examples | Miro*, no date).
- **Create your customer journey map template.** You can perform an in-person workshop by using a large sheet of paper to create a grid you will stick to a whiteboard or wall and fill in. Otherwise you can use a digital tool to create your template, see **Figure 7** for an example (e.g., Google Sheet) (*How to Create a Customer Journey Map: Template & Guide*, no date).

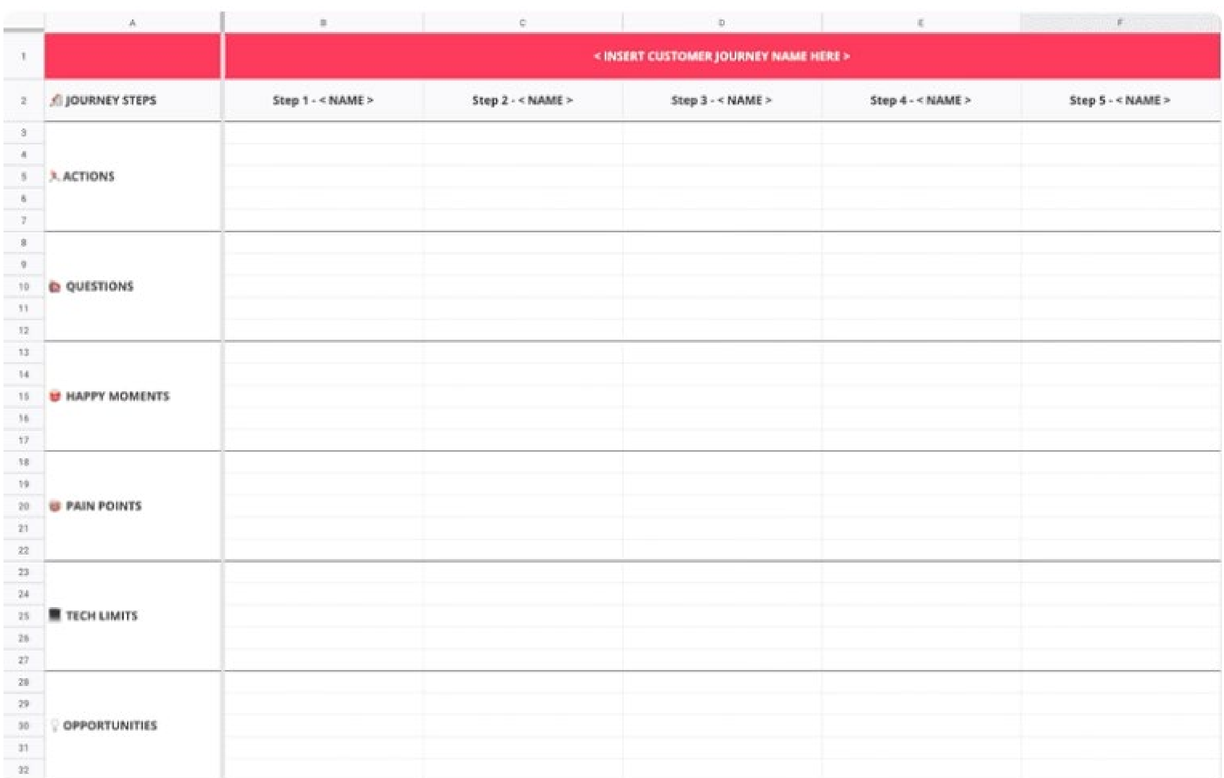

Figure 7. An example of a customer journey map template

When executing a customer journey, go through the following phases:

- **Awareness.** This is the moment where a user becomes aware of your product/technology. This can happen through a variety of mediums, from social media to a word-of-mouth referral. Your product/technology can increase awareness and attract more users through marketing practices and advertising (*What is a Customer Journey Map? Tips & Examples | Miro*, no date).
- **Consideration.** After your target users are aware of your product/technology, they move into a consideration stage. This is a stage of ideation in which the user considers whether they need the product/technology. You can implement a post or a guide about the product/technology (*What is a Customer Journey Map? Tips & Examples | Miro*, no date).
- **Decision.** After the user has considered their options, it is time to decide on the product/technology they are going to use. If the users are going against the product/technology, then that will be the end of their personal customer journey. If that is the case, your organisation should focus on improving awareness and consideration stages.
- **Retention.** The customer journey does not end once they have used the product/technology. Every organisation wants a loyal base of users who will use the product/technology every time.
- **Advocacy.** Letting other people within the organisation know about your product/technology that you offer. Users are more likely to advocate for your organisation if they are completely satisfied throughout each stage of the customer journey.

Tips for a successful evaluation of the process are described below.

- You can **digitalize** your journey map so you can easily update and share it with other stakeholders (*How to Create a Customer Journey Map: Template & Guide*, no date).

- Provide a **summary**_explaining what you did and your key takeaways to provide context for other stakeholders (*How to Create a Customer Journey Map: Template & Guide*, no date).
- Clearly state the **follow-up actions.** For instance, if you have identified opportunities for change and improvement, you may want to validate these findings via customer interviews and user tests (*How to Create a Customer Journey Map: Template & Guide*, no date).

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4.3 Human-centric interface

General description

Human-centric interfaces (HCI) prioritise human needs and experiences in digital system design. While early interfaces focused mainly on technical functionality, today's complex digital environments demand user-focused approaches. These interfaces range from traditional screens to advanced systems with voice commands, haptic feedback, and virtual environments, aiming to ensure intuitive and accessible interaction across diverse workplace settings.

HCI addresses four key areas: ensuring accessibility and safety for intended users, improving worker productivity through alignment with natural behaviour, enabling smooth integration of technology into existing workflows, and supporting the development process by identifying and addressing usability challenges early.

Semantic and semiotic analysis are essential to HCI design. Semantic analysis ensures interface elements match users' mental models, while semiotic analysis examines how signs and symbols convey meaning across different contexts. These approaches help create intuitive interfaces that align with users' cultural, professional, and cognitive frameworks.

In a semantic analysis for HCI, key frameworks help formalize meaning in human-system interactions. Early research (Kong *et al.*, 2014) established foundational methods for understanding behavioural semantics through interaction pattern analysis, while later work (Pustejovsky and Krishnaswamy, 2022) advanced multimodal semantics by developing frameworks that integrate gesture, speech, and environmental context into unified semantic models. Recent developments (Zeng *et al.*, 2024) have focused on semantic enrichment in construction environments to bridge the gap between visual information and high-level semantic understanding. At the same time, parallel studies (Zayed *et al.*, 2024) have explored how semantic analysis can systematically capture and formalise social values and design intentions in built environments.

Semiotic analysis in HCI has evolved through comprehensive frameworks (Hartmann, 2014, 2013, 2012) for building information systems, which identified three fundamental domains: use process, system content, and user expression. This built on earlier theoretical foundations (Nadin, 1988) that established design principles as structured semiotic systems for achieving human goals, with subsequent research (Sowa, 2000) expanding this understanding to demonstrate how semiotic theory can advance both research and practical applications in interface design across diverse cultural and professional contexts.

Application

Human-centric interfaces (HCI) find applications across various industries where user experience, safety, and efficient human-machine interaction are critical. A prominent example is the construction industry, where HCI principles are being applied to screen-based applications. For instance, interfaces must be designed for use with gloved hands, incorporate clear safety warnings, and use intuitive symbols that make sense in the construction context. This approach improves both usability and safety, enhancing worker efficiency while reducing the risk of accidents or errors.

HCI are also valuable in industrial settings such as warehouses, where voice-based systems must function reliably in noisy environments. For example, HCI principles help ensure that voice commands work effectively even in environments with up to 85dB of background noise while maintaining user comfort and efficiency. Similarly, in healthcare settings, HCI helps design interfaces that protect patient privacy while allowing efficient data management and access to critical information. By considering these real-world conditions and user needs, HCI helps create more effective and reliable systems. Finally, HCI are essential in applications where worker safety and performance are critical, such as industrial monitoring systems and wearable devices. In these domains, HCI provides developers with frameworks to create functional and user-friendly interfaces. For example, HCI principles guide the design of wearable fatigue tracking devices and safety monitoring systems, ensuring that they provide clear, actionable information without distracting from primary tasks. This approach leads to more effective workplace tools that better serve both workers and organisations.

Based on current research and development in the SEISMEC project, Human-Centric Interface design follows two primary directions, adapted to specific use cases and pilot requirements. The first direction focuses on creating intuitive, accessible interfaces for end users using screen devices, enhancing safety and efficiency while promoting better human-computer interaction. This is supported by the main objectives of Task 2.6, which are the development and creation of targeted recommendations, interface design guidelines, and digital libraries based on semantic and semiotic analysis. The second direction targets the development and implementation of advanced interface technologies, including voice commands and feedback, focusing on improving system effectiveness while maintaining usability in real-world conditions and how these can be supported by the objectives mentioned.

Referral to transversal themes

Cybersecurity and privacy : HCI can rely on biometric data for authorization and identification and shall thus comply to GDPR guidelines to implement such functionalities. Developing HCI, and more especially immersive HCI, is a way to provide information to users on a need-to-know basis.

Trust and understanding : HCI shall provide understandable and reliable information to the users based on the explainability layers.

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Inclusion in design and implementation : understand the activity of operators by relying on a relevant task break-down that involves the users in the definition of the main functionalities of the interfaces.

Design guidelines

The following design guidelines are envisioned from the Human-Centred Design (HCD) and Human-Autonomy Teaming (HAT) perspectives.

- When designing human-centric interfaces for interaction with autonomous or semi-autonomous systems integrating AI, the main point consists in **clearly identifying to what extent the system is autonomous at a given time and the interdependence between all the actors involved in the activity** to clearly understand the expectations of the user when interacting with the system.

General design guidelines for HCI can be summarised as follows:

- **Ensure adaptability to the user profile.** The user must be able to modify the interface to make it more convenient to use relatively to his needs or his habit.
- **Prevent and recover from human errors.** As human-centred interfaces put the activity of the human operator at the heart of the design, preventing human errors and mitigating their consequences is an essential consideration in design.
- **Make sure there is consistency in design**. The same action on the user interface shall always produce the same result and the representation shall always be similar.
- **Interacting with the system should be efficient.** The objective is to reach the desired functionality in a minimum of required actions.
- **Interacting with the system should not increase cognitive work load.**
- **Enable trust by creating a system that is understandable.** The user shall be trustful towards the system by having a clear and concise representation of the system and the current actions.

When working with eXtended Reality (XR) interfaces, some additional guidelines have to be taken into account for the design.

- **Developers shall ensure that XR applications are quick to respond to users' inputs to maintain engagement and willing to use.** As XR interfaces are more immersive and subject to direct interaction of the user with his surrounding environment, they shall be designed with clarity in mind. Motion sickness can be intensified when interface is cluttered as virtual items in the interface. Moreover, interfaces with numerous elements are likely to lead to more errors and less efficient interactions.

- **XR applications shall be developed with respect to new standards such as OpenXR**[4] in terms of interoperability to work seamlessly across different devices and operating systems.
- **The focus on privacy and cybersecurity**, which is essential in more conventional user interfaces, is more important for XR applications as they require constant access to cameras and location data. Other sensors might also access to biometric data when gaze is used for interaction or iris recognition is used to grant access to XR applications.
- Deploying XR applications in real-world and professional conditions is challenging as outdoor or dark environments are very demanding for XR devices. Indeed, XR interfaces and devices are still relatively new for professional applications and not widely used. To improve adoption by professional users, **XR applications shall not hinder reliability and functionality and it is mandatory to include user feedback to continuously refine and improve the application design.**
- By relying on XR devices' sensors, **XR application shall enable more natural interactions (gaze, voice, gestures) to reduce physical and cognitive workload.**

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4.4 Co-active design

General description

The co-active design method can be used for teams of humans and automated agents. Such a team might be formed when full automation is not possible or not desired. In the team, the human and automated agents have a joint responsibility to carry out a task. Specific challenges should be addressed to make such a team successful (Klein, Woods, Bradshaw, Hoffman, & Feltovich, 2004). The co-active design method was created to systematically address the challenges that emerge when human and automated agent activities are intertwined. The method was developed by Johnson (2014) and applied in the DARPA robotics challenges as described in the paper of Johnson *et al.* (2014). A key element of the method is the notion of human-automation interdependency, where interactions can assist to improve task execution. This approach is opposite to the approach that aims for automation autonomy that aims for task execution with minimal human intervention. A key principle of the method is the analysis of how the execution of a task by one agent (human or automated) can be improved with the help of another agent (automated or human). If such an improvement is possible, interactions should be designed that facilitate these synergies. Johnson (2014) describes three branches of interactions. Observability interactions make the status or knowledge of one actor known to others, predictability interactions make sure the actions of one actor can be anticipated by others, and directability give power to actors to influence each other's actions. The method also promotes to implement redundancies such that successful execution of a task can be achieved in different ways. This makes the team resilient. Wolffgramm, Corporaal, Groen, & Roij (2024) use this possibility to tailor to the preferences of individual users, by making the uses of an automated agent optional instead of prescribed.

Application

The approach was originally developed for open-ended situations, specifically the DARPA robotics challenge (Johnson *et al.*, 2014). However, the method might be applied to many cases where there is a combination of human and automated actions needed to carry out a task. In general, automation is an approach adopted across industries to reduce the influence of human error on the production process. Still, there are many cases where full automation is not possible. Especially at the interfaces of human and automated work, errors can occur. Introducing robots and human-automation teaming can also influence job quality (Baltrusch, Krause, de Vries, van Dijk, & de Looze, 2021; Hoffman, Hayes, Ford, & Bradshaw, 2012). Co-active design principles find applications in healthcare, where collaborative interactions between surgeons and robotic systems enhance surgical precision (Hoffman *et al.*, 2012). In transportation, human-assisted autonomous vehicle operations illustrate how co-active design can ensure safety and reliability. The co-active design method can be used to identify the necessary interfaces and improve the design of human-automated teams.

Referral to transversal themes

Trust and understanding: The co-active design method is aimed to let human and (robotic) agents co-operate in a team. The method describes what interactions are needed to observe, predict, and direct the actions of the robot. Implementing these interactions improves the trust and understanding of agents.

Design guidelines

- **Identify interaction between human and agents via an interaction analysis.** The Interdependence Analysis Table (IA Table) is introduced as a tool for identifying necessary interdependence relationships before implementation (Johnson, 2014). It can be utilized to systematically assess dependencies and interconnections, address questions of 'what should be automated' providing insights into how tasks, responsibilities, and decision-making processes are distributed between agents (Johnson *et al.*, 2014; Kaber, 2017).
- **Explore different pathways. for completing a task, from human alone to robot alone** To improve human-robot collaboration, a significant step is to explore different ways of completing a task, whether through full automation, human control, or a mix of both. Using Adjustable Autonomy and Mixed-Initiative Interaction can provide the flexibility to shift control between humans and robots as needed (Johnson *et al.*, 2014). This approach ensures that automation is used effectively while keeping the system adaptable to changing demands.
- **Determine OPD requirements** (Observability, Predictability, and Directability). It is crucial to establish what information needs to be shared, with whom, and

when, to prevent information overload. Robots should communicate their status and intent clearly, ensuring that human operators can understand and anticipate their actions. Additionally, co-active design necessitates designers to consider and plan for failure (Boger *et al.*, 2018). Mapping out roles (i.e. who needs to observe, predict, and direct) helps create a well-coordinated team, improving efficiency and decision-making (Johnson *et al.*, 2014; Johnson, 2014).

- **Implement human-robot communication strategies.** Human-robot collaboration requires intuitive, transparent and clear communication methods that balance autonomy and human control, such as visual feedback, direct commands, and shared mental models. Operators should be able to intervene and adjust automation in real time. By using predictability cues, humans can anticipate robotic actions (Johnson *et al.*, 2014).
- **Foster iteration moments and feedback loops.** Co-active design is a continuous process that requires regular updates and optimizations based on real-world feedback to improve human-robot interactions. The system can for example be evaluated through the analysis of (unanticipated) failure scenarios, system performance, and identification of weaknesses in the OPD requirements,

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4.5 Personas

General description

Personas are hypothetical archetypes of actual users that represent distinctive user groups for a technology (Värmland County Administrative Board, 2019). The detailed, fictional characters are used to represent different user groupes who might use a product or service in a certain way. Personas are created based on real user data, often including a short biography, photo, and goals related to the technology (Dam, & Teo, 2024). Personas can be based on qualitative and quantitative data through methods such as interviews, surveys, and user observations. This data is then analysed to identify patterns and commonalities, which are used to create distinct personas that represent different user segments (Velsen, Gemert-Pijnen, & Nijland, 2012). According to Dam and Teo (2024), personas help designers step out of their own perspectives and recognise the diverse needs and expectations of different users, guiding a human-centric implementation of technology.

One of the main advantages of using personas is that it will help enhance the understanding of the types of people you aim to design for and ask them the right questions (Dam, & Teo, 2024). A literature study revealed five key benefits of using personas (Miaskiewicz and Kozar 2011). Firstly, they help design teams to focus on the actual goals and needs of the target users, rather than being driven by technological possibilities. Secondly, personas assist in prioritising product requirements, ensuring that the most critical problems are addressed. They also help prioritize which user segments are most important, making the design efforts more targeted and effective. Additionally, personas challenge long-standing, often incorrect assumptions about, leading to more accurate and user-friendly designs. Finally, they prevent self-referential design by helping designers understand how users differ from themselves, thus avoiding the projection of their own preferences onto the product (Miaskiewicz, & Kozar, 2011). However, there are also some drawbacks to using personas. The article by Joni Salminen and colleagues categorises the disadvantages of personas into three main areas: creation, evaluation, and use. Creation issues include the significant time and expense required to develop personas, as well as the potential for bias and reliance on non-representative data. Evaluation concerns highlight that personas often lack credibility, accuracy, and relevance, and can be inconsistent. Finally, issues around the use of personas might arise, such as underutilisation of personas, their misuse for internal politics, and the risk of them becoming outdated.

Application

An example of how personas are created is given by ten Klooster *et al.* (2022). In developing a new eHealth platform for chronic disease management, ten Klooster *et al.* (2022) created personas to align technology with its target users throughout development. They used a three-step iterative approach to develop personas using clustering mixed data. They first used health-related data to create the personas. The personas, thus made from electronic patient data, was then enriched with person related data from conducted interviews and questionnaires. Finally, log data was added to the model to further refine the personas, demonstrating how they can evolve after collecting log data from a pilot study or once the eHealth technology is launched and used by end users.

During each step, the personas were further defined and tailored. This iterative model of created personas is defined as the Personas Approach Twente. This structured, iterative approach ensures that eHealth solutions are not only technically robust but also highly relevant and engaging for end-users. Ten Klooster *et al.* (2022) found that their method made the results easier to interpret, ensured that mixed data could be included and made an iterative development possible.

Referral to transversal themes

Privacy and cybersecurity: Personas could be helpful in understanding different vulnerabilities, connected with different kinds of users. Testing of multiple scenarios could be helpful here. However, this solution direction might well only be a partial solution for privacy & cybersecurity. Trust and Understanding: Personas can be useful to explore barriers to trust and understanding. Worker Inclusion: Workers are preferably included in the design process of personas. Understanding them by observations, interviews and surveys is of added value to the quality of the personas.

Design guidelines

- **Make a time frame of the technology implementation and development process and determine which methods you will use to gather data.** Qualitative methods may take longer due to in-depth interviews and focus groups, while quantitative methods can be quicker but require extensive data analysis. Keep in mind to continuously update personas with new data to maintain their relevance. Creating personas is an iterative process, ensuring continuous improvement of the outcomes and an up-to-date description of relevant personas (Karolita *et al.*, 2023).
- **Collect data of your end users.** This could be done both qualitative and quantitative. One can use interviews, focus group discussions, brainstorming and/or workshop, but also use a cluster analysis technique to categorise all of the variables that were mentioned or observed. With this latter, a persona could represent a specific cluster of variables. Conduct in-depth interviews

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with users to understand their opinion about technology and their needs. Ask about topics that are of interest for your organisation/pilot and the technology you want to implement. Observe users to see how they interact with technology and how they perform their tasks. Use open-ended questions to gather detailed responses about user experiences and preferences. For example, ask what features they find most useful and what improvements they would suggest. Make sure to identify collaboration preferences, ensure privacy and provide incentive to encourage participation (Karolita *et al.*, 2023).

- **Decide on the number of personas.** Determine how many personas you need based on the diversity of your user base and the goals of your project. This helps in managing the complexity and ensuring each persona is detailed and useful.
- **Identify a primary persona that represents the main user group.** This primary persona should embody the most critical needs and characteristics of your main user group, guiding the design and development process to meet their specific requirements.
- **Use the retrieved information to give content to the personas.** In essence, personas are a context-specific description of the actual users. Elaborate in the descriptions on demographic information, language, behaviour, cultural aspects, knowledge, skills, age characteristics, health condition, abilities, etc. The most common way of describing personas is through using the narrative form – a story telling approach without a specific structure or layout. This latter is also possible. The document describing the personas could then have major components such as a demographic profile, knowledge and skills profile and a interaction profile (Karolita *et al.*, 2023).
- **Make a tangible document of the personas.** Describing personas could be done in multiple ways, a textual description being the most frequent one. The latter could look like a curriculum vitae, with headings of the diverse topics that are discussed. Paragraphs of text is also possible, sketching the personas in a fluent matter. Another way to describe your personas is by means of visual

representations. One could use photographs or pictures, but also create a poster, or a model representation (Karolita *et al.*, 2023).

- **Make your personas specific and tailored to the goal that you want to achieve with implementing a technology.** Appoint multiple characteristics to your persona or make multiple personas to realise this. For example, if you want a technology that's suitable for individuals with disabilities, create a persona with disabilities. Describe in your personas information on the use of assistive technologies and descriptions of situations and contexts that are particularly challenging. This helps to have a broad understanding of the disability you aim to represent and meet the associated requirements (Dirks, 2020; Zimmermann, & Vanderheiden, 2008).
- **Validate your personas to check if the personas are different, complete, believable and trustworthy.** If not, they could be adjusted accordingly. Validation is most often performed by use of a focus group discussion, workshops and/or interviews with stakeholders, end-users and experts. Ensure that the validation process involves end-users to capture all relevant aspects. The validation of the created personas could be performed by the same group of stakeholders that were involved in the data collection, at the ideation phase of the process (Karolita *et al.*, 2023).
- **Conduct research to identify outliers and make sure to have access to a diverse and representative sample of users to create accurate personas.** Balance between providing enough detail and keeping the personas descriptions concise. Understand that personas created for small or specific projects may not be generalizable (Karolita, *et al.*, 2023).

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4.6 Inclusive design

General description

Inclusive design is a design approach that aims to create products, services, and environments that are usable and accessible to specific user groups, particularly those who are traditionally excluded (Clarkson, & Coleman, 2015). This approach requires designers and other stakeholders to consider various possible limitations of users, in skills or due to their circumstances, and involve users with diverse limitations throughout the design process (Toolkit Inclusie, n.d-b). This approach takes into account various aspects such as accessibility, age, economic situation, geographic location, language, and race into account. The goal is to fulfil as many user needs as possible by empathizing with users and adapting interfaces or products to address their diverse needs (Kendrick, 2022). Inclusive design addresses both the process and the design, specifically focusing on user diversity and aiming that the so that a full diversity of people can optimally use (digital) information and communication tools (Toolkit Inclusie, n.d-b).

