Enhancing digital transformation in SMEs with a multi-stakeholder approach

Michael Herzog, Uta Wilkens, Florian Bülow, Saskia Hohagen, Valentin Langholf, Esra Öztürk, Bernd Kuhlenkötter

1. Introduction

Digital transformation is still a tremendous challenge for companies due to the significant changes in processes, workflows, coordination, and cooperation (Legner et al. 2017). Not surprisingly, failures in digital transformation projects are reported frequently (Uchihira 2021). Typical examples are missing technology acceptance or bad integration of technologies into existing work processes (Cascio/Montealegre 2016). To better cope with these challenges, in Germany small and medium sized enterprises (SME) are supported by federal research programs. The aim is that academic knowledge about how to manage digitalization agendas can be transferred to practice. Vice versa research benefits from the observations and experiences gained through case study analysis in SMEs. In this context, it is broadly agreed but at the same time striking that a missing socio-technical systems (STS) perspective is considered as one major reason for failures in digital transformation projects (Hirsch-Kreinsen 2018).

While digitizing describes the process of encoding analogue to digital data and is thus only related to technical aspects, digitalization and digital transformation describe process improvements, process changes and business model innovation (Hess 2016; Legner et al. 2017). The interplay between technological characteristics, individual behaviour, and organizational properties (Strohm/Ulich 1998; Orlikowski 1992) matters for digital transformation. Thus, a STS perspective is state of the art in research. The perspective has always included consequences on social and economic level as well as trade-offs between different targets. Current research extends this balance between different objectives towards issues of sustainability (Lundborg et al. 2020).

Although this is widely approved (Hirsch-Kreinsen 2018), the multiple dimensions of digital change tend to be underestimated when it comes to practice. Maturity models are widespread approaches to support the dialogue and transfer from research to practise as they aim at systemizing academic knowledge for practical application. Some of them neglect the non-technological issues (Aronsson et al. 2021) while others explore a broader view on relevant dimensions (Lichtenthaler 2020, Wilkens et al. 2021a). However, the implementation journeys in practice tend to follow a narrow approach giving primarily emphasis to technological issues. The

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aim of our paper is to find explanations for this shortcoming and to derive propositions how to design a successful socio-technical implementation journey for the digital transformation in SMEs. Our assumption why current implementation is less advanced as it could be is twofold:

I. There are different interpretations of the meaning and implications of STS-theory for practical application in research.

II. The techno-centric approaches are more likely to be adapted in practice as they meet existing widespread interpretations and correspond to already developed ways of implementation and project planning in companies, especially in SMEs.

In order to underline this assumption, we first introduce conceptual baselines of STS-theory (paragraph 2). Afterwards, we take a closer look at different public-founded research projects for supporting the digital transformation in SMEs (paragraph 3) and classify the implementation projects against the theoretical background. The aim is to identify a framework for a holistic STS approach that is more likely to be adapted in practice (paragraph 4). A short summary and outlook will complete the paper.

2. Technological change and organizational transformation from a socio-technical systems perspective

The STS concept first gained prominence in the early 1950s under the impression of World War II (Trist 1981). Since then, theoretical frameworks and research methods have continuously been evolved. We first refer to the historical roots and then give attention to current co-existing interpretations in STS theory and projects. This allows to identify similarities and contradictions in nowadays scientific discourse.

2.1. Historical background of socio-technical systems

The STS perspective has its origin in the 1950s work of the Tavistock Institute in the British coal mining industry (Trist 1981). Concepts were