The five design principles of Inclusive design (Design Council, 2024) to improve digital services and make them as user-friendly as possible, also apply to the more general designing for inclusion. The *first* principle is keeping the user central by designing based on the needs and context of people, not from the technology or your organisation. In doing so, a diversity of users in terms of skills and circumstances must be considered. The *second* principle is to be engaged in a process of continuously designing, testing, measuring, and improving. This also required including a diverse range of users in this process. The *third* principle focuses on making it simple for the user, realised by designing simple processes, creating user-friendly systems, and writing clearly. This includes taking physical, cognitive, and psychosocial limitations of users into account. The *fourth* principle focuses on basing design development on facts rather than preconceived ideas or assumptions. Finally, the *fifth* principle of inclusive design is focused on creating awareness about inclusion among all stakeholders in the design process, documenting insights, and sharing them with others (Toolkit Inclusie, n.d-b).

Several factors contribute to the success of inclusive design. Conducting thorough user research to understand the diverse needs and preferences of users is crucial. Educating stakeholders about the importance of inclusive design and involving them in the research process also helps ensure alignment and support. Continuously testing and refining designs with a diverse group of users helps identify and address potential issues early on. Designing flexible and adaptable interfaces that can accommodate various user needs and preferences is key to achieving inclusivity. Finally, clearly communicating the benefits and importance of inclusive design to the entire team fosters a shared commitment to creating inclusive products (Kendrick, 2022).

Application

The SAM (Stress Autism Mate) app exemplifies the application of inclusive design by addressing the unique needs of people with Autism Spectrum Disorder (ASD). Developed by TNO and GGZ Centraal Emerhese, the app involves users with ASD throughout the design process to ensure it effectively helps them recognise and manage stress. Key features include stress monitoring, personalised feedback, and customisable settings, all designed with user diversity in mind. The app's design principles emphasize simplicity, clear communication, and user involvement, ensuring that it is accessible and user-friendly. Research has shown that SAM significantly reduces stress, enhances self-reliance, and improves the quality of life for its users, demonstrating the positive impact of inclusive design (Toolkit Inclusie, n.d-a).

Referral to transversal themes

Worker Inclusion is begin addressed by choosing the Inclusive Design method if users are being involved in the design process. This is an important aspect of the method and involving them in the research process also helps ensure alignment and support. Moreover, Inclusive Design can be utilised to increase trust in technology, and to enhance fairness of the technology. Therefore, the Trust and Understanding theme is addressed as well. Inclusive design engages the CAPS factors by means of participatory and collaborative processes that enable the empowerment of various users. It congruent with creativity by promoting unique ideas, autonomy by allowing the user to use the services independently, participation by involving a number of users and scalability by designing flexible systems for the needs gap (Toolkit Inclusie, n.d.-b).

Design guidelines

- **Use inclusive design if you aim to develop objects, systems and environments that can be accessed by the maximum number of people by considering limitations** such as accessibility, age, economic situation, geographic location, language. The needs of diverse users are considered from the beginning of the design stage (Clarkson & Coleman, 2015).
- **Engage relevant stakeholder groups** such as diverse user groups, advocacy organisations, and domain experts from the outset. This ensures that products and services are designed for a wide range of people with different disabilities and backgrounds, rather than adding accessibility features after development (Kendrick, 2022). Including users early in the design process is crucial for creating relevant and easy-to-use designs, building user trust, and fostering engagement. It's important to select users carefully and integrate their input thoughtfully. Effective inclusive design addresses the needs of various people, promoting personal well-being, social inclusion, and a positive experience for everyone (Åhman, Yngling, & Gulliksen, 2014).
- **Use interviews, surveys and usability testing to determine the needs of various users.** Always rely on the first-hand data and not the assumptions. It is important to identify barriers (physical and learning difficulties, visual and hearing impairments, mental ill health etc.) and address them as early as possible in the design process so that the design can overcome these barriers. This process will ensure diversity and difference (Åhman, Yngling, & Gulliksen, 2014).
- **Apply the five key principles[5] of inclusive design as described above.** These principles are aimed at enhancing digital services and maximizing user-friendliness, which are also essential for creating inclusive experiences. Key features include stress monitoring, personalized feedback, and customizable settings. Provide customizable interfaces such as large text, voice control. Avoid unnecessary complexity that may exclude users with cognitive

[5] The Principles of Inclusive Design

limitations. Have regular usability testing with real users and in diverse conditions. Then, use the real-world input to redesign and solve the problems that may crop up. Make your teams and other stakeholders aware of the value of inclusive design. There are success stories and examples to share to ensure that others support the cause.

- **Ensure compliance with accessibility standards.** Get information on legal requirements of digital accessibility to ensure that you are up to date.

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4.7 Universal design

General description

People can be significantly or minorly influenced by the design of products, buildings, or services particularly in how this makes their use or experience accessible. Universal design aims for a design that makes accessibility possible for as many people as possible (Connell *et al.*, 1997, Mace *et al.*, 1991). This human-centric approach is aimed at creating accessible and useable products, environments, and services for everyone, regardless of age, ability, or other factors (Burgstahler, 2009). In contrast to Inclusive Design, where the focus lies on creating multiple solutions or adaptable features to meet diverse needs, Universal Design aims for a single, all-encompassing solution (Bikkani, 2023). Connell *et al.* (1997) illustrates, in seven principles, the guidelines to create inclusive and accessible designs that benefit everyone, regardless of their abilities or circumstances. These principles include 1) equitable use that ensures the design is useful and marketable to people with diverse abilities; 2) flexibility in use which accommodates a wide range of individual preferences and abilities; 3) simple and intuitive use which ensures the design is easy to understand regardless of the user's experience or knowledge; 4) perceptible information which emphasises the need for communicating necessary information effectively, regardless of sensory abilities; 5) tolerance for error which minimizes hazards and adverse consequences of accidental actions; 6) low physical effort requirement which ensures the design can be used efficiently and comfortably with minimal fatigue; 7) size and space for approach and use provide appropriate size and space for approach, reach, manipulation, and use, regardless of the user's body size, posture, or mobility. These principles collectively ensure that designs are accessible, usable, and beneficial to all users (Connell *et al.*, 1997).

Application

The universal design principles can be applied in the design of every product or environment. An example of Universal Design applied to technology is the development of text-to-speech (TTS) technology. This technology converts written text into spoken words, making digital content accessible to individuals with visual impairments or reading difficulties. It also benefits those who prefer auditory learning or need to multitask while consuming content. Another example includes high contrast text. This enhances readability by making text stand out more clearly against the background. In this case, high contrast themes were designed to make text and other elements on the screen easier to see, especially for users with low vision. Moreover, users can often customize high contrast settings to suit their preferences, adjusting colours for text, hyperlinks, and backgrounds. High contrast modes are available on many operating systems, including Windows and macOS and can be easily toggled on or off (Sizemore, 2022).

Referral to transversal themes

Universal design requires worker inclusion into the design process, which aligns with the theme Worker Inclusion. This is an important aspect of the method and involving them in the research process results in an all compassing design for all kinds of users. Moreover, Inclusive Design can be utilised to increase trust in technology, and to enhance fairness of the technology. Therefore, the Trust and Understanding theme is addressed as well.

Design guidelines

Universal design consist of seven principles that represent the design guidelines. When selecting an Universal design approach, make sure to hold on to the general principles of human-centric design and look into the guidelines of Inclusive design.

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5 Technologies

5.1 HAI: Human-AI interaction (General)

Human-AI interaction is a multidisciplinary field that studies the design and evaluation of systems in which humans and artificial intelligence interact with each other. By focusing on how humans and AI systems interact and divide tasks, insights from this discipline can be used to create systems that are more human-centric. That is, improvements in the quality of interaction and the allocation of tasks between humans and AI can help to improve collaboration, enhancing trust, usability, and performance. In this section, we discuss three key techniques that enable such improved interactions: **human-AI co-learning, explainable AI, and a human-in-the-loop** approach. Human-AI co-learning, explainable AI, and human-in-the-loop systems are all related techniques that often work together to help AI be more effective and human-centred. While each concept emphasises a different dimension—mutual learning, transparency, and oversight—they share common goals: enhancing trust, supporting user understanding, and improving system performance through human input. For instance, explainable AI can serve as a foundation for both co-learning and human-in-the-loop approaches by clarifying system outputs and enabling informed human responses. Likewise, a human-in-the-loop structure can facilitate co-learning by creating space for iterative interaction and adaptation. Together, these approaches provide complementary strategies for aligning AI systems with human values, needs, and capabilities.

5.2 HAI: Human AI co-learning

General description

We refer to human-AI co-learning as a collaborative process where humans, such as employees, and artificial intelligence systems learn from each other to improve their capabilities and decision-making. The principle where humans and machines learn from each other is sometimes also referred to as "mutual human-AI learning", "human-machine learning" and "reciprocal learning" (e.g., see Zagalsky, 2021). In systems where co-learning occurs, AI components are not static tools that simply keep executing what they learned in the past. Instead, they evolve through interactions with users, learning from their expertise, feedback, and decision-making. Conversely, employees or other users learn from the model output and about the capabilities of the AI. Such learning can, for example, be achieved in a situation where the system provides information on its decisions (e.g., by using explainable AI described in section 9.1.2), or when users develop an internal model of the AI's strengths and weaknesses by experience. In this regard, human-AI co-learning goes a step further than active learning (Settles, 2011) and co-active learning (Shivaswamy, 2015), as in human-AI co-learning the human also improves its own decision making and interaction with the system. The concept of such reciprocal learning is sometimes considered an essential component in "hybrid intelligence" systems (e.g., see Dellerman, 2019).

Human-AI co-learning may contribute to making AI systems more human-centric by improving the interaction with and support of users in the workplace. By incorporating human feedback and contextual understanding into the AI learning process, these systems may become more attuned to the specific needs, preferences, and values of their users. This "personalization" enhances user acceptance of AI technologies, as employees are more likely to trust and feel comfortable with systems that adapt to their working styles and preferences (Amershi, 2014). Moreover, when AI systems are developed and refined through co-learning, they are better equipped to handle complexities in real-world tasks, which increases their usability in daily operations. On the other hand, when users learn about the output and strengths and weaknesses of the system, they gain trust and improve their interaction with the system. This contrasts sharply with traditional AI systems that do not involve co-learning, which often lack flexibility and may be perceived as rigid.

Application

Applications where human-AI co-learning can improve human-centricity range across sectors. The applicability mainly depends on the specific situation. One factor is the complexity of the task to be carried out. For marketing analysts, for instance, an expert may use an AI system to provide recommendations for how to segment (potential) customers into different groups or provide suggestions for which advertisement strategy might be most optimal. The marketing analyst may learn from these suggestions to improve his or her own decision making. An explainability component may further inform the expert about the certainty of the output and the information that the output was based on. This helps in developing an internal model of the AI system, which improves future interaction with the system. On the other hand, the expert can correct the model whenever it disagrees with its output or the information and reasoning that the decision was based on. This helps the system improving future performance. Similarly, in manufacturing, AI systems can work alongside human operators to monitor machines and predict system failures. As these AI systems learn from the operators' knowledge and experience, they become more accurate in anticipating failures and suggesting preventive measures, thus improving workplace safety and reducing downtime. In simple and highly repetitive tasks that a machine can perform (almost) perfectly, on the other hand, the system may not need to continuously improve its performance over time once deployed. Another factor that determines the applicability of co-learning next to task complexity is variability across users. Personalization of the AI system with respect to a specific user is most relevant in situations where needs, preferences or knowledge levels vary significantly across users (Liao, Kush, Varshney & Varshney, 2021). A worker may need different types of guidance depending on his or her knowledge level, age or other characteristics and different workers may want to learn about different tasks depending on their interests. In cases where such differences are irrelevant, human-AI co-learning may not be an appropriate technique to incorporate.

Finally, some situations require AI systems to provide deterministic outputs that do not vary over time or across users. In legal settings, for example, similar cases should often be treated similarly, independent of the specific user of the system at that time. In such settings, it may not be desirable that a system is continuously adapting its parameters and output.

Referral to transversal themes

Trust and Understanding: as the AI adapts to the needs of the human, the usability may increase. In addition, using XAI to communicate to the human can enhance trust when collaborating.

Inclusion: adapting to the skills and other characteristics of the human can enhance inclusivity as a wider spectrum of individuals may be able to adequately work with the system.

Learning and skills: the human can learn from AI-based feedback and insights.

Design guidelines

- **Assess the need of human-AI co-learning.** Not all systems benefit from human-AI co-learning. If tasks are repetitive and require little adaptation, a static AI model may be sufficient. However, in dynamic environments where user expertise or preferences change over time, or where the task context that determines appropriate system behaviour can change, adaptability though learning can be helpful. Assessing the need for co-learning prevents unnecessary complexity.
- **Involve the end users in the design process**. For co-learning to be effective, AI systems should be designed with the user in mind. This means involving users in defining how the system adapts to the user or to the task context, determining how the AI should provide feedback to the user, and how (potential) users may influence system improvements. An idea is to organise co-design sessions with users to define interaction and learning mechanisms.
- **Define the roles that humans and AI play**. Give users clear instructions on how to interact with the system and how their input will help AI and humans. Indicate whether humans will offer task-specific coaching, contextual feedback, or corrections, as well as how the AI will convey itself.
- **Enable effective human-AI interaction.** The learning process should be structured so that AI benefits from human input and users benefit from AI

insights. Feedback loops allow users to correct mistakes by AI or provide relevant context to the AI, while users may learn from AI insights, such as recommendations and reasoning. Indicating certainty levels in AI recommendations can help users in evaluating and learning from AI-generated output, as well as calibrate their reliance on automated parts, preventing blind trust or unnecessary scepticism.

- **Consider stakeholder impact beyond direct users**. Human-AI co-learning does not only affect direct users but also those who rely on AI-generated outputs. For example, in healthcare, a learning AI system affects not just doctors but also patients. Ensuring the system evolves in a way that benefits all stakeholders is crucial for ethical and practical adoption. An idea is to conduct stakeholder workshops to evaluate the broader impact of the system.
- **Evaluate and improve the system**. Human-AI co-learning must be assessed to ensure that it leads to better outcomes rather than unnecessary complexity. Metrics such as system accuracy should be monitored and user trust, satisfaction and feedback should be gathered. If the AI does not show meaningful improvements or users struggle to interact with it, adjustments should be made to refine the co-learning process.

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5.3 HAI: Explainable AI

General description

Explainable AI (XAI) refers to the set of techniques and methods that make an AI system's decisions and behaviour understandable to humans. Contemporary AI systems, using Deep Neural Networks (DNNs) such as Large Language Models (LLMs) and Vision Language Models (VLMs), can achieve remarkable performance through their highly complex architecture and inner mechanisms. However, the lack of transparency in how these systems reason and reach their conclusions can undermine user trust, leading to a recognized need for XAI research that can clarify and explain their behaviour (Mamalet et al., 2021). The opaqueness of the so called "black box" AI systems can lead to a lack of trust or difficulties in assessing the system's reliability, especially in high-stakes domains like healthcare (Salahuddin et al., 2022). XAI aims to address this challenge by providing transparency into how and why an AI system produces a specific output or recommendation. Typically, this involves highlighting critical input factors, such as important input variables in tabular data or significant image features in images that influenced the system's decision, or providing insights into the AI system's reasoning process.

Explainable AI aims to address four main issues (Adadi & Berrada, 2018; Saeed & Omlin, 2023). First, it is vital that autonomous AI systems are held accountable for their actions. XAI is essential for meeting legal and ethical requirements in such contexts, where the reasoning behind the system's decisions must be clear (Pavlidis, 2024). Second, XAI improves user trust and acceptance of AI systems, by providing clear and understandable explanations that allow both experts and non-experts to interact with the system more effectively. Third, XAI enables the discovery of meaningful relationships and correlations between input data and AI system outputs, facilitating deeper domain knowledge and leading to improved future solutions for the task at hand. Finally, XAI can be used during the development of ML systems, aiding in identifying biases, inconsistencies, or other issues in the training data and AI system, which can be corrected to build more accurate, robust systems for end users.

Application

Explainable AI finds application across various industries where transparency, trust, and human-AI collaboration are critical. A very prominent domain where all these factors apply is healthcare (Hossain et al., 2025), which is a leading field for XAI research. For example, explainability is vital when AI systems provide diagnostic or treatment recommendations to medical professionals. In this case, an explainability layer could inform the medical expert about the factors that led to the output, as well as the system's confidence in its decision. This aims to improve user trust and acceptance of the system, enhancing the decision-making process as well as patient care (Pahde et al., 2025). In a similar approach, XAI can be used to assist first responders handling emergency situations, such as identifying the severity of an incident or suggesting optimal response strategies. In finance, XAI can be used to explain decisions that affect clients, helping to ensure that these decisions are free from biases or errors, and allowing bank employees to justify AI-based decisions to clients, increasing trust and ensuring compliance with regulatory requirements (Adadi & Berrada, 2018).

XAI is also valuable for insight discovery in industries such as manufacturing, where discovering and understanding the relationships between input data and AI system outputs can lead to operational improvements (Ahmed et al., 2022; Alexander et al., 2024). For example, XAI can reveal how specific parameters impact production efficiency, as well as to assist in predictive maintenance of machinery and equipment. Similarly, in quality assurance, XAI can identify which factors contribute to defects or inconsistencies in products, enabling faster error detection and resolution.

Finally, XAI is essential in applications where AI system's robustness and safety are critical, such as autonomous systems like self-driving cars (Atakishiyev et al., 2024). In these domains, XAI provides developers with tools to identify and correct mistakes that could compromise safety. For example, XAI can help developers understand how the AI interprets input data, like detecting objects or responding to environmental changes, ensuring that the system is making reliable decisions. This approach leads to more robust and trustworthy autonomous systems that are better equipped to handle real-world challenges.

Building on the description and applications outlined so far, the XAI tools that will be developed in Task 2.4 will follow two primary directions, based on the specific needs of each use case and pilot requirements. The first direction focuses on providing explanations to the end users of the system, in order to enhance their understanding of the system's reasoning, capabilities, and limitations, thus promoting better human-AI collaboration. The second direction targets the development phase of the AI system, where explanations will be used to support AI development and validation, focusing on improving system robustness and validation of the system's decision-making process.

Referral to transversal themes

Trust and understanding: the user may gain trust in the system due to transparency.

Learning and skills: the user can learn from AI explanations

Design guidelines

- **Establish communication between research and pilot teams.** Clear and frequent communication between the research team and the pilot team is essential at all stages of XAI implementation. This collaboration ensures that explainability goals align with pilot objectives, data availability, and AI model constraints. Regular check-ins and defined points of contact will help prevent misalignment and enable quick adaptation to changing requirements.
- **Define the purpose of explainability.** Outline the purpose of integrating explainability into the AI system of the pilot. Potential goals include: fostering end user trust in the system by making AI decisions more transparent, supporting AI developers in debugging and refining AI system architectures, ensuring regulatory compliance and ethical accountability of the automated system, assist stakeholders in decision-making by uncovering data correlations (Bhatt et al., 2020).

- **Identify target users and needs.** Based on the previous defined goals of explainability, identify the user groups that will interact with the AI explanations. These could potentially be the end users of the system or the AI development team (Yu & Shi, 2018).
- **Define data and system type.** Establish the type and size of data that will be collected and used, as well as the AI system architecture developed and used by the pilot. For example, data types include tabular data, images, and text. AI model types include complex deep learning models, simple models like decision trees, and optimization tools used for optimal problem-solving with constraints.
- **Conduct literature review.** Perform a targeted literature review on Explainable AI methods relevant to the pilot's data type, AI model, and use case. This helps identify relevant state-of-the-art explainability techniques, best practices in similar applications, and recognize potential challenges that may arise during the execution phase.
- **Select suitable explainability techniques.** Choose the explainability approach and methods that will be implemented as a starting point, based on the data, model type, pilot use case, and literature review. Considerations include: local vs global explanations (explain a single sample or explain how the entire model works?), intrinsic vs post-hoc methods (will the AI system be inherently interpretable by design?), and explanation output type (what will be presented to the user?) (Mohseni et al., 2021).
- **Integrate explainability layer into AI development.** Implementation of the selected XAI methods, using relevant libraries. The integration of the explainability layer in the AI system requires communication, collaboration, and iterative progress updates between the research and the pilot development teams.
- **Provide user-centric explanations.** Tailor explanations to the needs and requirements that have been set by the users. This involves three key dimensions: timing (e.g. appearing alongside every AI decision or only on user demand), depth and complexity (matching the user's expertise and current

task requirements), and accessibility (using clear language and output formats that include all users) (Haque et al., 2023).

- **Facilitate collaboration between roles.** Create communication channels for ongoing collaboration between the research team, the AI development team, facilitators, and the users interacting with the explanations. This allows for more efficient problem-solving of any challenges that come up during the implementation.
- **Establish feedback loop.** The application of the explainability layer can be refined through iterative feedback loops, established through communication between the roles. This allows for gradual improvements made in the AI system and its respective transparency level (Panigutti et al., 2023).
- **Remain flexible.** Flexibility is required, adjusting as needed to changes in pilot requirements, AI models, or user feedback. Flexibility might involve switching explanation methods if a chosen approach proves problematic, modifying the explainability approach if a different AI system is used instead of the original, modifying output to better suit users, and adjusting collaboration processes if communication issues arise between roles.
- **Assess explainability effectiveness.** Evaluate how well the XAI methods meet user and system goals, using both qualitative and quantitative measures defined in the assessment criteria. This potentially includes conducting user studies, experiments with the Explainable AI system, as well as the use of algorithmic approaches to evaluate the explainability layer (Doshi-Velez & Kim, 2018).
- **Perform pre- and post-explainability comparisons.** Conduct before-and-after comparisons to measure the impact of explainability. This includes using user studies to measure shifts in user trust and decision-making efficiency when using an a transparent instead of an opaque AI system (Schoonderwoerd et al., 2021).

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5.4 HAI: Human-in-the-loop

General description

In contrast to fully autonomous systems, systems that incorporate a "human-in-the-loop" (HITL), are systems in which both humans and automated components participate in the operational process. That is, in HITL systems, a human is, by design, able to intervene or provide oversight to the output of automated components. Such human oversight is often a better strategy to achieving objectives such as increasing productivity, safety or quality of output than completely automating a system, and better quality of jobs.

Sheridan & Verplank's ten levels of automation have been widely used to understand variations in automation (Sheridan & Verplank, 1978). The ten levels are listed in **Error! Reference source not found.** below. As the Sheridan & Verplank model suggests, workers may be incorporated in HITL systems in multiple ways. In a decision support system, a worker may simply consult an AI module whenever he/she desires. The worker may also be involved in a more autonomous system and oversee the system's outputs to ensure it functions as intended and intervenes when anomalies occur. The stage at which the worker evaluates this output may also differ. Every intermediate step may be evaluated or only the final output of the system may be evaluated by the worker. HITL can therefore be

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implemented in various ways, roughly corresponding to different levels of automation on Sheridan & Verplank's ladder (**Tabel 1**).

Level	Description
Low	1. The computer offers no assistance
	2. The computer offers a complete set of alternative actions
	3. The computer narrows down the selection to a few
	4. The computer suggests one alternative
	5. The computer executes that suggestion if the human approves
	6. The computer allows the human a restricted time to veto before automatic execution
	7. The computer executes automatically, then necessarily informs the human
	8. The computer informs the human only if asked
	9. The computer informs the human only if it, the computer, decides to
High	10. The computer decides everything and acts autonomously, ignoring the human

Tabel 1. Summary of Sheridan-Verplank levels of automation (Sheridan & Verplank, 1978).

As detailed in Shneiderman (2020), it is not necessarily desirable to automate as many parts of a system as possible (i.e., moving up the ladder of Sheridan & Verplank), as it is not a goal in itself. Instead, it can be helpful to think of automation as a means to give workers control in achieving other goals, such as higher quality of product output, safety or work satisfaction. It depends on the task-specific characteristics as well as task-context which components should be automated in a HITL system and to what extent.

Application

Most tasks can be divided into work activities that need to be carried out. Activities that are highly repetitive and boring may be very well suited for being automated (Brynjolfsson & McAfee, 2014). Examples of such highly repetitive activities may be data entry and validation in data processing or sorting and assembling in manufacturing. Other types of activities that may be (partially) automated are activities that are dangerous to humans (e.g., see Sheridan 2016), as well as activities in which AI outperforms human workers. These can, for example, be activities involving the quick processing of high data volumes or activities that require extremely high precision (e.g., see Thananjeyan *et al.*, 2017). A HITL approach, however, is critical in contexts where decisions have significant consequences. Here, human oversight may enhance performance and ensure that the decisions are aligned with human values and judgment (Grønsund and Aanestad, 2020). Having a human in the loop is also more relevant for tasks involving uncertainty or requiring nuanced judgment, as AI alone may struggle in novel or ambiguous situations. For example, in tasks requiring contextual understanding human judgment may be needed to validate AI output (Zagalsky *et al.*, 2021).

In sum, task-specific characteristics such as repetitiveness, monotony, danger, speed, and data volume, along with contextual factors like high-risk environments, high-stake decision-making, task ambiguity, and uncertainty, collectively determine the appropriate balance between automation and the level of human oversight.

Referral to transversal themes

Trust and understanding: in contrast to fully automated systems, a HITL can increase compatibility of decisions with human judgement, thereby increasing trust in and understanding of the system.

Design guidelines

- **Assess the need for a human-in-the-loop approach.** Before implementing HITL, determine if human oversight is necessary. HITL is crucial for tasks involving ambiguity, ethical concerns, or high-risk consequences, where human judgment can prevent errors or bias. However, in routine or highly structured tasks, full automation may be more efficient. Conducting a risk-benefit analysis can be helpful in defining the right level of automation and human control. When assessing the need for HITL, incorporate the individuals that currently perform the tasks that may be partially automated, as well as other relevant stakeholders, such as individuals working downstream the operation process.

- **Define the roles that humans and AI play.** Clearly outline the role of the human, such as when and how human intervention should occur. This can range from full human control to occasional oversight in high-risk scenarios. Defining roles prevents over-reliance on the system while ensuring that human oversight remains meaningful and effective. This clarity is essential for accountability and user confidence in the system.
- **Involve the end user in the design process.** When it is decided that a HITL approach may be desirable, end users should be involved in the design process to ensure usability, efficiency, and alignment with their workflows. Including these individuals early helps identify potential challenges and ensures that automation supports rather than disrupts their work. An idea is to use co-design sessions to gather feedback throughout development.
- **Consider stakeholder impact beyond direct users.** Beyond direct users, other stakeholders—such as decision-makers, customers, or regulators—may be affected by the system's outputs. Their needs should be considered to ensure transparency, fairness, and alignment with broader operational goals. An idea is to organise focus groups with such stakeholders to gather input on their perspectives.
- **Evaluate and improve the system.** HITL systems should be monitored to assess their functioning. Regular evaluations should measure whether human intervention improves decision quality, reduces errors, and enhances user trust. Metrics such as system accuracy should be monitored and user trust, satisfaction and feedback should be gathered to refine the roles of the system and the human optimally.

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5.5 Digital human models

General description

In relation to human-centricity, Digital Human Models (DHMs), sometimes referred to as virtual humans, are sophisticated computer-generated representations of human beings used to simulate and analyse human interactions with products, environments, and systems. Digital human models used in VR-settings and computer games are not covered here. Current models such as Ramsis (Humanetics, n.d.) and Jack (Siemens PLM, 1992) incorporate detailed anthropometric, biomechanical, and physiological data to create simulations of human movements, postures, and behaviours. DHMs are widely used in product design and workstation and work process design, to enhance the design process and improve human-centric outcomes (Reed, n.d.).

Where the human has been part of the technical systems, be it products such as driver cabins or industrial processes, engineers have tried to also digitise the human component of this system. Before digital design, 2D manikins from paper or plastic, were used to make sure products met anthropometric requirements.

In digital design manikins became 3D digital human models. At first they were static models that needed to be positioned in a certain posture by the user of the software, nowadays they are able to perform certain movements, or they can mimic movements of a person wearing motion tracking sensors. Well-known is Jack software (Siemens PLM, 1992), that is still used in designing industrial workstations and driver cabins.

Application

The strength in applying DHM's is that, contrary to using physical mock-ups and testing these with real users, using digital mock-ups with DHM's allows the designer to quickly test several scenarios (Demirel *et al.,* 2022). In addition, built-in assessment modules, allow the design team to evaluate the effect of design choices on physical loads on the body.

As mentioned above, DHMs are predominantly used for product design and workstation design.

In product design, vehicle cabin design is dominant where the DHM is used to assess the suitability of a design for users with different dimensions, regarding reach, vehicle operation and viewing aspects. In product design (such as vehicle engines) DHMs may also be used to test how well parts can be reached for (dis)assembly and servicing.

In workstation design and work process design DHM are similarly used to achieve workstations that allow for optimal postures and body loads. DHMs are further used to optimise workflow and thus minimise waste (non-value added movements, such as large walking or carrying distances).

Being over-reliant on DHMs poses risks for human-centricity as important design aspects may be missed (Bertilsson, 2010). For example, body loads depend on how someone moves. DHMs are still not capable of showing realistic behaviour given a designed work setting, especially with respect to how a worker will behave with conflicting task demands or strong incentives to take safety shortcuts.

Further, all digital human models are based on biomechanical and kinesiological properties. To date it has not been possible to create DHMs or a set of DHMs that incorporate psychological and social aspects of human behaviour and could therefore be used to simulate and evaluate realistic task design or even organisational design on psychological factors before actually implementing the design. There are, however, initiatives to develop such features in human digital twins (HDT's) (Wang *et al.,* 2024), who, unlike DHMs do not necessarily have a physical appearance. A worker in a digital twin could also be represented by several figures relevant to a production process, such as assembly speed, fault rate, fatigue development, and skills. The consequence of the limited representation (biomechanical/kinesiological) is that in the 3D design of work systems, the human representation is limited by design. It is therefore important that designers are aware of these limitations and realise that DHMs cannot replace mock-up testing and testing with real users.

Lastly, the risk of using DHMs can be that they can lead to technical engineers applying a technical systems approach in which the human is just another element in the system, represented by a persona, or digital human model (Shorrock, 2017). The conclusion must therefore be that, while very useful in design, DHMs cannot fully replace end-user involvement.

Referral to transversal themes

Worker Inclusion: different designs can be created for different types of users.

Design Guidelines

- **Decide whether DHM's have added value in the design process and whether to invest in DHM's from a software and skills point of view.** It is only useful if the software is used regularly by someone with human factors knowledge.
- **Involve an expert.** Treat DHM work as a project in its own right. Don't assign a complex modelling task to untrained staff without support – this risks errors or abandonment of the tool. Make sure team members have dedicated time for simulation and analysis.
- **Engage stakeholders early.** Get management and cross-functional buy-in by highlighting DHM benefits (fewer physical prototypes, improved ergonomics).

Also involve end-user representatives from the start to ensure simulations reflect real working conditions and needs.

- **Define clear goals and criteria.** Decide what questions the DHM analysis will answer (e.g. can all intended users reach a control? where are the injury risk hotspots?) and set measurable success criteria. Clear goals keep the project focused and provide benchmarks for checking results.
- **Make sure to have a skilled team and proper tools**. Assemble a cross-functional team and equip them with the right DHM software and hardware. Ensure at least one member is proficient in the software (or get training as needed), and set up the necessary licenses and equipment early.
- **Use up-to-date anthropometric data covering the range of your user population.** Prepare digital models of the work environment or product (CAD files or measured layouts). If these aren't available, allocate time to capture measurements or photos for building accurate virtual models.
- **Set aside adequate time and budget.** A basic DHM analysis might take a few days; more complex projects can take weeks. Plan for iterations and review sessions. Budget for software, training, and implementing any design changes coming out of the analysis.
- **Schedule a kick-off session and define the project scope and objectives with stakeholders.** Agree on what will be modelled (which product, workstation, or process) and which human factors outcomes to examine (posture, reach, visibility, force, etc.).
- **Build the digital model.** Gather input data and construct the virtual scenario. Import or create the environment/product geometry and set up digital human avatars representing your user demographics (e.g., a short, average, and tall individual). Incorporate real task details (steps, durations, loads) gathered from observations or user input.
- **Run the simulated tasks in the DHM software and observe results.** Identify design issues or inefficiencies (awkward postures, excessive reaches, collisions, high forces) and quantify them using the software's metrics (joint

loads, posture scores, etc.). Test variations (different user sizes or methods) to evaluate design robustness.

- **Present the results in an accessible format (charts, heatmaps, or animation of the digital human) and review them.** Explain the human impact of any issues – e.g. "a shorter operator would need to overstretch to reach X." Verify with stakeholders (especially those doing the job) that the findings match reality. Use their feedback to agree on necessary design or process changes.
- **Build a quick/paper prototype**. It is preferred to build a simply mock-up, e.g. with carton boxes, to be able to test a set-up with users. For workers and other stakeholders it can be difficult to judge the quality of a design from a (digital) drawing. Therefore, building a prototype is recommended.
- **Apply improvements to address the identified issue, test them in the model and do this iteratively.** Adjust the design or workflow (move components, change heights, add tools) and re-run the simulation to verify improvements. Repeat this cycle until the DHM results meet the success criteria. Use DHM findings and stakeholder input to refine the design in cycles, rather than expecting a one-and-done solution. Document the changes and lessons learned for future projects.
- **Train the team and set expectations.** Ensure the team understands the DHM software's capabilities and limitations. Provide training so team members can run simulations and interpret results confidently. Set realistic expectations – DHM informs decisions but doesn't replace human judgment.
- **Include a diverse range of digital humans to represent your actual users.** Use varied body dimensions, strengths, and conditions to catch design issues affecting different groups.
- **Check results against human factors guidelines.** For example, compare reach distances and forces from the simulation to accepted workload limits. Flag any exceedances for redesign.
- **Don't trust the model blindly.** Don't accept simulation output without question. Models have limits, and they may not capture every nuance of real human

behaviour. Cross-check critical issues with expert opinion or on-site observation. Build mock-ups.

- **Avoid using rough estimates or out-of-date data.** Poor anthropometric data or inaccurate environment models will mislead analysis. Invest time in accurate data so the simulation reflects reality.
- **Don't model every minor detail at the start.** Overly complex simulations can overwhelm stakeholders and bog down the process. Begin with critical tasks and issues; add detail in later iterations only if needed. Rule-of-thumb: simulations benefit form representing the most important behaviours of the real situation. Realism itself is no goal.

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5.6 Digital twins

General description

A digital twin (DT) is a virtual representation of an object or system designed to accurately represent the object or system (IBM, n.d.). Digital twins range from virtual environments to be used in VR applications to industrial digital twins which may be an accurate digital version of an industrial process or a digital representation of it's behaviour for which 3D representations are not strictly necessary. In essence, this also applies to digital representations of humans in a production process: this can be digital human models or a set of metrics that represent the worker in the system.

In the following, the focus will be on industrial digital twins.

Industrial digital twins strive to leverage real-time data, simulations, and advanced analytics to mirror and optimize its physical counterpart (Grieves,

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2014). Digital twins can help many kinds of organisations simulate real situations and their outcomes, ultimately allowing them to make better decisions.
The core components of DTs are:

- Data integration from IoT[6] devices, sensors, and enterprise systems;
- Modelling and simulation for predictive and prescriptive analytics to anticipate outcomes and optimize performance and;
- Continuous feedback loop for interaction between the physical and digital models to ensure synchronisation and adaptability.

Application

In the application of industrial DT's, currently the operator plays a limited or no role. Therefore the application does not necessarily serve a human-centric purpose. The challenge is two-fold.
First of all, to date it is not possible to create a human digital twin that mimics realistic behaviour in an industrial digital twin. Digital human models, the human DT, do not incorporate psychological and social aspects of human behaviour and can therefore not be used to simulate and evaluate realistic task design or even organisational design on psychological factors before actually implementing the design. There are, however, initiatives to develop such features in human digital twins (HDT's) (Wang *et al.,* 2024).
The consequence is that in digital twins of work systems, the human representation is limited by design. Therefore from a human-centric point of view, assumptions in a DT with respect to workers, such as human productivity figures, should be carefully reviewed and preferably checked in mock-up or real life situations.
The second challenge is that digital twins may stimulate (re)design without worker involvement if the worker is digitally represented in the DT, even if only limited.

[6] IoT=Internet of Things, meaning that elements of the system are connected to each other through the internet.

The following serves as an example of the state of art of human representation in DT's. The German Industrial Digital Twin Organisation (IDTO) is currently developing submodels of digital twins ((Industrial Digital Twin Association e. V., 2025). TNO is involved in the development of the submodel Workstation Worker Matching Data. The goal is to be able to match (human made) worker profiles with work requirements for scheduling purposes.

As a result of above-mentioned limitations, applying DT's do not necessarily lead to a human-centric outcome, even if engineers view HDT's as essential to developing a human-centric Industry 5.0 (Wang *et al.,* 2024), instead of promoting human involvement in design processes.

Referral to transversal themes

Considering an industrial DT's reliance on sensor data and connectedness, cybersecurity needs special attention (Edge Industry Review, 2024). If sensor data is used of human behaviour then privacy preserving measures are fundamental (see under Privacy preserving models and methods for worker feedback).

Trust and understanding: DT's can lead to trust and understanding of complex technical systems as simulations can be done and information can be added or hidden depending on the user and purpose of application.

Inclusion: Digital twins can at the same time endanger and enhance inclusion. It endangers inclusion if the DT contains human elements as these are most likely limited in its represention of real users (see above). It may enhance inclusion if the DT's presentation is adapted to its user.

Learning and skills: Digital twins can help user to learn new skills in a safe and cost-efficient way.

Design guidelines

Given the limitations of worker representation in industrial DT's, guidelines for applying DT's for the sake of human-centric design of workplaces are limited. The most important guideline is that application of DT's should be accompanied by

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worker participation and mock-up testing to warrant realistic expectations of system behaviour (including workers) and human-centric work design.

- **Validate the use-case and domain.** Ensure the target process is complex enough to benefit from a digital twin (e.g., involves high downtime costs or safety-critical tasks). Clearly define the problem and value proposition to justify the twin. For a human-centric focus, determine which outcomes (e.g., improved safety or creativity) are desired and establish how to measure them (Roundy, 2020).
- **Engage stakeholders and end-users.** Identify key stakeholders (management, IT, domain experts, front-line workers) and involve them at appropriate stages. Secure executive sponsorship early for strategic alignment, and include end-users in design/prototyping sessions to ensure the twin is user-friendly and addresses real needs.
- **Focus on human and business benefits**. Tie the twin's purpose to clear human and business goals (e.g., reducing worker stress, improving teamwork). For example, virtual testing can reduce on-site stress and raise employees' confidence and job satisfaction. Keeping benefits visible helps maintain stakeholder buy-in.
- **Assess data readiness and IT fit**. Check that required data streams (sensors, logs, etc.) and enterprise IT systems are available to support the twin. Involve IT stakeholders to ensure the twin will integrate with existing systems (ERP, IoT platforms) rather than stand-alone. Confirm that data quality is sufficient or plan improvements, since the twin's accuracy depends on reliable inputs.
- **Technology and data infrastructure.** Secure the necessary tools and data. Set up the digital twin platform and any IoT sensors or data feeds required. Ensure you can collect and combine data from all relevant sources. Also prepare integration interfaces (APIs or middleware) so the twin can exchange data with enterprise systems.
- **Time and budget allocation**. Allocate a few months for developing and testing a pilot (with some buffer for surprises). Plan regular check-ins (e.g., weekly team meetings, monthly stakeholder reviews) to monitor progress. Budget for

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software, hardware, and staff effort, as well as training and maintenance after launch (Tobler Technologies, 2025).

- **Define goals and secure stakeholder input**. Clearly identify the process or asset to model and the goals the digital twin should achieve. Establish business value and human-centric targets (e.g., safety improvements, better collaboration). Involve stakeholders early (through workshops) to gather requirements and ensure consensus on scope and success metrics.
- **Plan design and integration**. Design the twin's architecture and integration plan before building. Identify data sources and how the twin will interface with existing enterprise systems. Plan for interoperability so the twin fits into the current IT landscape. Also address resource needs (team roles, tools) and any data governance or security requirements at this stage.
- **Develop iteratively (start small, at best with a prototype)**. Build the digital twin in manageable increments. Begin with a pilot model of a critical component or process rather than attempting the entire system at once. Use an agile approach with short development cycles and frequent check-ins. This iterative development lets you adjust on the fly and reduces project risk.
- **Don't "boil the ocean"**. Avoid trying to build an all-encompassing digital twin in one go. Overly broad scope can overwhelm the team and dilute focus. Start with a focused project (prototype with solid use-case!) that delivers tangible results, then expand once it's proven.
- **Test and validate with users**. Continuously test the twin against real data and scenarios to verify accuracy. Validate functionality with domain experts and gather feedback from end-users throughout development. Iterate based on feedback – refining the twin's models and interface to better serve user needs.
- **Deploy pilot and evaluate**. Roll out the twin in a controlled pilot environment once it's validated. Train the pilot users so they know how to use the twin in their daily work. Monitor key performance indicators and CAPS outcomes during the pilot (e.g., productivity changes, user satisfaction). Use pilot results to decide on scaling up and to guide improvements for full deployment.

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- **Training and support materials**. Be ready to educate users about the twin. Develop simple documentation or tutorials for the twin's interface and insights. Schedule training workshops around deployment so employees become comfortable with the new system.
- **Don't neglect the people side.** Don't assume employees will instantly embrace the new tool. Skipping user training or not involving them will hurt adoption. Make sure the twin is seen as aiding their work, not replacing it (this is never the goal with DTs), to avoid fear and resistance. Plan change management with training, intuitive interfaces, and clear communication of the twin's purpose to staff. Another concern to be addressed is overcomplication: DTs should aim to make the user's life easier and should be communicated as such (once it is proven that it does in fact make life easier).
- **Ensure high-quality data**. Remember the twin is only as good as its data. Establish data governance for accuracy and consistency, and pull data from diverse sources . Clean and update data regularly – bad data will yield bad results, so fix quality issues at the source.
- **Prioritise security and privacy**. Make cybersecurity and data privacy non-negotiable. Secure data pipelines and control access to the twin's information. Use encryption and authentication per company IT policies to safeguard sensitive data. Address privacy concerns proactively (e.g., anonymise personal data) to build user trust.
- **Don't ignore maintenance.** Launching the twin is not the end of the journey, but the start of working with the twin. If it's not kept updated as real-world processes change, its value will decline. Plan for ongoing maintenance and improvements (e.g., regular model updates and data refreshes), and allocate resources for this upkeep. More mature models have automated updates. If automated updates are not relevant to your case, it might still help to ask what such updates would need from a data and planning perspective, and to come up with an update protocol.
- **Don't remove human oversight.** Never leave important decisions to results of simulations from the digital twin (Modoni & Sacco, 2023). Even with advanced

automation, keep a human in the loop for critical judgments and to handle unexpected situations. The twin should augment human decision-making, not replace it. Maintaining human oversight ensures the system stays aligned with human values and common sense, safeguarding factors like safety and trust. But also prevents critical errors.

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5.7 Privacy preserving models and methods for worker feedback

General description

The development of privacy preserving algorithms for understanding and predicting human behaviour in work environments can significantly benefit from the integration of wearable technologies and sensor data. Wearable devices, like smartwatches, are pivotal in monitoring physical and biomechanical performance, thus enabling real-time analysis of markers of workers' physical and mental state (McDevitt et al., 2022; Poitras et al., 2019). These technologies facilitate the collection of diverse physiological signals, including heart rate, skin conductance and temperature, and kinematic information from inertial measurement unit (IMU) sensors. For protecting individual privacy there are methods available for all raw physiological signal streams. Data anonymization and pseudonymization by removing or obscuring information at the source, local processing on the device or an adjacent edge node, differential privacy by adding statistical noise and encryption, ensure no personally identifiable data ever leaves the secure perimeter. A combination of these methods, ensures robust privacy protection.

This information can help users better understand negative working conditions, such as by monitoring stress levels, assessing fatigue and recognizing normal or abnormal human activities, like falls (Poitras et al., 2019; Alhejaili, 2023; Gupta et al., 2021; Qian et al., 2022). The extracted fusion of different monitored physiological signals (heart rate and skin conductance) can be fused at different levels in working environments through enhanced algorithms. These methods represent a multidisciplinary approach that combines machine learning, physiological monitoring, fatigue monitoring, human activity recognition and contextual analysis. By leveraging these methodologies, organisations can empower workers to work in a way that is better aligned with their physiological and psychological needs, leading to improved workplace dynamics and overall

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worker's well-being. The goal is not, to determine the biochemical composition of stress or fatigue, but rather to detect indicators that can help anticipate workers' behavior and responses in real-world working environments.

Detecting stress and fatigue through computer vision techniques has also gained significant attention in recent years, building on advancements in facial expression analysis and machine learning. Stress detection is crucial in various fields, including psychology, healthcare, and human-computer interaction, as it can improve user experience in technology applications. One of the primary methods for detecting stress involves analysing facial expressions. Research indicates that facial image parameters can serve as effective indicators of psychological stress, allowing for remote evaluation (Egawa et al., 2018). To uphold privacy, facial video is analysed entirely on-device or on a local workstation, with no raw images transmitted externally, and only abstracted feature descriptors are retained for further processing.

The detection of workers' physical and mental state through passive or active sensors, particularly utilizing computer vision techniques and postural estimation, is a burgeoning field that integrates various methodologies to interpret human states. Head pose estimation is a critical component of this endeavour, as it provides insights into a person's attention. Research indicates that head pose can be indicative of social interactions and behaviour responses, making it a valuable tool in affective computing and human-computer interaction (Varadarajan *et al.*, 2018). All pose computations occur at the edge layer with only anonymized head-orientation vectors transmitted for analytics, thereby preventing any linkage back to the individual's identity.

Application

Because sensors used for worker feedback capture deeply personal information, it's essential to start by asking: what real value does the worker gain from this data? Data collected purely for business optimization and never shared with the individual fails the test of human-centricity. By contrast, when workers receive clear, actionable feedback and retain the ability to view, control, or pause data collection, they can adapt their behavior or work environment for their own benefit. The same principle applies when data is used to tailor task assignments or workloads. If the worker is informed, empowered, and in control, the monitoring technology truly serves human-centric goals. Moreover, all data collection and processing must employ above mentioned privacy-preserving measures, to ensure that personal information remains secure and confidential.

Typical examples of work settings where human state monitoring may be beneficial, but its use must be justified, either as single measurement or as continuous monitoring, are the following:

Physically demanding jobs in industries like construction, manufacturing, and logistics. Motion tracking is used to analyse biomechanical risks, heart rate monitoring may be used in work with high oxygen consumption such as biking, frequent and long stair climbing. In average work, heart rate monitoring to analyse work intensity is seldom useful.

High-stress environments such as healthcare, emergency services, and high-stakes project management. Monitoring could be used to help workers recognize stressful situations they would otherwise not register and to help an organisation to mitigate stressful work settings. As data does not necessarily speak for itself, worker input via interviews or questionnaires is needed.

Remote or hazardous locations. Application in remote or hazardous work environments, such as mining or offshore drilling, can ensure worker safety through real-time monitoring.

In environments with high cognitive load, such as air traffic control, experiments have been done with EEG sensors (e.g. Hui et al., 2024), eye movements and facial expressions (Skaramagkas et al, 2021) and vocal feature analysis (Huang, 2024). Human state monitoring technologies are not yet proven technologies and may therefore be dangerous to rely on in high risk environments. In any case, they require multi-modal physiological data (Aust et al, 2024.). Also, Human state monitoring techniques should not be used for workplaces where data is used for management control.

Posture and movement

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Gravitational sensors are used to capture posture and movement. Simple measurements distinguish between moving and not moving.

In occupational settings this type of measurements seldom has human-centric purposes other than reminding employees in sedentary professions to regularly changes posture or get up and move.

To capture detailed posture and motion of (parts of) the human body (other terms are motion capturing or mocap and advanced postural analysis), sensors are needed on all moving body parts or AI-based video analysis is used (see e.g. Nawo solution[7]). In work settings this type of measurement is typically used in physical demanding jobs (i.e., constructions, logistics) to analyse biomechanical risks. AI-based activity tracking my also be used to identify hazardous behaviour and improve work design factors leading to such behaviour.

For more subtle and subconscious movements, such as facial expressions and eye movement, AI driven video analysis is used, for example to detect signs of fatigue or increased stress.

Physiological responses

Several types of sensors may be used to use to register physiological responses such as heart rate, heart rate variability and skin conduction, relying on either electrical or optical measurements (Cleveland Clinic, n.d.).

Depending on the device, measurements can be very accurate. However, what the measurements reflect and how accurate they reflect e.g. physical loads or stress, is very much dependent on the situation during the measurements.

At low exertion levels, heart rate reflects both exertion and arousal levels that can fluctuate very easily and may therefore not have any relationship with the work performed.

Skin conduction measurements (GSR-galvanic skin response or EDA – electro dermal activity) may lead to interpretations challenges at low or moderate occupational stress levels as they do not necessarily align with an individual's subjective experience of stress (Nasir et al, 2024). GSR readings can also

[7] Ergonomic analysis solution to indentify MSDs - Nawo Solution

fluctuate significantly based on the time of day and individual physical states, complicating the interpretation of stress levels (Ariayudha et al., 2023). Research suggests that combining GSR with skin temperature allows accurate distinction between psychological and physical stress (hard work) (Anusha et al, 2018).

Preserving privacy

When monitoring human state with sensors, protecting worker privacy is essential. European frameworks emphasize worker autonomy in initiating and controlling data collection, which fosters trust and aligns with GDPR standards. Privacy preserving methods use edge processing to analyse data locally—on the device or a nearby secure node—so sensitive information doesn't travel over public networks. If data must be shared for AI training, it is pseudonymized and protected by differential privacy, ensuring individuals cannot be identified. Workers are given clear, simple controls to start, pause, or stop data collection at any time, with each action logged for transparency. This privacy-by-design approach ensures compliance with EU regulations while supporting real-time, privacy-sensitive monitoring.

Referral to transversal themes

Privacy preserving models and methods for worker feedback guarantee privacy or cyber-security provided the rigorous safeguards mentioned above are in place. Building trust requires clear, worker-centric communication: employees must understand what's being collected, how it's processed, and what actions they can take. When workers receive transparent feedback and concrete "action perspectives" based on their own data, they can help shape better workplace designs, adding to inclusion and confidence in the system.

Finally, these worker feedback methods can drive in-work learning and skills development, helping individuals reflect on and improve their own behavior.

Design guidelines

Human-state monitoring techniques demand both a thorough understanding of human factors and specialized expertise tailored to each sensor type. Because these systems collect highly sensitive personal data, implementation requires a

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careful ethical assessment to guarantee transparency, secure worker consent, and enforce privacy-preserving data protection measures.

The general guidelines for human-state monitoring are described below, followed by more specific recommendations based on your target outcome measure (stress, fatigue, or safety risks).

- **Involve an expert.** Because most organizations lack in-house expertise in human-state monitoring and the ethical, privacy and technical nuances it entails, it is advisable to engage subject-matter experts with proven experience in human factors research, sensor technologies and data protection.
- **Take privacy concerns into account.** Avoid deploying wearables or motion-capture systems that harvest sensitive worker data without a comprehensive privacy framework. While raw kinematic streams (joint angles, acceleration, posture) are inherently observable, any derived metrics, like physical-load estimates, fatigue scores, or injury-risk indicators, constitute personal health information. All live inference should run on-device or on a secured edge node (so that no raw signals ever traverse the public Internet), and any data that must leave for model training must be pseudonymized and protected via differential privacy. Present high-level insights to employees in an accessible format and obtain explicit, informed opt-in consent before sharing with management. Finally, codify exactly what is collected, how it's processed, who may access it, how long it's retained, and when it's deleted, ensuring actionable safety insights without compromising worker privacy or enabling discrimination.
- **Take ethical considerations into account.** Workers must be clearly informed about data collection purposes and methodologies. Establish opt-in procedures that let staff members turn off surveillance whenever they'd want. Select the appropriate monitoring equipment and restrict data gathering to the required metrics. Provide workers access to their data, facilitating informed decisions regarding their health and safety. Prioritise data use for enhancing worker safety, well-being, and job satisfaction rather

than focusing solely on operational efficiency. Confirm data interpretation by using surveys, interviews for employee feedback and contextual data such as ambient temperature.

- **Include action perspectives when providing feedback.** Feedback to the worker should be accompanied by action perspectives so the worker can actually try to do something to improve the situation leading to a specific type of feedback.

Effective monitoring of worker well-being and safety leverages advanced biometric sensors and posture tracking technologies, combining both wearable and camera-based methods. Methodologies for detecting stress, fatigue, and safety risks are described separately below.

Stress Detection

- **Determine the type of data to collect and set up measurement methods.** Multiple physiological data, like photoplethysmography, skin conductance level, temperature etc., can be obtained from wearables, whereas posture tracking could be realised by using camera-based analysis of rigidity and nervous movements. You can also combine wearable devices and camera's to continuously gather biometric data, complemented by posture data from camera-based systems. Calibrate camera systems beforehand to guarantee correct placement and accurate capture of posture.
- **Process and analyse the data.** Extract relevant features from physiological signals, such as heart rate, respiration rate, and heart rate variability. Employ machine learning techniques to fuse physiological data for comprehensive analysis. Utilize GPU-accelerated methods to analyse posture deviations in laboratory settings, ensuring the analysis is tailored to each specific pilot scenario.
- **Ensure valid and accurate data collection.** Ensure wearable devices are consistently placed on participants to standardize measurements and increase accuracy. Establish real-time reporting and deployment platforms for immediate data analysis. Conduct structured stress tests, including

neutral baseline conditions and induced stress conditions tailored to each pilot's needs. To ensure precise stress measurement, participants should avoid caffeine and smoking for at least three hours before testing.

Fatigue Detection

- **Determine the type of data to collect and set up measurement methods.** See under stress detection. Additionally, utilize extended task performance to naturally induce and detect fatigue in experimental set-ups. Identify postural instability through signs like slouching, head tilts, and decreased movement control.
- **Process and analyse the data.** Extract relevant features from physiological signals, such as heart rate variability and respiration rate. Quantify fatigue levels through comprehensive analysis of physiological and biometric data.
- **Ensure valid and accurate data collection.** Mount unobtrusive wearable sensors on participants, preferably on the wrist, for physiological data monitoring. Establish a reporting platform to gain ground truth values based on the experiment phase. Structure the fatigue detection pipeline to include controlled activities that induce fatigue, similar to previously presented examples for stress detection.

Safety Risk Detection

- **Determine which type of data you want to collect and set-up your measurement methods.** Identify the required data stream, RGB video stream for posture and action recognition. Ensure camera stability and clear visibility of workers and their immediate environment. Establish clear risk indicators (e.g., specific joint-angle thresholds or prohibited motion patterns) derived from movement and posture analyses. For motion analysis, use real-time video capture to detect hazardous behaviours through advanced action recognition algorithms.
- **Process and analyse the data.** Feed RGB video stream through vision-based Deep Neural Networks (DNNs) to detect and flag unsafe behavior patterns. Rigorously evaluate each candidate DNN on labeled footage, measuring both accuracy and latency across varied lighting, occlusion, and apparel conditions,

to ensure optimal performance and reliability. In operation, continuously cross-reference detected postures and actions against your predefined "safe behavior" templates, issuing alerts only when movement patterns exceed the established risk thresholds.

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5.8 Serious gaming

General description

Serious gaming uses video game technology, design, and mechanics for education and training purposes. Hence, in contrast with traditional gaming whose primary purpose is entertainment, serious gaming focuses on providing learning and training materials and, just like the former, is designed to be immersive and engaging, by using game mechanics like rewards, levels, and leaderboards. This makes serious gaming especially useful when trying to encourage certain behaviour, or improve adherence for example in training or recurring courses. To be able to encourage certain behaviour three essential conditions need to be considered: capability, opportunity, and motivation (termed

'COM-B system') (Michie, 2011). The guidelines below provide directions on how to consider these conditions.

As technology advances, the adaptability and effectiveness of serious games is expected to grow, making them applicable for a larger variety of domains and training purposes.

Serious gaming offers the advantage of being engaging, interactive, and offers personalised learning. Despite their potential, serious games face challenges such as high development costs, varying user engagement, and potential issues with accessibility. Critics also highlight the need for rigorous evaluation to ensure that these games achieve their intended outcomes.

Human-centric design focuses on creating solutions that prioritise workers needs and experiences. Serious games align with this philosophy by engaging users in meaningful, personalised experiences that cater to their skills, challenges, and learning preferences. For example, simulation games designed for workplace safety training ensure that workers can practice and internalise safety protocols in a risk-free, interactive setting. If properly designed, these games should integrate feedback mechanisms to adapt to the worker's performance, reflecting a human-centric approach.

Another way in which serious gaming can contribute to human-centric practices is that it can be used for dynamic teamwork training. Serious games can be designed in such as way that they encourage teamwork, enabling participants to collectively address challenges, share insights and learn from each other. Finally, Immediate feedback within games empowers workers to reflect on their performance and identify areas for improvement, aligning with participatory principles.

Application

Serious gaming has been applied in Education and Training to enhance experiential learning and provide a risk-free environment for practice and experimentation. Examples include Minecraft Education Edition (Bar-El & E. Ringland, 2020) which helps students learn coding, history, and teamwork, while flight simulators prepare pilots for real-world scenarios (Nisansala *et al.*, 2015).

Another application is in healthcare and medicine where serious games are employed for both professional training and patient rehabilitation. For example, a game has been designed to help young cancer patients understand their treatment process and stay motivated (Kato *et al.*, 2008), while others assist surgeons in refining technical skills (Olgers *et al.*, 2021). Other applications include military and defence which used serious games for simulations and strategy training and teaching decision-making and teamwork in high-pressure situations (Mun *et al.*, n.d.); social awareness and change to address societal issues and promote empathy but also foster awareness and critical thinking about real-world problems.

A logistics company might use a serious game to simulate supply chain management scenarios, encouraging workers to propose solutions and see their impact in a virtual environment. Serious games like "The Lampshade Game" simulate production processes (Ozelkan & Galambosi, 2009), teaching students and industry professionals lean principles while encouraging them to identify inefficiencies and propose improvements. Organisations undergoing transformation can use games to simulate new workflows, allowing employees to adapt and provide input before implementation. Games like "Safety hunting" train workers to identify risks in the chemical processing industry, promoting safety while incorporating feedback to enhance training outcomes.

While serious gaming offers significant benefits, its successful integration requires alignment with worker needs so that it resonates with employees' skills, interests, and goals. Moreover, ensuring games have accessible design is necessary to promote inclusivity and user-friendliness, both of which are critical for widespread employee participation. Lastly, organisations must set metrics (often in consultation with workers) to assess the impact of serious gaming on engagement, learning outcomes, and organisational goals.

Referral to transversal themes

Serious gaming is especially useful for learning purposes. Using serious gaming, skills could be trained and the learning process could proceed faster and in a more engaging manner. It thus contributes to the theme of Learning and Skills.

Design guidelines

- **Match the motives and preference in the game, with those of the target group, to optimally benefit from the intrinsic motivation that can be achieved through serious games.** The target group should be involved in choosing the best game components, such as game design, controls, reward strategy, and sounds. For example through UX-laddering, in which potential end-users are presented with different options and are asked to pick their favourite and explain why this is important to them (de Vries *et al.*, 2018).
- **Make sure the serious games elicit the desired stimulation.** The difficulty or intensity should match that of the player of the serious game and should ideally be adaptive. Games that are too difficult can lead to frustration, whereas games that are too easy, won't elicit the desired effect and can be boring (de Vries *et al.*, 2020).
- **The serious games should be easy to find and to get access to by the end-user.** Avoid external applications that require additional log-in information if possible.

Involve end-users in the development and testing phase. For method to gather ideas, look into the Instruments chapter. For the development of the VR application, use the guidelines of Co-creation workshops. Other methods could be used as well, depending on your goal. Then, look into other solution directions mentioned in Chapter 0:

- Workplace level with end user involvement.
- **If VR technology is used, consider the fact that it might require a large dedicated space and that acclimatisation to the VR-system might be necessary.** Reserve time to become familiar with VR glasses and moving around in the application.

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6 Instruments

6.1 Ideation methods

Ideation methods are techniques used to generate and share (new) ideas and perspectives. They are often used for problem solving, innovation and other creative purposes. By incorporating various stakeholders in the application of ideation methods, these techniques can be used to enhance human-centric company practices and products.

In general, the ideation techniques mentioned in this section can be useful in various stages of the design process, from problem definition to refinement of solutions. Note that ideation methods are not limited to the Ideation phase as applied in Design Thinking.

Depending on the needs and resources, different techniques may be more useful. It is generally productive to initially begin with ideation methods that stimulate divergent thinking, where out of the box ideas are stimulated, followed by convergent thinking, where the best ideas are selected and further explored.

Below we describe several ideation methods and guidelines on how to apply them.

6.1.1 Brainstorming

Description

A brainstorming is an activity in which participants are encouraged to freely share ideas in response to a question or topic. The purpose is initially not to evaluate or judge the shared ideas, as the focus is on quantity and creativity. A brainstorming is therefore suitable for situations where there is a need for exploratory research, where many ideas and perspectives can be shared and where out-of-the-box thinking is encouraged. The inclusive character of the brainstorming approach ensures that the technological solutions are created in cooperation, leading to solutions that are consistently more relevant and usable. It applies to both small and large scale problems.

Brainstorming can be used to generate, present and evaluate ideas to build a strong foundation for progress and innovation (Wilson, 2013). Suggestions can be analysed, refined, and prioritised after the brainstorming. By encouraging free-flow idea generation and creativity in a non-restrictive environment, brainstorming can identify new angles and connections that structured discussions might overlook while making the pilot environment effective and enjoyable (VanGundy, 2005). It's important to consider innovation and creative problem solving as relevant added values for organisations to get flexibility and competitive advantage (McFadzean, 1998).

Guidelines

- **Include a diverse range of stakeholders in the brainstorming.** To ensure diversity the effectiveness of brainstorming as a supportive method within the pilot, includes diverse stakeholders with different expertise and perspectives hence ensuring cross-disciplinary input (Brown, 2009).
- **Create the right setting- environment.** Choose a comfortable and inspiring environment for your brainstorming session, ideally close to a park or forest. This allows for easy access to nature during breaks. The proximity to nature can help participants feel more relaxed and open to sharing ideas. Make sure that there is enough room for groups to split up without interference of the conversations. Ensure the indoor space is equipped with necessary amenities like whiteboards, markers, and comfortable seating.
- **Appoint a moderator, possibly two.** To have a successful brainstorming meeting, there has to be a facilitator to control the execution. They should be a person with experience on the subject matter and should explain each step of the process. To ensure equal participation the moderator also must make sure that the environment is suitable, so that no one feels ridiculed, and

employees' freedom of expression and participation is appreciated (Puccio, Mance, and Switalski, 2011).

- **Set-up an agenda of the session and present this at the start of the session.** Start the discussion by giving an initial thought to the factors and variables that are influencing the problem to tackle by involving both the cause and its solution (Brown, 2009). The moderator provides the collaborators all the available information about the object of study (Puccio, Mance and Switalski, 2011). Use diverse brainstorming techniques to gather ideas (see next guideline) and evaluate them afterwards. Keep brainstorming sessions between 30-60 minutes to maintain focus and engagement.
- **Use diverse brainstorming techniques.** Combine free brainstorming with structured methods like brainwriting or mind mapping (VanGundy, 2005). Brain-writing is a structured brainstorming technique conducted in silence, allowing participants to build on each other's ideas without verbal discussion. Each participant writes three ideas on a 9-square grid sheet, then exchanges it for another sheet, reading existing ideas before adding new ones until the grids are filled or time runs out, see **Error! Reference source not found.**. Mind mapping is one more way of coming up with ideas on paper, but it can be conducted alone. In this method, the problem solver first writes one main idea at the centre of the paper. Other ideas are written around the sheet of paper, with circles around the idea and lines drawn to connect the ideas. This technique helps in depicting the non-linear associations among possible solutions (CAS, 2015) .

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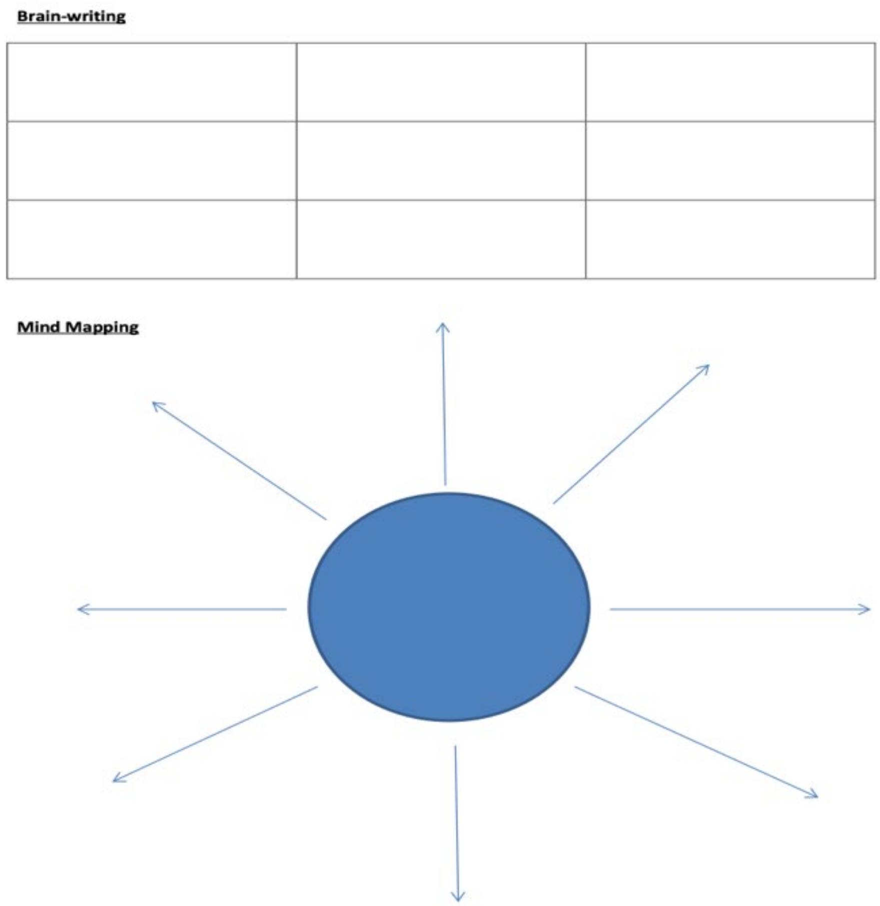

Figure 8. Template for structured methods like brainwriting or mind mapping (VanGundy, 2005).

- **Gather generated ideas and evaluate them in the group for individuals to give feedback on them and rank them.** List the ideas systematically and horizontally, ensure that everyone has an equal chance to express their opinion. Possibly, group similar ideas into themes (VanGundy, 2005) or sort them into categories based on relevance or subject. Gather opinions about feasibility and impact (Brown, 2009).
- **Post-brainstorm, categorize, and refine ideas into actionable insights** (Brown, 2009). Have other meetings or sprints scheduled to implement only the

selected ideas. Develop a summary of the findings and decisions to which the team can refer (Brown, 2009).

For more information on organising a session to gather ideas, look into the guidelines of the Workshop.

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6.2 Workshop

Description

A workshop is a facilitated session designed for idea generation regarding a particular topic, question or problem. Depending on the needs, workshops may host five to about twenty participants. Fewer participants allow for deeper discussions, whereas larger groups may enhance the diversity of the input and ideas. For larger groups, however, “break-out”-groups, where the larger group is temporarily divided into multiple smaller groups, may be useful to incorporate. Participants may include stakeholders or experts. Brainstorming (see below) and other explorative techniques are typically used within workshops to encourage creativity amongst participants (Gabriel et al., 2016). Within a workshop, it is intended that participants will be put to work, including collaboration and executing tasks.

Guidelines

- **Ensure that your workshop follows a pattern of divergent and convergent thinking.** Start by presenting the workshop's goals and objectives, and encourage participants to share their knowledge, ideas, and perspectives through brainstorming, mind mapping, or open discussions. Facilitate creative thinking activities like role-playing or scenario planning to explore a wide range of options. Next, review and categorize the collected ideas based on relevance and feasibility, using techniques such as dot voting or SWOT analysis to prioritize the most promising ones. Delve deeper into the top ideas, exploring potential challenges and resources needed, while encouraging feedback to refine them further. Finally, assess the refined ideas against the workshop's initial goals, using criteria like impact and feasibility, and facilitate a decision-making process to select the best ideas. Document the final decisions and create a clear action plan for implementation.
- **Create a workshop agenda, with no more than two topics to discuss and enough short and active breaks in between.** Communicate clear, concise and adapt to the needs of the participants if necessary. TIP: start with an energizing warm-up activity where participants must rank themselves on a specific topic. To determine their positions, they need to discuss and negotiate with each other. Another warm-up exercise could be to get to know each other’s names in a playful way. Examples are the Name Game and the Name Tag Switch. Make sure to choose engaging activities during the workshop that are aligned with the goals and objectives of the session. This could be realised

by letting participants point out the next individual that can bring up an idea, or integrating relevant objects to the workshop. Other formats are possible as well, the workshop does not fail if you don't include the former examples.

- **Create a script, including the agenda, duration of each part, involved people, and required materials for each part.** Use visual aids like flip charts, whiteboards, and slides to illustrate key points and keep the workshop dynamic. Collect all kinds of materials (post-its, markers, paper) beforehand, prepare your materials (by means of a drawn), set up the room (tables in right position), and make paper instructions that participants can refer to if needed.
- **Follow-up on determined actions after the workshop and keep participants posted on the progress of those actions.**

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6.3 World café

Description

The World Café is a structured activity in which an informal "café"-setting is created for participants to explore an issue by discussing it in small table groups (The World Café Community Foundation, 2015). Discussions are held in multiple rounds of 20-30 minutes, where in each round a pre-defined question or topic is discussed. After each round, individuals rotate to switch tables and converse with other participants. Between rounds, ideas are shared with the larger group and documented for future reference. The café atmosphere is intended to allow for more relaxed and open conversations to take place. The method is best suited for creative and exploratory purposes. The attractive informal setting can help encourage stakeholders to participate in the activity. More information on the World Café method can be found in The World Café Community Foundation (2015).

Guidelines

- **Set the context.** A world café is about creating a safe and welcoming environment for discussion. Create a room, most often modelled after a café (i.e. small round tables covered with pen, paper, vases of flowers, tablecloths etc.), that is large enough to allow participants to move freely. Arrange the room that it includes one table per small group, each with four chairs ('World Cafe Method', 2015a; jay, 2024).
- **Select participants and assign a role in the session.** Invite experts whose perspectives on the chosen topic are desirable. Participants do not need to prepare anything for the session. A group should include more than 15-20 people to arrange a world café session ('World Cafe Method', 2015a). Each table has a 'host' who remains at their table through the entire exercise. The role of the host is to welcome participants to the table, provide an overview of the discussion question(s), and summarize key takeaways shared by the previous guests at the table. At the end of the exercise, the host is responsible for sharing a summary of the discussion points from his/her table ('World Café Method', 2015; Intergroup Resources, n.d.).
- **Collect materials.** Required materials ('World Cafe Method', 2015a) include: a facilitation agenda and talking points; 3-4 large sheets of paper for every table; markers, crayons, pens in multiple colours for every table; and a flip chart .
- **Develop discussion questions.** Find questions that are relevant to the real-life concerns of the group. Powerful questions that travel well help attract collective energy and insights. You can use a world café to explore a single important question from multiple perspectives or you can structure the process to include several questions on a given topic. Determining which approach you will use is one of the first steps in preparing a world café.

    - Using multiple *questions*, you will need to determine how many rounds of conversations you would like to have and how many rounds will feature new questions.
- **Encourage everyone's contribution.** Enliven the relationship between the 'me' and the 'we' by inviting full participation and by fostering listening and speaking (The World Café Community Foundation, 2015; Intergroup Resources, n.d.).
- **Set-up the agenda for the session.** A world café session can last from 90 minutes to 2.5 hours, depending on the number of rounds of conversation desired. Start with a welcome and introduction (10 minutes). The overall host/facilitator begins with a warm welcome and introduction to the world café session. They set the context, share the café etiquette and put participants at ease ('World Cafe Method', 2015b; jay, 2024). The world café etiquette include: focus on what matters; contribute your thinking; speak your mind and heart; listen to understand; link and connect ideas; listen together for insights and deeper questions. Then, the small group discussions can begin (20 minutes per round). Instruct each table to begin the first round of conversation. Be sure to remind participants of the following: time of the conversation; explain the role of the host; question(s) for the discussion. At the end of the small group discussion, ask the participants (except the host) to move to new tables. Participants at one table should spread out so that ideas spread around the room. The host should remain at the table to share the insights from the first conversation with the new group ('World Cafe Method', 2015b). After the small group discussions, participants are invited to share their insights or results from their conversations with the large group. The results are reflected in a variety of ways, most often using graphic recording (e.g., flipchart or whiteboard) in the front of the room (The World Café Community Foundation, 2015; 'World Cafe Method', 2015).
- **The general host should provide participants with a clear overview of next steps.** For example, you may wish to share how the insights from the sessions will be used within the organisation ('World Cafe Method', 2015b).

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6.4 Focus group

Description

A focus group is a setting in which a small group of people share their thoughts, experiences, and attitudes about a specific product or topic. The setting is interactive, allowing participants to discuss and expand on each other's ideas. The discussions are guided by a moderator with the purpose of extracting the most relevant information from the participants. Focus groups are especially relevant for exploring new ideas and opinions, enriching quantitative findings (e.g., from a survey) and when interaction matters (e.g., when discussions between participants provide additional information) (Krueger, 1988). They tend to be more focused on deeper and more elaborate discussions and the convergence of ideas, compared to a brainstorming or world café. Focus groups are useful to incorporate both in the beginning of the research phase, where topics and ideas are explored and elaborated, as well as the end, where results and progress is evaluated.

Guidelines

- Use a focus group if you are interested in discovering ideas not previously considered and aiming for opinions on a broad scala of stakeholders. Focus group discussions are not suitable for collecting a large dataset that you want to generalise across a population (use surveys to do so) or to dive into anecdotes and personal stories (use interviews instead) (Academic Libraries North, n.d.).
- Determine the different stakeholder groups relevant to the technology implementation and decide on the participant composition. This could determine the direction of the discussion and is influenced by the goals you want to achieve. You could choose a broad-level discussion and invite one representative from each stakeholder group to ensure a wide range of perspectives. Be mindful of potential status differences that could influence the discussion, such as the presence of both managers and workers. Alternatively, you could invite multiple individuals from a specific stakeholder group to delve deeper into particular topics. This approach may provide a more detailed understanding but could limit the breadth of viewpoints. If you choose for a structure in between, remember to include all relevant perspectives without overwhelming the discussion with too many participants from any one group. When gathering opinions, ask the stakeholders whether they think that their opinion is generalisable for the population (or stakeholder group) they represent in the discussion, or whether they think that others might differ in their opinion.
- When conducting a focus group discussion, include 4 to 8 participants in the discussion and ensure that at least two organisers are present. One organiser should lead the discussion, guiding the conversation and ensuring all topics are covered, while the other takes detailed notes and asks follow-up questions to deepen the discussion. Remember to encourage conversation between

participants, instead of between the moderators and participants (Academic Libraries North, n.d.).

- Structure the discussion, starting with an introduction of the participants (possibly in an engaging matter, see the Workshop section for ideas), general information on the discussion and the goals of the session. Thereafter, decide on 1 or 2 topics or open-ended questions that you can answer in the session. Use a preformulated list of questions when doing so. If you select two topics, make sure to schedule a break in between. Do not discuss more than 2 topics during one session, and don't let the session take longer than approximately 2 hours. The optimal duration is 1.5 hour.
- Gather opinions on the topics you want to address. Use rating or ranking scales when doing so. Rating scales are used when you want participants to score various aspects of the product concepts. Use ranking scales to structure the concepts based on preferences. Conduct the evaluations in a controlled environment, such as a laboratory or meeting room, to minimize distractions and ensure focus. Record the sessions using video and audio equipment to capture all responses accurately. Additionally, use questionnaires to collect detailed evaluations from the participants (van Boeijen, Daalhuizen, & Zijlstra, 2020).

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6.5 Neo Socratic dialogue

Description

The Neo-Socratic dialogue (NSD) is a structured conversation between 5 to 12 persons about a complex ethical or philosophical question that draws on the principles of Socrates' questioning and inquiry style (Socratic Dialogue Foundation, n.d.). A facilitator guides the conversation with the objective of letting participants share their life-experiences about the topic, achieve mutual-understanding and lastly consensus. The facilitator is mostly involved in guiding the process of the inquiry and not so much in directly contributing to the content of the conversation. Participants are stimulated to be self-reflective and to discover and share their (hidden) assumptions about the topic and verifying whether these are correct.

The method is particularly useful in reaching mutual understanding and consensus amongst participants about ethical questions where diverse viewpoints may exist.

Guidelines

- Guidelines for turning a regular dialogue into a Neo-Socratic Dialogue (NSD).
- Define the **central question** and make sure it is open-ended. As mentioned in the description, the dialogue must revolve around a philosophical or fundamental question that affects human understanding. The central question should therefore be open-ended (e.g., *what is justice?* or *what does it mean to be free?*) and invite deeper reflection rather than factual answers.
- Shift to **Personal Experience-Based Reasoning**. In NSD, participants use personal experiences to illustrate their viewpoints instead of relying on external authorities, theories, or abstract speculation. Encourage responses that begin with: *"From my experience..."* or *"I have observed that..."*
- Apply **rigorous questioning** (Socratic Method). Make sure participants challenge assumptions by continuously asking clarifying and probing questions such as:

Why do you think that?
Can you provide an example?
Is this always true?
Are there exceptions?

- It is important to avoid rhetorical or leading questions—questions should encourage independent thought.
- Encourage **collective inquiry**. The goal is not debate or argumentation but collaborative truth-seeking. Participants should build on each other's ideas rather than be competing to be "right."
- Establish **dialogue rules.** For a successful dialogue it is important to apply the following rules:
    - Respectful listening: No interruptions, let each participant complete their thoughts.
    - Clarity over agreement: The focus is on understanding, not convincing others.
    - Paraphrasing & summarization: participants should occasionally restate others' ideas to confirm mutual understanding.
- **Guide** the Dialogue **to a conclusion** (but not necessarily a final answer). Unlike casual discussions, NSD aims for a collectively developed insight or a well-reasoned tentative conclusion. However, if no consensus is reached, that's acceptable—the process of questioning is more important than the outcome.
- Document **key insights**. Record key arguments, counterpoints, and conclusions for reflection or future discussions. By implementing these steps, an everyday conversation or debate can be transformed into a Neo-Socratic Dialogue, fostering deeper understanding and mutual intellectual growth.

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6.6 Interview

Description

Interviews are a widely used method for gathering information by asking a participant (i.e., the interviewee) questions. In general, interviews allow for the gathering of more in-depth information compared to, for example, a brainstorming. Depending on the needs, interviews typically last between 30 minutes to two hours. Interviews come in various formats depending on the level of structure and flexibility required. **Structured interviews** follow a fixed set of questions to ensure consistency and reliability. They are best suited for situations where quantitative or comparable data is important. This can be the case in large-scale studies where relatively many participants are questioned. **Unstructured interviews** are more informal. They do not follow a pre-defined list of questions, which allows for a freer conversation that follows the needs identified on the spot. They are more suitable for a deeper conversation on complex issues. **Semi-structured interviews** combine aspects of both types, using a set of guiding questions that are not strictly followed. This allows for flexibility in the order and wording of questions, as well as the inclusion of additional questions based on the conversation. This format is best suited to research where some consistency is needed, but flexibility is required to explore new insights that emerge during the interview.

Due to the self-reflexive nature of interviews, where the verbal and non-verbal communication of the interviewer may considerably impact the outcomes, conducting a good interview requires a few essential skills. For example, active listening is important for understanding, and possibly engaging with, the interviewee. Depending on the topic, empathy can be crucial to build trust. Thorough preparation is sometimes needed for complex or unfamiliar topics. Non-verbal communication, such as eye contact and other body language is crucial for a fluent and comfortable conversation. Lastly, time-management, being able

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to steer the conversation in a certain direction, and notetaking are usually important.

Guidelines

Conducting interviews is an effective method for uncovering the background of a participant's experiences. According to Burgess, interviews are "conversations with a purpose" (2002, p. 84). This approach allows the interviewer to gain in-depth information around a topic.

- **Design an interview guide that outlines key topics and questions to be addressed.** Including some follow-up questions helps to understand participants answers in more depth. Prior to developing your interview questions, it is crucial to clearly define the issue or requirement that will be addressed using the information collected through the interviews. This approach helps maintain a clear focus on the purpose of each question (McNamara, 2024). In a structured interview, a clear list of questions is followed without any diversions. However, when it comes to unstructured or semi-structured interviews, flexibility is key as there is room for the conversation to evolve naturally. In the guide, using clear, simple language is more beneficial than using jargon. Typically, open-ended questions are asked during the interview process.
- **Identify and recruit participants who can provide relevant data for your topic of interest** based on sampling criteria. Qualitative prefers purposive sampling which refers to "a way of setting up a collection of deliberately selected cases, materials or events" (Flick, 2007, p. 27). A sample size of 12 would be reasonable to study "shared perception, belief or behaviour among a relatively homogenous group" (Guest *et al.*, 2006, p. 76).
- **Arrange a convenient time and location for the interview to ensure confidentiality and minimal distractions.** In case it is possible, avoid places where interruptions or background noise could affect the recording quality.
- **Explain the purpose, format and length of the interview.** Make sure that participants understand the research objectives, the nature of the interview and the approximate length of it (usually between 20 minutes – 1.5 hours).

Before starting the interview, ask them if they have any questions and let them know how they can get in touch with you later if they want to.

- **Address ethical considerations** such as requiring ethics approval for the research, preparing informed consent forms that ensure participants' anonymity, confidentiality and voluntary participation. It is important to ensure that participants know their rights and how data will be used and protected. <u>Ask for permission to record the interviews</u>.
- **Create a comfortable environment where participants feel safe to share their experiences.** Starting with easier and less sensitive questions could help participants feel at ease. Approach sensitive or controversial topics carefully by respecting participants views and avoiding confrontations. Participants rights to their perspectives have to be acknowledged. Show genuine interest in understanding their point of view.
- **Ask open-ended questions to encourage participants to** elaborate (e.g. "How did you feel when…?"). Follow-up questions can help explore deeper layers of meaning. Ask one question at a time. Make sure that the key topics that are important for the research are covered but avoid double-barrelled, subjective questions. Aim to remain as neutral as possible and avoid strong emotional reactions to responses.
- **Listen actively, focus on what the participant is saying and avoid planning your next question early or respond too quickly.** Quick paraphrasing or summarise of what they have said helps show that they have been listened to and helps clarify any misunderstandings. Using active listening techniques like eye contact, nodding and verbal cues show the interest and engagement in the conversation. Non-verbal cues such as body language, tone of voice, pauses can also add nuances to the context of the interview. Provide transition between topics (e.g. "Now I would like to move on…")
- **Focus on self-reflections.** Recognizing your own epistemological position and how your background might influence the interpretation of data helps you better prepare for the interviewing phase. Considering questions such as 'Whose voices am I representing?' or 'How might my experiences shape my

understanding?' can help you understand your own stance before starting the interview process.

- **Note down key words, phrases, observations or moments that strike you while recording the interviews.** Capturing nuanced contextual details that could further enhance your understanding is significant.
- **Transcribe the interviews as soon as possible after the interviews.** Pay attention to details such as pauses, laughter, hesitations and other non-verbal cues (such as sighs or tone changes etc). It might be useful to note any immediate insights or questions that arise. Identifying themes or patterns in the data enables comparisons across different interviews (if applicable). Follow up on your reflections regularly when you start the data analysis. Organise your transcript into sections and start coding the data into themes or categories that relate to the research question(s). As part of the analysis, it can be advantageous to revisit the literature and connect the data to existing theories or concepts. Be aware of own biases, interpretations during the data analysis.
- **Reflect on how your perspectives may have influenced the interpretation of data**. As the interviewer and interviewee are linked interactively, the findings are created while the examination and interview process move forward (Guba & Lincoln, 1994, p. 111). Address any issues of power or privilege that may have affected the interview dynamics and how your own experiences may have shaped the conversation.
- When writing up your findings, ensure participant confidentiality and anonymity: **remove any identifying information and details** (i.e. properly anonymise / pseudonymise the data). Being transparent about the research process (e.g. how data was collected, analysed, interpreted) is an important point. If relevant / appropriate, share your findings with participants or feedback for feedback and validation particularly if the data has personal significance to them.

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6.7Observation

Description

Observations involve systematically looking and documenting how people behave, interact, or respond when using tools or performing tasks. It can help in uncovering "real world" needs and challenges that might not become clear when interviewing or surveying them, as these may be hard to notice or articulate. This makes observation useful for acquiring a more thorough understanding of the actual conditions, which can inform product and work-flow improvements. As a tool in itself it may not be sufficient to discover users' internal attitudes, as these may be hidden from the observer. It can, however, be used in concordance with other methods (e.g. interviews, surveys) that allow users to give feedback themselves. As different observers may retrieve different information from the phenomena of interest, it is useful to incorporate a structured approach in which observations are systematically documented. When doing quantitative observational measurements, inter-observer reliability can provide an indication of the reliability of the observations. An extensive documentation of how to conduct observational research can be found in Angrosino (2007).

Guidelines

- **Define the purpose of observation.** Clearly articulate what you aim to learn from the observation. Are you assessing specific tasks, behaviours, or overall workflows? Are you going to score specific actions? A well-defined purpose directs your focus and enhances the relevance of your findings.

- **Select appropriate observation tools.** Depending on the information you want to collect you will need to prepare differently. For e.g. objective data collection you may need a scoring form, where as for a task analysis a notepad may be enough. The most important tools are:
    - Recording checklists: standardized forms, with pre-set questions and responses, for observing specific behaviours or attributes.
    - Observation guides: forms that list behaviours or processes to observe, with space to record open-ended data.
    - Open field notes: narrative records of what observers hear and see; a flexible way to document observations.
    - Decide whether you want to film or take pictures. Most likely you will need permission to do so, from management and from those you are filming. Be aware that the more image material you collect, the more time it will take to sort, view and evaluate.
- **Develop a task checklist / protocol.** The minimum you will need is a checklist of tasks, activities, aspects and environments you intend to monitor. A first guided tour can help define such a checklist (see also point 4). Be aware that the more items you have a checklist or observation list, the more restricted you may feel while observing and seeing things in an order that is different from the list. Sometimes it is better to have few attention points. A much more strict protocol is needed if the observation is to collect objective data. **If possible and applicable, think of using standardised tools,** e.g. digital tools to ensure consistency in data collection. This helps in comparing observations across different settings, should this be required. If there is **more than one observer** and the purpose is to collect objective data, e.g. to score specific behaviour, you will need to train the observers, to make sure that everyone scores the same actions the same way (=inter-observer reliability).
- **Organise the visit.** It is often beneficial to start off with a 'guided tour' to gain first impressions what the shopfloor and working processes look like. This helps estimate how much time you will need for observations. Select the right time and place for the observations otherwise the activities you would like to

observe, may not be present. If you are an external visitor, ask whether it is possible to perform the observations by yourself, to be able to observe undistracted and talk to employees freely. If you need to be accompanied, make sure this is done by a person the workforce trusts.

- **Communicate with employees and inform the purpose of the observation.** If you cannot do this yourself, have someone inform workers about the upcoming visit and the purpose of the observations. Transparency fosters trust and reduces potential anxiety among participants. Additionally, not everyone may have been notified about your visit, so it is important to communicate this again during your visit. Let workers know why and what you are observing.
- **Ensure ethical conduct and let the participant sign an informed consent.** If you are going to use a camera: use an informed consent form. Use material preferably only for study purposes. Save material in a secure manner. Only use material for public purposes after written consent from your company and the workers on the imagery. Reinforce the importance of ethical behaviour, including respecting employee privacy and obtaining necessary consents. Ask permission from those involved if you would like to use identifiable observation material for all information sharing purposes, from social media to scientific papers. Be aware that you might record images a company does not want spreading. This can information about the production process, but also material that hasn't been stored properly. All persons should be either unrecognisable or have given written permission to use their images.
- **Observe objectively and take notice of context.** Focus on actual behaviours and actions without letting personal biases influence your observations. Objective observation yields accurate and reliable data. Take detailed notes, these are invaluable for subsequent analysis and deriving actionable insights. Context is an important driver of behaviours. It is therefore important to evaluate behaviours within the environment and circumstances they occur. Contextual understanding provides deeper insights into observed actions. Asking questions greatly helps in getting to understand context, or simply said:

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why does someone do what they are doing. This can reveal underlying issues that may not be immediately visible. If allowed, take pictures and/or record video.

- **Take your time.** If you an external to the company, it is easy to feel an intruder or a burden while observing, especially when you need to be accompanied. However, it is import that you take your time for the observations. It can be a good idea to sit down, check your checklist and if needed go back to where you might need some more observations.
- **Review and revise procedures.** Regularly assess and update observation methods and checklists to ensure they remain effective and aligned with personal and organisational. Continuous improvement enhances the accuracy and utility of observations.

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Other methods

6.8 Hackathon

Description

Hackathons are events where individuals collaborate in teams to develop innovative solutions, often in software development (Chau & Gerber, 2023). The events typically have a set time-frame of a few days, in which a challenge is posed that is tackled in a competitive manner across multiple teams. They are particularly effective in fostering creativity and prototyping, making them well-suited for situations requiring swift product development or addressing urgent challenges. It can be beneficial to incorporate teams with diverse skillsets, such as domain experts, software developers and user experience specialists. Benefits of hackathons may include networking amongst hosts and participants as well as accelerated innovation and (technical) skill development (Chau & Gerber, 2023). A common pitfall is not realizing potential solutions by not further exploring and improving them after the event. A famous example of a novel and successful product that directly resulted from a hackathon includes GroupMe, a mobile group messaging app (GroupMe, n.d.). The first prototype was created during the TechCrunch Disrupt hackathon in 2010 and within a year it was acquired by Skype (Ante, 2011).

Guidelines

- **Take your time** organising the event. The entire process of organising and performing the hackathon typically takes 30 to 40 days. Some websites even suggest to start organising 6 months before the planned event (HackerEarth, n.d.). Hacker Earth's planning kit divides the full process into the following stages (**Tabel 2**):

Stage	Content	Timing – Hackathon day minus x months

1	Theme and target audience	6 months
2	Format (physical or virtual), timing, date, venue, sponsors, budget, rules, giveaways	4 months
3	Judges, speakers, prizes and promotion	2-3 months
4	Last organisational steps	1 month to 1 week
5	Make sure all is ready to start and kick-off	0
6	Secure follow-up, keep promises	

Tabel 2. Stages of an Hackathon

- **Define clear objectives and themes.** Establish a specific focus or problem statement to guide participants, ensuring projects align with the event's goals. Define "Hackathon" broadly: emphasize that hacking is creative problem-solving, which doesn't necessarily involve technology. A hackathon is any event where people collaborate to address challenges. You may also consider alternative event names. The term "hackathon" might not resonate with everyone. Choose inclusive language that makes all groups feel welcome.
- **Secure appropriate sponsorships.** Engage sponsors to provide financial support, prizes, and resources, enhancing the event's appeal and sustainability. If you are organising an internal hackathon, sponsorship could also be seen as ensuring that colleagues cannot be called away. Make sure employees are free to forget about everyday responsibilities and restrictions and build something innovative.
- **Develop a detailed event schedule.** Plan the hackathon timeline meticulously, including coding sessions (if applicable), workshops, and breaks, to maintain participant energy and focus. The actual hackathon takes 1-3 days, seldom more as participants get drained or may not be able to be available for such a long period.
- **Establish judging criteria and panels.** As a hackathon is aimed at developing something new or solving a problem, it is important to be able to decide whether innovations are worth pursuing after the hackathon. Therefore transparent evaluation metrics should be defined and a panel of judges with

relevant expertise should be assembled to assess projects fairly. You should decide on prizes or opportunities. although the idea is to embed an innovation-driven culture in the organisation, prizes or some form of rewards (reward points, gift vouchers, incubation) always help.

- **Provide technical resources and support.** Ensure reliable internet access, power supplies, and necessary hardware/software, along with on-site technical assistance.
- **Foster positive energy and provide a learning opportunity.** Avoid unhealthy competition and unrealistic expectations. Be welcoming to newcomers: address "imposter syndrome" by guiding first-time participants to projects and ensuring they feel they have something valuable to contribute. Create opportunities for participants to form diverse teams, fostering collaboration among individuals with varied skills. Provide access to mentors and organise skill-building sessions to support participants throughout the event.
- **Plan for participant well-being.** Arrange for meals, rest areas, and wellness activities to maintain health and morale during the hackathon. Avoid unhealthy practices: discourage all-night sessions, excessive caffeine consumption, and competitive pressures. Prioritise participant well-being and sustainable energy levels.
- **Prepare for post-hackathon follow-up.** Plan for project showcases, feedback collection, and continued support to sustain momentum and engagement after the event, while ideas are developed further.

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6.9 Open space

Description

Open Space method is a unique and powerful approach to group facilitation for lager groups that allows participants to address complex issues, common problems and collaborate on meaningful solutions. It has been successfully used for a variety of purposes, ranging from organisational change processes to community development and conflict resolution. It is characterized by a flexible, self-organising structure that promotes active participation, inclusion, engagement, and collaboration (Wirtz, 2024).

Open-space meetings originated as a contrast to conventional conference meetings with a strict and rigid agenda and procedures. Open space meetings are dynamic and self-organising as the participants determine the agenda of the meeting on the spot. There may be one or more central themes of the meeting set a-priori, but it is assumed that the meeting is most fruitful when participants decide on the spot what, how and with whom to discuss it, as the participants are themselves the experts. Evidently, brainstorming might provide a useful method in open-space settings. It is advised to let participants document their findings in some way such that it can be used for later reference. Open-space meetings are likely to be most effective when the issues at hand are complex, which makes determining priorities and an optimal agenda difficult beforehand (similar to “unstructured interviews), and when participants are considered experts on the topic. For more information on open-space meeting, the reader may consult Open Space World (n.d.).

Guidelines

- **Define the central open question.** The central question should be one that engages participants, stimulates strong interest and aligns with broader strategic objectives. The question should be relevant and pressing, motivating participants to engage. Consulting with stakeholders can be beneficial to refine the question and ensure it addresses relevant challenges.

- **Choose a committed facilitator who a strong influence within the organisation to support and promote the Open Space event.** A facilitator needs to be capable of inspiring the group, aligning the theme with the organisation's strategy, and reinforcing the value of the process.
- **Draft a clear invitation that explains the event's goals, the central question and the process.** The emphasis should be on the non-traditional, self-organising nature of the event and on how everyone's participation is valued regardless of hierarchy or background. Encourage participants to start thinking about potential discussion topics in advance.
- **Prepare the space by arranging the physical setup and tools and materials.** Ensure that the environment is flexible, open and comfortable (e.g. arranging chairs in a circle). Ensure that the venue is large enough for breakout areas (Gay, 2011). Visual aids (e.g. whiteboard) and tools for noting down ideas (e.g. post-its, flip charts, digital collaboration tools) can be useful.
- **Engage participants early and clarify expectations.** It is important to ensure that participants feel prepared and know the value of their contribution. Clarify the level of decision-making authority by defining whether the outcomes of open space meetings will influence decision-making or they are exploratory. Communicate this clearly in the invitation to manage expectations (Gay, 2011).
- **Welcome participants** and begin with a speech by the facilitator who emphasises the central question, the organisation's commitment and the importance of the event.
- **As a facilitator, describe the open space process.** Explain the guiding principles (e.g. the self-organising nature of the event) and the Law of Two Feet (i.e. when participants lose interest in a breakout session, share all that they can, it is important to move on) (Owen, 2008).
- **Allow participants to propose topics they would like to discuss.** Each participant writes down their session idea and presents it to the group. In essence, participants create the agenda. Once topics are presented, participants place them on the agenda matrix, selecting time slots and rooms.

The facilitator supports this process, ensuring that all voices are heard, and the agenda reflects diverse interests.

- **Group similar topics if needed and adjust agenda as required.** Allow room for flexibility and spontaneity, accommodate any changes throughout the event. New sessions can emerge based on participants' needs or outcomes from earlier discussions.
- **Make sure session times and locations are visible so people can navigate easily.** It is also possible to assign volunteers to help 'first-timers' understand the format.
- **Facilitate sessions.** Each proposed session is led by the participant who suggested the topic. They are responsible for managing the discussion and ensuring outcomes are documented (e.g by using shared digital documents or physical boards for real-time documentation).
- **Support and maintain energy: ensure that sessions remain dynamic and engaging.** If energy level drops, encourage participants to seek out other sessions. Coffee breaks play an important role in supporting reflection.
- **Wrap-up sessions by summarising key outcomes, decisions and any action points.** Everyone is invited to share their impressions in the final reflection round. Participants should ensure that results are documented for later sharing. Sessions might extend beyond their initial time slot as the event's natural flow should guide the timing rather than the other way around.
- **Process and document results.** After the event, compile the outcomes of each session (i.e. key insights, action items, any follow-up steps). Make the results accessible by sharing them with participants in a concise manner (e.g. via a report, email summary, digital platform)
- **Evaluate the event's success: collect feedback from participants on their experience.** Reflect on whether the event met its objectives, how the central question was addressed and whether the expected level of engagement was achieved.
- **Track progress and continuous communication.** Setting up a task force or working can be useful to monitor the implementation of key actions and

decision points. Keep participants updated and share progress to show that actions decided upon during the open space event is acted upon.

- **Incorporate learnings by assessing the open space method itself.** Assess the advantages, challenges and areas for improvement. Based on them, future open space sessions can be further adjusted.
- **Create a feedback loop by setting up mechanisms to keep participants involved after the event** (e.g. by organising regular check-ins, follow-up meetings). If open space is used regularly, build a culture of ongoing iteration and learning.

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6.10 Participatory strategic planning

Description

Participatory Strategic Planning (PSP) is a method used by groups, teams, or organisations to create long-term plans for their activities. It involves a participatory process where all members, such as management teams or working groups, contribute equally. PSP is a collaborative, stakeholder-driven approach to strategic planning, designed to create more inclusive, effective, and sustainable plans. The strategic aspect includes analysing the current situation, identifying strengths and weaknesses, and planning how to overcome or avoid

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obstacles. The planning results in a clear plan for a chosen period (minimum 1 year, maximum 5 years) and a detailed plan for the first quarter or two. The method ensures that each participant's input is valued equally, often using written inputs like post-its or small cards to facilitate expression, especially for those less comfortable speaking out loud. It's crucial that decision-makers are included in the workshop to authorise the plans (Mulder Training, n.d.). PSP methods are typically structured into multiple phases such as initiation, analysis, and innovation. Throughout these phases, diverse perspectives, knowledge and expertise are applied to develop socially sensitive technological solutions that align with business needs and the practical realities of the workplace, such as organisational structures, workflows and employee engagement. PSP aims to provide the necessary propositions for the design and redesign of plans (Zirufo-Briones, 2023). It adapts an iterative approach to planning that allows stakeholders to adjust and improve strategies as conditions change, helping plans stay responsive to new developments (Hidalgo & Morell, 2019) and ensuring effective operational strategies (Khakee & Grassini, 2015).

Guidelines

- **Use PSP to make a long term planning for work-related activities or a change in direction.** PSP can help to align organisational goals with the priorities of those directly impacted by the changes. Its applications are broad from urban development, environmental planning to organisational management and community development.
- **Encourage participants to discuss their perspectives collaboratively, in a consensus-oriented way rather than top-down** It can be difficult to address power imbalances and institutional resistance and at the same time ensure equitable participation. Ensuring a collaborative environment and addressing power imbalances could counter this. Facilitation tools might be used to reduce inequities, which can increase the diversity of contributions and create more balanced outcomes (Legacy, 2016; Graaf & Dewulf, 2010).
- **Include a broad range of stakeholders, including people who can give authorisation for changes in strategic planning,** such as business leaders and

department heads. The group size can vary between 5 and 50 individuals. Successful PSP initiatives often depend on cross-sector cooperation and on multi-actor decision-making processes which allow different stakeholders to come together and work toward shared goals (Evers *et al.*, 2019). Of importance here is support from political, social and business environment.

- **Reserve one or two days for the workshop, create an agenda and prepare the workshop.** Do advance work, including deciding who gets an invite, gathering feedback early, sharing materials ahead of time, and having an agenda. Take general workshop guidelines into consideration, see the Brainstorming and Workshop section for more information.
- **Within the session, make sure to get aligned on the vision and long-term goals.** Doing so, clarify the company's vision and ensure everyone understands it. Ensure all team members are on the same page and address any concerns. Discuss specific, measurable, achievable, relevant, and time-bound (SMART) long-term goals that support the vision (Walton, 2023).
- **Perform a SWOT analysis,** identify the current state of the organisation and potential threats, and build a roadmap on where you want the organisation or innovation to direct to (Walton, 2023).

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7.1 Appendix C – Extended questions and prompts of Research Protocol (TUB)

Table of contents

1 (Participant) Observation

1.1 Introduction:

An observation protocol is a structured approach to documenting, analyzing, and understanding real-world behaviors, interactions, and environmental contexts without workers' active involvement.. It is a critical method in qualitative and ethnographic research, especially in fields like human-centered technology design, workplace studies, and participatory innovation.

1.2 Purpose:

- Follows consistent standards across researchers
- Captures rich, contextual insights into user or worker experiences
- Aligns with ethical, practical, and scientific principles

1.3 Roles in Participant Observation:

Observers	Stakeholders	Participants
Persona: Researchers from EUR, TUB, CERTH, TNO, UCC	Persona: site managers, supervisors, officers of the pilot	Persona: workers, operators, technicians of the pilot
Responsibility: - Lead observation - Maintain neutrality and avoid interfering - Log observations using templates - May conduct follow-up interviews for clarification	Responsibility: - Enable access and provide institutional permissions - Ensure safety and ethical compliance	Focus to observe: - Their tasks, - Interactions with coworkers - behaviors toward technology

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1.4 Considerations:

- Ethics and Non-Intrusive Observation
  - Obtain ethical approval and informed consent before observations begin
  - Explain the research purpose and ensure transparency
  - Avoid interrupting tasks or influencing behavior
  - Use discreet note-taking tools or digital templates
- Objectivity and Context
  - Record what is seen and heard, avoid assumptions
  - Separate interpretation from observation
  - Note workplace cultures, including: Power dynamics, Gender roles, Language use, Organisational context, Spatial and temporal context
- Privacy and Safety
  - Anonymize personal or sensitive information
  - Follow GDPR for data security
  - Follow site safety regulations and use necessary PPE (Personal Protective Equipment)

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1.5 The 7P Framework

Pillar	Key Focus	Example Questions or Prompts
Purpose	What is the purpose of this observation? What broader research questions are being addressed?	- What behaviors or interactions are we trying to understand? - Why is this relevant to technology design or worker wellbeing?
Problem	What problems are being addressed or revealed through observation?	- Are workers experiencing confusion, frustration, or risks? - Are there gaps in communication or system usability?
Product	What technologies or systems are involved?	- Which tools, machines, or digital systems are being used? - How do workers interact with these technologies?
People	Who are the key participants and stakeholders?	- Who is doing the work, and who is supporting/overseeing it? - How do roles and responsibilities affect the observed behavior?
Process	What activities and workflows are being carried out?	- What are the sequences of actions? - Are there delays, workarounds, or bottlenecks?
Preparation	What needs to be prepared for successful observation?	- Consent forms, observation checklists, PPE, context briefing - Do you need translations or technical background knowledge?
Practical Concerns	When, where, and how will the observation take place?	- Duration of each session, time of day, number of observers - Will it cover multiple locations or only one site?
Pitfalls	What are potential risks and how can they be mitigated?	- Could observation cause discomfort or distraction? - Are there risks of misinterpretation, bias, or data loss?

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1.6 Observation Log Template (example)

Time	7P Pillar	Observation Focus	Location	Observed Event	People Involved	Tools/Tech Used	Notes
08:00	Purpose	Reason behind the task	Assembly line	Worker checking screen before start	Line worker, Supervisor	Dashboard interface	"This helps us know what target we have today."
08:25	Problem	Issues or inefficiencies	Workstation B	Barcode scanner not reading properly	Worker	Barcode scanner	Repeated 3 times; worker hit it lightly and sighed
09:15	Product	Technology interaction	Packing area	Worker used exoskeleton to lift heavy boxes	Worker	Passive exoskeleton	Smooth lift; but worker paused afterward, adjusted straps
10:00	People	Roles, relationships, communication	Conveyor zone	Supervisor explaining changes to shift team	Supervisor, 3 Workers	Voice only	Workers nodded; one asked "Will this affect our quota?"
10:30	Process	Workflows, task execution	Inspection station	Sequential quality check: inspect > tag > upload	Quality checker	Mobile app, checklist form	Process clear; but upload took 15s per item, slowed work
07:45	Preparation	Setup and readiness	Entry gate	Workers collecting PPE and scanning badges	All workers	ID scanner, PPE cabinet	New gloves ran out; some workers waited 5+ minutes
11:00	Practical Concerns	Timing, logistics, routines	Break area	15-minute coffee break observed	All workers	N/A	Observed informal peer talk about last task's issues

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2 (Ethnographic) Interview

2.1 Introduction:

Ethnographic interviews are semi-structured or open-ended conversations that aim to understand participants' lived experiences, practices, and perspectives within their real work environments. They allow researchers to uncover underlying meanings, motivations, and contextual factors often missed by surface-level data. Questions below act as a guideline clustered by aspects, relevance and empathy map/ SWOT factors to ease analysis post interviews. Researchers can apply the questions, but not necessarily have to use them all at once.

Note:
T2.3 – Methods for Worker participation
T2.4 – Explainable AI methods
T2.5 – Privacy preserving models for Worker Feedback
T2.6 – Human-centric Interface
T4.2 – Human Trust and Understanding
T4.3 – Inclusion and critical issues in design and implementation
T4.4 – In-work Learning and Skill development
T5.1 – EU Industrial Competitiveness

2.2 Purpose:

- Gather rich, narrative-based data
- Explore cultural, social, and organizational meanings
- Enable iterative reflection and adaptation of technologies

2.3 Roles in Ethnographic Interview:

Observers	Stakeholders	Participants
Persona: Researchers from EUR, TUB, CERTH, TNO, UCC	Persona: site managers, supervisors, officers of the pilot	Persona: workers, operators, technicians of the pilot
Responsibility: - Prepare and adapt interview guides - Create a safe, open environment - Reflection without leading answers - Analyze emergent themes	Responsibility: - Supervise interview process - Facilitate access, - Help finding the suitable participant - Ensure worker availability	Focus to observe: - Personal and work-related stories - Attitudes toward technology - Coping strategies and adaptations

2.4 Considerations:

- Ethics and Respect
  - Obtain informed consent verbally and/or in writing
  - Respect privacy and boundaries; stop if discomfort arises
  - Ensure voluntary participation and right to withdraw
- Empathy and Listening
  - Prioritize participant voice over researcher assumptions
  - Be patient with silences and unexpected narratives
  - Reflect on researcher positionality
- Privacy and Anonymity
  - Avoid recording sensitive identifiers
  - Store transcripts securely and pseudonymize all quotes
  - Avoid sharing identifiable content with external parties

2.5 Interview questions

2.5.1 Preparation

1. Workers

Aspects	Example of Questions	Relevance	Empathy map / SWOT
Current state	Could you walk us through your daily routines at work?	General	Say
	How do you currently interact with technology in your workplace?	T2.4, T2.5, T2.6	Do / Strength, Weakness
	What are important factors being in concern and affect how you work? (e.g., stress, fatigue, physical strain)	T2.4, T2.5, T2.6	Think
Participatory & Co-design	How would you describe the level of autonomy and decision-making power that workers currently have in their roles?	T2.3	Feel
	What mechanisms are currently in place to support worker involvement in organizational or technological decisions?	T2.3	Think
	How do you currently make decisions or solve problems during your work? What kind of tools or support do you rely on (digital tools, peers, instinct)?	T2.4	Do / Stregth, Weakness
Expected benefits & challenges	What improvements / benefits do you expect (X) to bring to daily work (e.g., tasks, safety, or wellbeing)?	T2.4, T2.5, T2.6	See / Opportunity
	What are specific outcomes (e.g., productivity, skill development) you think should be being prioritized?	T2.4, T2.5, T2.6	Think / Strength
	What are challenges in current technology and what risks do you foresee with integrating new technologies? *(technical, social, ethical)*	T2.4, T2.5, T2.6	Think / Threat

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Opinion on Development of new technology	How do you think about the potential/ new technologies (X)? What excites or worries you about (X)?	T2.4, T2.5, T2.6	Think / Opportunity
	When talking about the possibility of (X), what do others (e.g., supervisors, peers) say about it? *(do they seem supportive, skeptical, or uncertain?)*	T2.4, T2.5, T2.6	Hear
	How do you foresee the concerns about resistance or acceptance among your peers?	T2.4, T2.5, T2.6	See / Weakness
	What kind of explanation would help you understand the interaction with (X)? (e.g., text, visual, examples)	T2.4, T2.5, T2.6	Think / Opportunity
Ideation/ Feedback	How do you usually give feedback at work? Who will you reach and what kind of approaches you are using?	T4.4	Say / Do
	How does the managers/supervisors react to the feedback?	T4.4	Hear
	If you could change one thing about the process or the technology, what would it be?	T4.4	Feel / Opportunity

2. Managers/ Supervisors

Aspects	Example of Questions	Relevance	Empathy map / SWOT
Current state	How do you see the typical user journey in current state? Could you walk us through the process/steps?	T2.3	See / Do
	Can you describe the purpose of the new technologies? What are important factors being in concern and affect workers?	T5.1	Think
	What are important factors being in concern and affect how you and the employees work? (e.g., stress, fatigue, physical strain)	T2.4, T2.5, T2.6	Feel / Weakness

Participatory & Co-design	How do you currently involve workers in the design and implementation of new technologies in your organisation? Could you give specific example?	T2.3	Do / Strength
	How do you usually assess your employees' needs in different stages of new technology implementation? (before/during/after implementation)	T2.3	Do / Strength
	What support, tools or resources would help your organisation facilitate more effective and meaningful worker participation?	T2.3	See / Opportunity
Expected benefits & challenges	What improvements / benefits do you expect (X) to bring to daily work (e.g., tasks, safety, or wellbeing)?	T2.4, T2.5, T2.6	See / Opportunity
	What are specific outcomes (e.g., productivity, skill development) you think should be being prioritized?	T2.4, T2.5, T2.6	Think / Strength
	What are challenges in current technology and what risks do you foresee with integrating new technologies? (technical, social, ethical)	T2.4, T2.5, T2.6	Think / Threat
Opinion on Development of new technology	How do you think about the potential/ new technologies (X)? What excites or worries you about (X)?	T2.4, T2.5, T2.6	Think
	What behavioral patterns or preferences are important to consider?	T2.4, T2.5, T2.6	See
	How do you plan to capture the typical user journey or interaction with the new technology?	T2.4, T2.5, T2.6	Do / Opportunity
	How do you foresee the concerns about resistance or acceptance among workers? between workers vs. managers? What would be your strategies?	T2.4, T2.5, T2.6	Feel / Threat
Ideation/Feedback	How do you gather workers input/feedback prior to technology implementation (e.g. workshops,	T4.4	Do / Strength

	surveys, user testing, feedback sessions etc.)?		
	Who will be involved in the selection/design of new technologies?	T4.4	Say / Opportunity
	If you could change one thing about the process or the technology, what would it be?	T4.4	Feel / Opportunity

2.5.2 Action Research Phase

1. Workers

Aspects	Example of questions	Relevance	Empathy map / SWOT
Introduction	Can you describe your current role and responsibilites within the company?	General	Do
	How do you interact with the new technology? What are changes you experienced so far?	T2.4, T2.5, T2.6	Do / Strengths
Participatory & Co-design	How can you describe the experience of you and your peers in learning new skills according to new technologies?	T4.4	Feel / Opportunities
	Can you describe your involvement in the design and development of the technology? What opportunities have you had to influence the design of the technology?	T2.3	Do / Strengths
	What support/tools/resources that organisation need to prepare to facilitate your participation to new technologies implementation?	T2.3	Opportunities
	How do you think your participation has impacted the final product/technology?	T23	Think / Opportunities
	How do you think gender and other intersecting factors influenced the co-development and implementation of the technology?	T4.3	Think / Strenght, Opportunities

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Interaction with technology	How is your understanding / perception regarding (X) when you are trying to use it?	T4.2	Think
	How do you feel when making decisions or solving problems during your interaction with (X)? How has your daily work changed with the introduction of the (X)?	T4.2	Feel, Do / Strength
	When you and your peers talk about the (X), what are positive and negative things that you can describe?	T4.2	Say / Strength, Weaknes
	What do your supervisors/managers say about your experience with (X)?	T4.2	Hear
	When you and your peers talk about the (X), how do you discuss the fairness and inclusivity of the technology? What aspects that are important?	T4.3	Hear / Think
	How do you describe the element or factors that makes (X) easier/harder to be used?	T4.3	Think / Weakness
	Can you identify any gender-specific challenges or benefits in the technology development process?	T4.3	See / Opportunities, Threat
Usability & Workflow Integration	Can you walk me through how you used the system during your task?	T2.4, T2.5, T2.6	Do
	Were there any moments where it felt difficult or unnatural to interact with the system? Can you describe what was happening?	T2.4, T2.5, T2.6	Feel / Weakness
	How did the system fit into your usual way of working? Has anything disrupted your workflow?	T2.4, T2.5, T2.6	Think / Threat
Trust & Confidence	How does it feel to use (X) during your tasks? How is your confidence and comfort when interacting with the system?	T2.4, T2.5, T2.6	Feel

	Can you share an example of a moment that made you trust the system more—or less?	T2.4, T2.5, T2.6	Say / Feel
	What made you feel confident (or not confident) in relying on the system during your work?	T2.4, T2.5, T2.6	Feel / Strength, Weakness
Interpretability	How did the system communicate back to you? Can you describe how you understood its responses?	T2.4, T2.5, T2.6	Say, Hear / Strength, Weakness
	Were there any moments when you were unsure what the system was doing or what it meant? What did you do in those situations?	T2.4, T2.5, T2.6	Do / Threat
Cognitive & Emotional Load	How did it feel to use voice commands during your tasks—mentally, emotionally, or physically?	T2.4, T2.5, T2.6	Feel / SWOT - mixed
	Were there parts of the interaction that made you feel stressed, tired, or frustrated? Can you describe what was happening?	T2.4, T2.5, T2.6	Feel / Weaknesses, Threat
Expected benefits & challenges	How is your understanding / perception regarding (X) when you are trying to use it?	T4.2	Think, do
	What improvements / benefits do you feel (X) has brought to your empowerment? What are specific outcomes you feel has been improved?	T2.3, T4.2	Feel / Opportunity
	What are new challenges risks do you see with integrating new technologies in the working place?	T2.3, T4.2	Think / Threat
Fairness	In your experience, do you think the design and implementation process has been inclusive of different genders?	T4.3	Think / Strength
	Can you identify any gender-specific challenges or benefits in the technology development process?	T4.3	Think / Opportinity, Weakness

	How do you think gender and other intersecting factors influenced the co-development and implementation of the technology?	T4.3	Think / SWOT – Mixed
Feedback	How do you give feedback during the implementation? Who will you reach and what kind of approaches you are using?	T2.3, T4.4	Say, Do
	How does the managers/supervisors react to the feedback?	T2.3, T4.4	Hear
	If you could change one thing about the process or the technology, what would it be?	T2.3, T4.4	Do / Opportunity
	What would help the system to work better for you?	T2.3, T4.4	Think / Opportunity

2. Managers / Supervisors

Aspects	Example of questions	Relevance	Empathy map / SWOT
Introduction	Can you describe your current role and responsibilites within the company?	General	Say
	How do you interact with the new technology? What are changes you experienced so far?	T2.4, T2.5, T2.6	Do
Participatory & Co-design	What benefits have you observed from involving workers in the technology design and implementation process? (e.g. improved adoption, productivity, job satisfaction?)	T2.3, T4.4	See / Opportunity
	What challenges have you encountered in engaging workers in the technology design and implementation? (e.g., time constraints, lack of interest, communication issues etc.)	T2.3, T4.4	Do / Weakness, Threat

	How do you invove workers during the initial implementation of (X) in your organisation? Could you give specific example?	T2.3	Do
	Have workplace learning practices have been proactively taken into account: Y/N	T4.4	Think / Strength
	Are workplace learning practices planned for: - before the implementation(Y/N), - during the implementation(Y/N), - after the implementation (Y/N)?	T4.4	Think / Opportunity
	Which of following workplace learning practices have been/planned to be implemented: - experiential learning, - social learning, - training/formal learning activities?	T4.4	Do / Opportunity
	How are learning practices have been designed and executed? what the expected transfer of learning will be in terms of AI adoption?	T4.4	Do / Opportunity
Interaction with technology	What are common challenges (i.e. biases or data gaps) in the (X)? How do you address these?	T4.2	Think / Threat
	What are the worker acceptability criteria? in which way is user understanding promoted (e.g. pilot trials, simulations or prototypes)?	T2.4; T2.5; T4.2	Do / Strength
	What criteria do you use to evaluate whether workers are comfortable with a new technology?	T4.2; T2.4	Do / Strength, Weakness
	How to measure the system's decisions are understandable and fair for all types of workers?	T4.3	Do, Think / Strength, Weakness
	Can you share any experiences where disability-specific accommodations were (or were not) made?	T4.3	See / Opportunity
Usability & Workflow Integration	From a managerial perspective, how well does (X) integrate into your team's existing workflow?	T2.4, T2.5, T2.6	See / Strength

	Have you observed disruptions or friction in your team's workflow due to (X)? Can you describe them?	T2.4, T2.5, T2.6	See / Threat
	Were there any training, adaptation, or coordination efforts needed to make (X) work efficiently?	T2.4, T2.5, T2.6	Do / Strength
	How do you evaluate the system's impact on your team's productivity and task performance?	T2.4, T2.5, T2.6	Do / Opportunity
Trust & Confidence	What influences your trust in (X) as a tool that supports your team's work?	T2.4, T2.5, T2.6	Feel / Opportunity
	Can you recall an incident where your trust in the system increased or decreased? What happened?	T2.4, T2.5, T2.6	Say / Threat
	How do you assess your team's level of confidence when using (X)? How do you support them when issues arise?	T2.4, T2.5, T2.6	Do / Opportunity
Interpretability	How do you interpret the system's outputs or decisions when reviewing reports or supporting your team?	T2.4, T2.5, T2.6	Say / Strength, Weakness
	Are there moments where the system's behavior or feedback was unclear to you or your team? How did you respond?	T2.4, T2.5, T2.6	Do / Strength, Weakness
	How do you think regarding the transparency in monitoring and managing work provided by the system?	T2.4, T2.5, T2.6	Think / Strength, Weakness
Cognitive & Emotional Load	Have you noticed any impact—positive or negative—on your team's mental or emotional workload when using (X)?	T2.4, T2.5, T2.6	See / SWOT – Mixed
	In which ways (X) reduces or adds your own managerial load?	T2.4, T2.5, T2.6	Do / Strength, Weakness
	How do you address or mitigate stress, frustration, or fatigue related to the use of (X) in your team?	T2.4, T2.5, T2.6	Do / Opportunity

Expected benefits & challenges	What improvements / benefits do you believe (X) has brought bring to the workers and working empowerment?	T4.2	See / Opportunity
	What are specific outcomes (e.g., productivity, skill development) you think should be being prioritized?	T4.2	Think / Strength
	What are new challenges risks do you see with integrating new technologies in the working place?	T4.2	See / Threat
	What training data or historical patterns of AI system seem to influence its decisions most? What are factors and strategies to improve it?	T2.4	Think / Threat
Fairness	How to measure the system's decisions are understandable and fair for all types of workers?	T4.2	Do / Opportunity
	Can you share any experiences where disability-specific accommodations were (or were not) made?	T4.3	See / Opportunity, Threat
Feedback	How do you gather workers input/feedback during technology implementation (e.g. workshops, surveys, user testing, feedback sessions etc.)?	T2.3, T4.4	Do / Opportunity
	Who are in-charged in the testing and implementation of (X)? How do they react to the feedback?	T2.3, T4.4	Hear
	If you could change one thing about the process or the technology, what would it be?	T2.3, T4.4	Do / Opportunity
	What would help the system to work better for your employees?	T2.3, T4.4	Think / Opportunity

2.5.3 Evaluation Phase

1. **Workers**

Aspects	Example of questions	Relevance	Empathy map / SWOT
Participatory & Co-design	Based on your experience when is the best time/stage that you want to be involved in the technology development process? (e.g. initial design, prototyping, testing, implementation)	T2.3	Do, Think / Opportunity
	What changes or improvements would you like to make in your approach to worker participation in technology design and implementation?	T2.3	Do / Opportunity
	What support/ tools/ resources would help your organisation facilitate more effective development in (X) or new technology?	T2.4, T2.5, T2.6, T42	Say, Think / Strength
Interaction with technology	What are behavioral changes you feel when making decisions or solving problems with (X)?	T4.2	Feel / Strength
	When you and your peers talk about the (X), what are positive and negative things that you can describe?	T4.2	Say, Hear / Strength, Weakness
	What do your supervisors/managers say about your experience with (X)?	T4.2	Hear / Strength, Weakness
Fairness	When you and your peers talk about the (X), how do you discuss the fairness and inclusivity of the technology? What aspects that are important?	T4.3	Hear / Strength, Weakness
	How do you describe the element or factors that makes (X) easier/harder to be used?	T4.3	Think / Strength, Weaknesses
	Can you identify any gender-specific challenges or benefits in the technology development process?	T4.3	See / Threats

Improvements	Since the new version was introduced, how has your experience with the system changed?	T2.4, T2.5, T2.6,	See / Strength
	Can you describe any differences you've noticed—positive or negative—while using it in your daily tasks?	T2.4, T2.5, T2.6,	Say / Strength, Weakness
	Thinking back to problems (i.e. misrecognition or slow responses), how have those issues changed for you?	T2.4, T2.5, T2.6,	Think / Weakness, Opportunity
Usage Behavior	Are there any features or ways of interacting with the system that you now use more often? What made you start using them?	T2.4, T2.5, T2.6,	Do / Opportunities
	Was there anything you avoided before that feels more comfortable now? Can you explain why?	T2.4, T2.5, T2.6,	Do / Weakness, Opportunity
Workflow	How has the system affected the way you do your tasks now compared to before?	T2.4, T2.5, T2.6,	Do / Strength, Opportunity
	Can you describe a time when the new version helped you finish something faster, or maybe slowed you down?	T2.4, T2.5, T2.6,	Say / Strength, Weakness
Trust and Emotional	How has your sense of trust in the system changed over time? Can you share an example of when you felt more or less confident using it?	T2.4, T2.5, T2.6,	Feel / Opportunity, Threat
	How does using the system make you feel emotionally—less stressed, more frustrated, more supported? Has that changed with the new version?	T2.4, T2.5, T2.6,	Feel / Strength
Expected benefits & challenges	How was your overall experience when you are interacting with (X)? How long do you use it until you feel comfortable?	T4.2	Feel / Strength

	What improvements / benefits do you feel (X) has brought to your empowerment? What are specific outcomes you feel has been improved?	T4.2	See / Opportunity
	What are challenges risks you still encounter when interacting with (X) in the working place? Have you noticed any new challenges or issues with the system since the update?	T4.2	Feel, See / Threat
	Is there still any part of the system that doesn't work well for you? Can you describe a time that happened?		See / Weakness
Fairness	In your experience, do you think the design and implementation process has been inclusive of different genders?	T4.3	Think / Opportunity, Threat
	Can you identify any gender-specific challenges or benefits in the technology development process?	T4.3	See / Opportunity, Threat
	How do you think gender and other intersecting factors influenced the co-development and implementation of the technology?	T4.3	Think / Strength, Opportunity
Feedback & recommendation	How do you give feedback during the implementation? Who will you reach and what kind of approaches you are using?	T2.3, T4.4	Say / Opportunity
	How does the managers/supervisors react to the feedback?	T2.3, T4.4	Hear
	Based on your experience, what recommendations would you share to fellow colleagues when developing similar technologies?	T2.3, T4.4	Say / Opportunity
	If you could change one thing about the process or the technology, what would it be?	T2.3, T4.4	Feel / Opportunity

2. Managers / Supervisors

Aspects	Example of questions	Relevance	Empathy map / SWOT
Participatory & Co-design	Based on your experience when is the best time/stage that you involve workers in the technology development process? (e.g. initial design, prototyping, testing, implementation)	T2.3, T4.4	Do, Think / Opportunity
	Based on your experience, what best practices or recommendations would you share with other organisations trying to implement worker participation initiatives?	T2.3, T4.4	Do / Strength
	What changes or improvements would you like to make in your approach to worker participation in technology design and implementation?	T2.3, T4.4	Do / Opportunity
	What support/ tools/ resources would help your organisation facilitate more effective development in (X) or new technology?	T2.4, T2.5, T2.6, T42	Say, Think / Strength
Interaction with technology	What are common challenges in the (X) and in which way can these challenges be effectively addressed?	T4.2	Think, See / Threat
	What are the worker acceptability criteria? in which way is user understanding promoted (e.g. pilot trials, simulations or prototypes)?	T2.4; T2.5; T4.2	See / Opportunity
	What criteria do you use to evaluate whether workers are comfortable with a new technology?	T4.2; T2.4	Do / Strength
Fairness	How to measure the system's decisions are understandable and fair for all types of workers?	T4.3	Do / Opportunity
	Can you share any experiences where disability-specific accommodations were (or were not) made?	T4.3	See / Opportunity, Threat

Improvements	Since the new version of the system was introduced, how has your *team's* experience with it changed from your perspective?	T2.4, T2.5, T2.6,	See / Opportunity
	Have you observed any noticeable improvements or regressions in how the system supports your management tasks?	T2.4, T2.5, T2.6,	See / Strength, Weakness
	Reflecting on past challenges (e.g., misrecognition, delays), how have those issues evolved? Are they now more manageable?	T2.4, T2.5, T2.6,	Say / Strength, Weakness
Usage Behavior	Are there any features or functionalities of the system that you personally rely on more than before? What influenced that change?	T2.4, T2.5, T2.6,	Do / Opportunity
	Have you seen changes in how your team uses the system? What patterns or behaviors stand out to you?	T2.4, T2.5, T2.6,	See / Strength, Opportunity
Workflow	How has the system influenced the way you plan, delegate, or oversee tasks compared to before the latest version?	T2.4, T2.5, T2.6,	Do / Strength
	Can you share a situation where the new version improved workflow efficiency for you or your team? Or, conversely, caused delays?	T2.4, T2.5, T2.6,	See / Opportunity, Threat
Trust and Emotional Response	How has your trust in the system developed over time? Have there been specific events that increased or reduced your confidence?	T2.4, T2.5, T2.6,	Feel / Strength, Opportunity
	On an emotional level, has the system made your role as a manager feel easier or more stressful? How has that changed with the system's updates?	T2.4, T2.5, T2.6,	Feel / Strength, Weakness
	Do you feel more supported or more burdened by the system today compared to when it was first introduced?	T4.2	Feel / Strength, Weakness

Expected benefits & challenges	What improvements / benefits do you believe (X) has brought bring to the workers and working empowerment?	T4.2	See / Opportunity
	What are specific outcomes (e.g., productivity, skill development) you think should be being prioritized?	T4.2	Think / Strength
	What are new challenges risks do you see with integrating new technologies in the working place?	T4.2	See / Threat
	What training data or historical patterns of AI system seem to influence its decisions most? What are factors and strategies to improve it?		See, Think / Opportunity
Fairness	How to measure the system's decisions are understandable and fair for all types of workers?	T2.4	Do / Opportunity
	Can you share any experiences where disability-specific accommodations were (or were not) made?	T4.3	See / Opportunity, Threat
Feedback & recommendation	How do you gather workers input/feedback during technology implementation (e.g. workshops, surveys, user testing, feedback sessions etc.)?	T2.3, T4.4	Do / Opportunity
	Who are in-charged in the testing and implementation of (X)? How do they react to the feedback?	T2.3, T4.4	Hear
	If you could change one thing about the process or the technology, what would it be?	T2.3, T4.4	Do / Opportunity
	Based on your experience, what best practices or recommendations would you share with other organisations when developing similar technologies?	T2.3, T4.4	Think / Opportunity

2.5.4 Interview productivity challenges new technologies (T5.1)

Topic	Interview questions
Objectives of the technology implementation	Which investments are we focusing on? In which phase of the project will they be implemented and finalised?
	Can you describe the purpose of these technologies?
	What are the investments needed for these technologies/changes?
	When is the project successful?
Value added generated	What is the added value that you plan to generate by the technology or work change? What do you define as the 'added value'?
	What does this added value represent for the different actors involved in the change process?
Implementation process, participation, division value added	Which are the main stakeholders in your companies for realising the investment/project?
	How are these stakeholders included in the implementation of the investment/project?
	How is the added value divided among stakeholders? Who are the stakeholders?
	What topics are addressed when negotiating compensation for contributions to solution development (e.g., training, job security, renumeration)?
	What form does the division of added value take (e.g., salary, fringe benefits, shares)?
Industry 5.0	The Seismec-project looks at human-centricity. This is one of the values of Industry 5.0. Industry 5.0 looks at human-centricity, sustainability and resilience.

	How do you perceive these values?
	Have you considered these values in the investment for the Seismec project? How?

3 Participatory Behavioral Assessment

3.1 Introduction:

Participatory behavioral assessments involve collaborative evaluation of tasks or interactions, when using the advanced technology. This method foregrounds the participant's interpretation of their own behavior and perception as well as towards the environment when testing the advanced technology.

3.2 Purpose:

- Empower workers to reflect on their actions
- Identify friction or enablers in real-time processes
- Support inclusive technology evaluation

3.3 Roles in Participatory Behavioral Assessment:

Observers	Stakeholders	Participants
Persona: Researchers from EUR, TUB, CERTH, TNO, UCC	Persona: line managers, supervisors, floor coordinators	Persona: workers, operators, technicians of the pilot
Responsibility: - Facilitate sessions with respect and neutrality	Responsibility: - Ensure timing doesn't disrupt workflows	Focus to observe: - Real-time task executions

- Use prompts and observational tools collaboratively - Document participant reflections	- Allow flexible scheduling for assessments - Find suitable participants	- Ergonomic/physical challenges - Worker feedback on usability or adaptation

3.4 Considerations:

- Inclusion and Agency
  - Co-create the reflection or assessment process
  - Let participants lead the framing of challenges and solutions
  - Avoid imposing external judgments
- Context Sensitivity
  - Adjust to site-specific constraints and task types
  - Use appropriate language and visual aids
- Data Integrity and Ethics
  - Record co-created notes or videos with consent
  - Highlight collaborative findings in reporting
  - Respect participant interpretations

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3.5 Participatory Behavioral Assessment Example

Method	Behavioral Focus	Data Collected	Example Assessment	Implications
Task-Based Usability Testing	Observable interaction patterns (e.g., hesitation, trial-and-error, error correction)	Task completion time, error types, navigation behavior, help requests	"Please complete this task using the system without external help." Observer notes: - How many times did the participant hesitate or stop? - When did the participant ask for help or show signs of confusion? - What types of errors were made (navigation, input, logic)? Objective: Identify usability breakdowns and behavioral patterns during interaction.	Identifies usability breakdowns
Eye-Tracking Studies	Visual attention, fatigue and cognitive effort during interaction	Fixation duration, gaze paths, attention	"Follow this scenario while wearing the eye-tracker; focus naturally."	Reveals attentional load, spatial confusion, and

		heatmaps, re-fixations, blinks	Data collection prompts: - What was the average fixation duration on key UI elements? - Were there areas of visual confusion or excessive re-fixations? - Where did users' eyes go first (gaze path analysis)?	visual prioritization; informs layout, visual hierarchy, and perceptual ergonomics
			Objective: Assess cognitive load, visual hierarchy understanding, and ergonomic design effectiveness.	
Performance Metrics	Task execution behavior (e.g., fluency, speed, consistency)	Success rate, time-on-task, error frequency, steps taken	"Complete the assigned task as efficiently and accurately as possible."	Provides quantitative insight into workload, task complexity, and efficiency; supports evidence-based
			Metrics to log: - Time to complete the task (in seconds/minutes) - Number of steps taken	

			- Success/failure rate - Frequency of errors	iteration of interaction design
			Objective: Measure consistency, fluency, and workload efficiency.	
NASA-TLX (Task Load Index)	Perceived behavioral demands and task strain	Ratings on mental, physical, and temporal demand, effort, frustration	Rate the following dimensions from 1 (Low) to 20 (High): - Mental demand: How mentally demanding was the task? - Physical demand: How physically demanding was the task? - Temporal demand: How hurried or rushed was the task? - Performance: How successful were you in accomplishing the task? - Effort: How hard did you have to work?	Guides cognitive load calibration

			- Frustration: How irritated, stressed, or annoyed were you?	
			Objective: Understand perceived workload and guide design adjustments.	
Wearable Device Logging	Embodied behavioral signals related to stress, fatigue, or attention	Heart rate variability, skin conductance, motion/posture, gesture frequency	Continuously monitor while participant engages in tasks.	Enables affective state detection
			Trigger follow-up questions if abnormal readings are detected: - "You showed increased heart rate variability—how is your stress level at that moment?" - "What were you focusing on when the skin conductance spiked?"	
			Objective: Detect affective states such as stress, fatigue, and attention loss.	

4 Survey

4.1 Introduction:

Survey collects quantifiable data across multiple participants. To profile the respondents, it will be started with T4.3 demographic survey containing questions about their profile including sex, gender, age, ethnicity, race, minority status, disability as well as their socio-economic, education and employment background. However, the demographic questions are not included in this list and will be provided as part of in Transversal analysis work T4.3 Inclusion and critical issues in design and implementation. The list of questions below will only contain the questions related to CAPS factors and technological assessment.

4.2 Purpose:

- Standardize data collection across pilot sites
- Quantify worker perceptions and experiences
- Enable triangulation with qualitative findings

4.3 Roles in Survey:

Observers	Stakeholders	Participants
Persona: Researchers from EUR, TUB, CERTH, TNO, UCC	Persona: line managers, supervisors, floor coordinators	Persona: All related stakeholders in pilot
Responsibility: - Deploy the instruments	Responsibility: - Facilitate dissemination and communication	Focus to measure: - CAPS factors - Transversal analysis

- Ensure clarity and accessibility of questions - Analyze results using statistical tools	- Encourage participation without coercion	

4.4 Considerations:

- Design and Accessibility
  - Use inclusive language and avoid complex vocabulary
  - Translate into native languages when needed
- Ethics and Consent
  - Clarify purpose and voluntary nature of participation
  - Avoid tracking personal identifiers unless explicitly agreed
  - Closely collaborate with the organisation
  - Include informed consent page in digital or paper form
- Data Security and Compliance
  - Store responses securely and comply with GDPR and institutional data policies
  - Aggregate results to avoid identifying individuals

4.5 Survey Questions

Scale:

1 – Strongly Disagree

2 – Disagree

3 – Neither Agree nor Disagree

4 – Agree

5 – Strongly Agree

4.5.1 CAPS Survey

The CAPS survey questions are derived from example questions in Table 6 and Table 7 of Deliverable 1.1 Benchmark of concepts and dimensions of human-centrism. The open questions were transformed into likert-scale questions.

1. **Employee level**

Collaboration					
Item	**1**	**2**	**3**	**4**	**5**
I frequently use digital tools and technologies to collaborate with colleagues.	☐	☐	☐	☐	☐
My company provides training that helps me understand the collaborative potential of new technologies.	☐	☐	☐	☐	☐
I feel confident in using new technologies for team collaboration.	☐	☐	☐	☐	☐
(X) have improved collaboration between human and human in my tasks.	☐	☐	☐	☐	☐
(X) have improved collaboration between human and machine in my tasks.	☐	☐	☐	☐	☐
I feel confident promoting X to collaborate with my colleague	☐	☐	☐	☐	☐

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There is a high degree of collaboration between humans and robot/digital systems in my company	☐	☐	☐	☐	☐

Creativity					
Item	1	2	3	4	5
My manager supports the implementation of employee-generated innovative ideas.	☐	☐	☐	☐	☐
My creativity in the workplace contributes to company performance and productivity.	☐	☐	☐	☐	☐
New technologies stimulate creativity in my role.	☐	☐	☐	☐	☐
I am encouraged to explore new ideas and strategies in my daily work.	☐	☐	☐	☐	☐
My ideas and stratetegies for the workplace are appreciated	☐	☐	☐	☐	☐
Feedback for innovative ideas from employee is scheduled regularly	never ☐	rarely ☐	sometimes ☐	often ☐	always ☐

Autonomy					
Item	1	2	3	4	5
I have the freedom to make decisions about how I perform my work tasks.	☐	☐	☐	☐	☐
I can choose which tools or technologies to use for my tasks.	☐	☐	☐	☐	☐
I am trusted to manage my workflow independently.	☐	☐	☐	☐	☐
I have a high level of autonomy in my interaction with machines and digital systems.	☐	☐	☐	☐	☐
(X) enhances my decision-making at work.	☐	☐	☐	☐	☐
(X) restricts my decision-making at work.	☐	☐	☐	☐	☐

Automation					
Item	1	2	3	4	5
I have the opportunity to choose which tasks in my work are automated.	☐	☐	☐	☐	☐
I am involved in evaluating the impact of automation on my daily tasks.	☐	☐	☐	☐	☐
Automation of daily tasks has a positive impact on my well-being.	☐	☐	☐	☐	☐
Job scheduling affects how automation influences my well-being.	☐	☐	☐	☐	☐
My organization considers human safety and workload when implementing automation.	☐	☐	☐	☐	☐
My organization takes employee trust and behavior into account when automating tasks.	☐	☐	☐	☐	☐

Privacy					
Item	1	2	3	4	5
I am well informed about how my work-related data is collected and used.	☐	☐	☐	☐	☐
I trust the systems used to protect my personal and work-related data.	☐	☐	☐	☐	☐
My company considers privacy risks when integrating new technologies.	☐	☐	☐	☐	☐
My company provides clear explanations about data use and privacy.	☐	☐	☐	☐	☐
I feel empowered to raise concerns about data use or potential misuse.	☐	☐	☐	☐	☐
Occupational risks are taken into consideration in human-centric computing, human-machine	Very little extent	little extent ☐	Moderate ☐	Large extent ☐	Very large extent

interaction and collaboration and integration of AI in human work processes.	☐				☐

Productivity see TAM Perceived Usefulness (Davies, 1989)					
Item	**1**	**2**	**3**	**4**	**5**
Using (X) in my job would enable me to accomplish tasks more quickly	☐	☐	☐	☐	☐
Using (X) would improve my job performance	☐	☐	☐	☐	☐
Using (X) in my job would increase my productivity	☐	☐	☐	☐	☐
Using (X) would enhance my effectiveness on the job	☐	☐	☐	☐	☐
Using (X) would make it easier to do my job	☐	☐	☐	☐	☐
I would find (X) useful in my job	☐	☐	☐	☐	☐

Safety					
Item	**1**	**2**	**3**	**4**	**5**
I feel physically safe in my workplace.	☐	☐	☐	☐	☐
I feel mentally and emotionally safe in my workplace.	☐	☐	☐	☐	☐
I know how to use tools or systems to report safety concerns.	☐	☐	☐	☐	☐
I am encouraged to actively contribute to improving workplace safety.	☐	☐	☐	☐	☐
Safety in my workplace is shaped by research on human factors and human-machine interactions.	☐	☐	☐	☐	☐
I feel physically safe in my workplace.	☐	☐	☐	☐	☐

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Satisfaction Adapted from Minnesota Job Satisfaction Scale (Weiss et al, 1967)					
Item	1	2	3	4	5
I am satisfied with the tools and technologies I use at work.	☐	☐	☐	☐	☐
Integration with (X) enhances chances for advancement on this job	☐	☐	☐	☐	☐
(X) gives the chance to do different things from time to time	☐	☐	☐	☐	☐
(X) gives the chance to try my own methods of doing the job	☐	☐	☐	☐	☐
(X) gives the chance to do something that makes use of my abilities	☐	☐	☐	☐	☐
My job satisfaction is regularly assessed	☐	☐	☐	☐	☐
Feedback on job satisfaction is using structured method	☐	☐	☐	☐	☐
There are available platforms to give feedback on my satisfaction.	☐	☐	☐	☐	☐

2. Organisational level

Collaboration					
Item	1	2	3	4	5
Our company provides variety of tools to support team collaboration.	☐	☐	☐	☐	☐
Employees are consulted before or during the planning phases of the new technologies.	☐	☐	☐	☐	☐
Employee feedback is actively collected during the implementation of new technologies.	☐	☐	☐	☐	☐
Employees are consulted and feedback is collected after the implementation of new technologies.	☐	☐	☐	☐	☐
There are clear procedures for integrating employee feedback into technology-related decisions.	☐	☐	☐	☐	☐

Feedback from staff is meaningfully integrated into X development and deployment.	☐	☐	☐	☐	☐
Incentives or performance metrics are in place to encourage employee collaboration on technology adoption.	☐	☐	☐	☐	☐

Creativity					
Item	1	2	3	4	5
Job descriptions across our teams allow space for creative contributions using digital tools.	☐	☐	☐	☐	☐
Employees are actively encouraged to propose and experiment with innovative solutions involving X.	☐	☐	☐	☐	☐
We provide structured opportunities for employees to co-design new technologies	☐	☐	☐	☐	☐
We promote and value the process of creative problem-solving on new technology from employees	☐	☐	☐	☐	☐
There are recognition or reward systems for employees who take creative initiatives with X.	☐	☐	☐	☐	☐

Autonomy					
Item	1	2	3	4	5
Our company has clear policies that support employee autonomy in using digital technologies.	☐	☐	☐	☐	☐
There are company policies specifically addressing autonomy in the use of AI tools.	☐	☐	☐	☐	☐
The policies are reviewed and updated alongside technological advancements.	☐	☐	☐	☐	☐
The company has systems to monitor the implementation and impact of autonomy-supporting policies.	☐	☐	☐	☐	☐

Employees have the freedom to choose tools and methods that suit their workflow within set boundaries.	☐	☐	☐	☐	☐

Automation					
Item	1	2	3	4	5
A significant portion of tasks and procedures in my organization are fully automated.	☐	☐	☐	☐	☐
My organization uses a mixed model that combines manual and automated processes.	☐	☐	☐	☐	☐
Clear criteria or factors are used to decide which tasks or procedures should be automated.	☐	☐	☐	☐	☐
I understand who is responsible for deciding and implementing automation in my organization.	☐	☐	☐	☐	☐
Human safety, trust, workload, and behavior are taken into account when automating tasks.	☐	☐	☐	☐	☐

Privacy					
Item	1	2	3	4	5
Our organization has well-defined policies to protect employee data in digital workflows.	☐	☐	☐	☐	☐
We promote a workplace culture that respects and upholds digital privacy standards.	☐	☐	☐	☐	☐
A Data Protection Officer oversees compliance and supports data privacy efforts.	☐	☐	☐	☐	☐
Employees know how to report data misuse and are confident these concerns are taken seriously.	☐	☐	☐	☐	☐
Employees are regularly trained or briefed on personal data protection practices.	☐	☐	☐	☐	☐

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Productivity					
Item	1	2	3	4	5
Our company uses clear frameworks to monitor productivity in a fair and consistent way.	☐	☐	☐	☐	☐
Technologies implemented are selected with productivity optimization in mind.	☐	☐	☐	☐	☐
Mechanisms are in place to balance productivity expectations with ethical and well-being concerns.	☐	☐	☐	☐	☐
Productivity-enhancing technologies are rolled out with transparency and employee input.	☐	☐	☐	☐	☐
Digital tools used for productivity monitoring do not compromise trust or morale.	☐	☐	☐	☐	☐

Safety					
Item	1	2	3	4	5
Risk assessments are performed before deploying (X)	☐	☐	☐	☐	☐
All staff are adequately trained on health and safety for using X	☐	☐	☐	☐	☐
Procedures to assess and mitigate risks related to new technologies are clear	☐	☐	☐	☐	☐
Cybersecurity protocols are integrated into our broader safety culture.	☐	☐	☐	☐	☐
Safety protocol for technological change are regularly updated	☐	☐	☐	☐	☐

Satisfaction					
Item	1	2	3	4	5
Job satisfaction metrics are gathered regularly within the company	never ☐	rarely ☐	sometimes ☐	often ☐	always ☐

We use surveys to give feedback regarding job satisfaction	☐	☐	☐	☐	☐
We use conversational input to give feedback regarding job satisfaction	☐	☐	☐	☐	☐
Insights from satisfaction monitoring lead to real changes in policies or practices.	☐	☐	☐	☐	☐
We actively invest in tools and processes aimed at improving employee satisfaction.	☐	☐	☐	☐	☐

3. Industrial Level

Collaboration					
Item	**1**	**2**	**3**	**4**	**5**
Our industry promotes frameworks that support cross-companyal collaboration.	☐	☐	☐	☐	☐
Industry consortiums facilitate structured dialogues to relevant stakeholders (trade unions, NGO, etc) around collaborative technologies.	☐	☐	☐	☐	☐
Our industry initiatives incorporate multi-stakeholder perspectives to improve human-machine collaboration.	☐	☐	☐	☐	☐
Inter-company collaboration is considered a key driver of successful technology integration.	☐	☐	☐	☐	☐
Consultation with external stakeholders during technology transformation process is scheduled regularly	never ☐	rarely ☐	sometimes ☐	often ☐	always ☐

Creativity					
Item	**1**	**2**	**3**	**4**	**5**
Creativity is recognized as a critical component of innovation in our industry.	☐	☐	☐	☐	☐

There are formal industry standards encouraging creative practices within the workforce.	☐	☐	☐	☐	☐
Our sector promotes co-learning opportunities (e.g. cross-company labs, joint R&D, shared training) to foster creativity.	☐	☐	☐	☐	☐
Creative problem-solving is embedded in industrial innovation frameworks.	☐	☐	☐	☐	☐
Industry initiatives encourage employee involvement in developing tech-enabled creative solutions.	☐	☐	☐	☐	☐
Creativity is recognized as a critical component of innovation in our industry.	☐	☐	☐	☐	☐

Autonomy					
Item	**1**	**2**	**3**	**4**	**5**
Automation has improved overall performance and competitiveness in our industry.	☐	☐	☐	☐	☐
There are established metrics for assessing the impact of automation on worker well-being.	☐	☐	☐	☐	☐
Automation are shaped by considerations of economic and ethical outcomes.	☐	☐	☐	☐	☐
Industry leaders are aware of and actively manage the social impact of automation.	☐	☐	☐	☐	☐
The efficiency gains from automation are being reinvested for employees well-being	☐	☐	☐	☐	☐

Automation					
Item	**1**	**2**	**3**	**4**	**5**
Automation has improved overall performance in my industry.	☐	☐	☐	☐	☐
The industry actively assesses how automation affects worker well-being.	☐	☐	☐	☐	☐

Increases in efficiency through automation also lead to improved worker well-being.	☐	☐	☐	☐	☐
The benefits of automation are shared fairly between the organization and its workers.	☐	☐	☐	☐	☐
Automation decisions in my industry consider both productivity and human well-being.	☐	☐	☐	☐	☐

Privacy					
Item	**1**	**2**	**3**	**4**	**5**
Our industry upholds high standard with data protection regulations (e.g. GDPR) to a high standard.	☐	☐	☐	☐	☐
Sector-wide codes of conduct address personal data use and minimize privacy risks.	☐	☐	☐	☐	☐
There are clear protocols across the industry for responding to data breaches or misuse.	☐	☐	☐	☐	☐
The industry promotes transparency in how worker and customer data are used.	☐	☐	☐	☐	☐
Privacy is treated as a collective responsibility at industry level	☐	☐	☐	☐	☐

Productivity					
Item	**1**	**2**	**3**	**4**	**5**
Our industry is actively seeking ways to balance productivity with human-centric values.	☐	☐	☐	☐	☐
Productivity goals are being reframed to include ethical, environmental, and social dimensions.	☐	☐	☐	☐	☐
Sectoral initiatives recognize the role of digital tools in enabling both efficiency and inclusion.	☐	☐	☐	☐	☐
Industry leaders encourage dialogue on the risks of over-optimization.	☐	☐	☐	☐	☐

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Investments in X also include parallel efforts to safeguard employee well-being.	☐	☐	☐	☐	☐

Safety					
Item	1	2	3	4	5
Industry-wide safety standards exist to guide the implementation of new technologies.	☐	☐	☐	☐	☐
Our sector is proactive in adopting and updating cybersecurity frameworks.	☐	☐	☐	☐	☐
Digital safety (physical, mental, and cybersecurity) is treated as integral to workplace safety.	☐	☐	☐	☐	☐
The industry collaborates with regulators and experts to refine safety practices around emerging technologies.	☐	☐	☐	☐	☐
AI safety and ethics are considered strategic priorities at the industry level.	☐	☐	☐	☐	☐
Industry-wide safety standards exist to guide the implementation of new technologies.	☐	☐	☐	☐	☐

Satisfaction Adapted from Minnesota Job Satisfaction Scale (Weiss et al, 1967)					
Item	1	2	3	4	5
Job satisfaction is a recognized and discussed metric at the industry or association level.	☐	☐	☐	☐	☐
The industry has developed guidelines or case studies on improving job satisfaction through technology.	☐	☐	☐	☐	☐
Sector-wide research efforts aim to understand worker needs and preferences in digitally transformed workplaces.	☐	☐	☐	☐	☐

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Digital transformation initiatives across the industry increasingly include a satisfaction or well-being component.	☐	☐	☐	☐	☐
There is growing awareness of the role of AI and digital systems in influencing long-term job satisfaction.	☐	☐	☐	☐	☐

4.5.2 Transversal Analysis Survey

Transversal analysis survey will be covering:

T4.2 – Human Trust and Understanding,

T4.3 – Inclusion and critical issues in design and implementation

T4.4 – In-work Learning and Skill development

1. Trust and Understanding

Human(X)Computer Trust Model (Gulati et al., 2019)					
Item	**1**	**2**	**3**	**4**	**5**
I believe that there could be negative consequences when using (X)	☐	☐	☐	☐	☐
I feel I must be cautious when using (X)	☐	☐	☐	☐	☐
It is risky to interact with (X)	☐	☐	☐	☐	☐
I believe that (X) will act in my best interest	☐	☐	☐	☐	☐
I believe that (X) will do its best to help me if I need help	☐	☐	☐	☐	☐
I believe that (X) is interested in understanding my needs and preferences	☐	☐	☐	☐	☐
I think that (X) is competent and effective in (X)	☐	☐	☐	☐	☐
I think that (X) performs its role as (X) very well	☐	☐	☐	☐	☐
I believe that (X) has all the functionalities I would expect from (X)	☐	☐	☐	☐	☐
If I use (X), I think I would be able to depend on it completely	☐	☐	☐	☐	☐
I can always rely on (X) for (X)	☐	☐	☐	☐	☐
I can trust the information presented to me by (X)	☐	☐	☐	☐	☐

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Trust in Technology (McKnight et al., 2009)					
Item	1	2	3	4	5
My typical approach is to trust new technologies until they prove to me that I shouldn't trust them	☐	☐	☐	☐	☐
I usually trust a technology until it gives me a reason not to trust it	☐	☐	☐	☐	☐
Trust in AI (Choung et al., 2022)					
Item	1	2	3	4	5
Smart technologies care about our wellbeing	☐	☐	☐	☐	☐
Smart technologies are sincerely concerned about addressing the problems of human users	☐	☐	☐	☐	☐
Smart technologies try to be helpful and do not operate out of selfish interest	☐	☐	☐	☐	☐
Smart technologies are truthful in their dealings	☐	☐	☐	☐	☐
Smart technologies keep their commitments and deliver on their promises	☐	☐	☐	☐	☐
Smart technologies are honest and do not abuse the information and advantage they have over their users	☐	☐	☐	☐	☐

2. Understanding

TAM Perceived EoU (Davies, 1989)*					
Item	1	2	3	4	5
Learning to operate (X) would be easy for me	☐	☐	☐	☐	☐
I would find it easy to get (X) to do what I want it to do	☐	☐	☐	☐	☐
My interaction with (X) would be clear and understandable	☐	☐	☐	☐	☐
I would find (X) to be flexible to interact with	☐	☐	☐	☐	☐
It would be easy for me to become skillful at using (X)	☐	☐	☐	☐	☐
I would find (X) easy to use	☐	☐	☐	☐	☐

*) Note: Need small adaptations needed for Action Research Phase and Evaluation Phase

TOAST (Wojton et al., 2020)					
Item	1	2	3	4	5
I understand what the system should do	☐	☐	☐	☐	☐
I understand the limitations of the system	☐	☐	☐	☐	☐
I understand the capabilities of the system	☐	☐	☐	☐	☐
Learning to operate (X) would be easy for me	☐	☐	☐	☐	☐
I would find it easy to get (X) to do what I want it to do	☐	☐	☐	☐	☐
My interaction with (X) would be clear and understandable	☐	☐	☐	☐	☐

3. Fairness

<u>Preparation Phase:</u>

Outcome Fairness (Jiao & Zhao, 2014)					
Item	1	2	3	4	5
I believe the resources my peers and I will need will be provided on a fair basis	☐	☐	☐	☐	☐
The benefit my peers and I will get from the new (X) will be fair and equal	☐	☐	☐	☐	☐
The possible increase in workload due to (X) will be attended to and reimbursed accordingly	☐	☐	☐	☐	☐
The benefits that my peers and I will receive from the (X) will be fair comparing with the efforts we will spend on (X)	☐	☐	☐	☐	☐
The tasks/activities assigned to my peers and I as part of the overall innovation will be fair	☐	☐	☐	☐	☐

<u>Action Research Phase:</u>

Procedural Fairness (Jiao & Zhao, 2014)					
Item	1	2	3	4	5
During the new implementation, the concerns of my peers and me were taken into account on a fair basis	☐	☐	☐	☐	☐
During the new implementation, the procedures established for implementation are fair	☐	☐	☐	☐	☐
During the new implementation, the voice of my peers and me were attended to by the managers on a fair basis	☐	☐	☐	☐	☐

During the implementation, management behaved impartially and fairly towards my peers and me	☐	☐	☐	☐	☐
The procedures of resolving conllicts incurred by the implementation are handled on a fair basis for my peers and me	☐	☐	☐	☐	☐

Evaluation Phase:

Implementation (Jiao & Zhao, 2014)					
Item	1	2	3	4	5
During the implementation, my peers and I had the right to participate in the decision(X)making process	☐	☐	☐	☐	☐
The company authority communicated actively and frequently with my work unit and gave us timely and useful feedback	☐	☐	☐	☐	☐
My work unit received adequate and detailed information about the (X) innovation from the company authority	☐	☐	☐	☐	☐
The process in which the company authority implemented the (X) was open and transparent	☐	☐	☐	☐	☐
During the implementation, the company authority listened to my peers' and my voice carefully	☐	☐	☐	☐	☐

4. Co-design

Worker Co-Design (NWO Intrap, 2018)	
Item	Options
Has your company implemented new technologies in the past two years (you can choose more than one option)	☐ (Implementation of new technology related to products (e.g. product features, smart products, digital add-ons) ☐ Implementation of new technology related to services (e.g. service platforms, AI-driven customer support) ☐ Implementation of new technology in working methods, production processes, or IT systems (e.g. automation, robotics, ERP systems) ☐ Implementation of new technology that changed the work organisation or organisational

	structure (e.g. remote collaboration tools, workflow platforms) ☐ Implementation of new technology that affected the deployment or roles of employees (e.g. digital scheduling tools, algorithmic management) ☐ Implementation of another form of new technology not mentioned above ☐ No new technologies have been implemented in the past two years
To what extent and in what way are operating employees involved in the co-design and implementation of technology	(open ended question)

5. Productivity

TAM Perceived Usefulness (Davies, 1989)					
Item	1	2	3	4	5
Using (X) in my job would enable me to accomplish tasks more quickly	☐	☐	☐	☐	☐
Using (X) would improve my job performance	☐	☐	☐	☐	☐
Using (X) in my job would increase my productivity	☐	☐	☐	☐	☐
Using (X) would enhance my effectiveness on the job	☐	☐	☐	☐	☐
Using (X) would make it easier to do my job	☐	☐	☐	☐	☐
I would find (X) useful in my job	☐	☐	☐	☐	☐

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5 Diary Studies

5.1 Introduction:

Diary studies invite Pilots and researchers to document the interaction between pilots and researchers, the research activities and any task-related communication over time. These entries are structured in a free form and timed format, offering longitudinal insights into lived experiences of research activity.

5.2 Purpose:

- Track changes in experience over time
- Capture subtle or evolving dynamics
- Enable reflections from research pressure

5.3 Roles in Diary Studies:

Observers	Stakeholders	Participants
Persona: Researchers from EUR, TUB, CERTH, TNO, UCC	Persona: All pilots and researchers	Persona: Pilots and related researchers
Responsibilities: - Provide clear templates or prompts - Offer both analog and digital submission options - Analyse temporal patterns	Responsibilities: - Approve timeframe and workload impact - Maintain communication flow	Focus to measure: - Interactions and communication, - Research plan and activities - Strategies, successes, breakdowns - Reflections on technology integration

5.4 Considerations:

- Content Details
    - Keep entries as detailed as possible
    - Provide date when activities happened and mention person in contact
- Clarity and consistency
    - Use open-ended log and provided format
    - Put entries immediately within dedicated period
- Ethics and communication
    - Closely collaborate with the organisation

5.5 Diary Studies Assessment Example

5.5.1 Pilot Diary Log Example

Name of Pilot: MOS

Pilot co-ordinator: TUB

Pilot description: Co-implement AI-driven camera-based technology and wearable device to enhance risk detection, ultimately enabling safety, privacy and worker-empowering technologies through data access, personalisation, and ownership.

Activity log

Date	Activity
23.01.2024	Pilot met with researcher to discuss possible applications of decision support / optimisation in safe and efficient scheduling.
14.10.2024	A meeting with researcher: a) Select the proposed use case scenarios: b) Define contributions from based on previous projects/research. c) Provide an overview of the possibilities for demonstrating the chosen use case(s).

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5.5.2 Pilot Journey Example

Pilot Journey will be done every semester which starts from cycle M12. This contains a log of activities, research, CAPS goals, and Solution Direction strategies that have happened over the past 6 months. Pilot Journey aims to see the development of piloting processes over a period of time.

Dec 2024 - June 2025		
M12-M18 Startup Measurement Moments		
Inputs	**Item**	**Month**
	CAPS factors	M6
	Pilot logbook	M6
	Solution Directions	M12
Activities	**Identify relevant CAPS factors**	
	Safety	
	Privacy	
	Satisfaction (optional)	
	Factor 3 (optional)	
	Factor 4 (optional)	
	Discuss pilot's solution directions	
	Co-creation - Participatory design / co-design (considered)	
	Human – AI interaction (considered)	
	Solution Directions Considered	
	Solution Directions Considered	
	Comments	
	Discuss pilot's technical needs	
	Drop-down menu	
	Explainable AI	
	Select Additional tool(s), if applicable	
	Comments: Why this tool, how implemented in pilot, etc	
	TRL at start	*4*

	TRL at end	*5*	
	Transversal theme baseline measurements		
	Privacy:	Doc request	TRUE
	Trust:	Survey 1	TRUE
	Inclusion:	Doc request	FALSE
	Learning:	TBD	FALSE
	Competitiveness:	Interviews	TRUE
	Competitiveness:	Observations	TRUE
	Competitiveness:	Observations	FALSE
	Competitiveness:	Ethnography	TRUE
Summary	**Outputs**		
	Identify relevant CAPS factors		*Status*
	Technology plan		*Status*
	Data collection plan		*Status*
	Worker participation plan		*Status*
	List all researchers working with pilot		
	TUB, Researcher name(s), T2.2, T2.6, T3.4		
	CERTH, Researcher name(s), T2.5		
	Comments		
	Tasks engaged with in this stage of the pilot		
	TRUE	T2.4 (XAI)	
	TRUE	T2.5 (privacy preserving models)	
	TRUE	T2.6 (HC interfaces)	
	FALSE	T3.1 (work organization)	
	FALSE	T3.2 (skills/training + health/safety)	
	FALSE	T3.3 (enterprise management)	
	FALSE	T3.4 (taks for workers)	
	TRUE	T4.1 (privacy/cybersecurity)	
	TRUE	T4.2 (trust/understanding)	
	FALSE	T4.3 (inclusion)	
	TRUE	T4.4 (in-work learning)	
	FALSE	T5.1 (industrial competitiveness)	
	Additional comments		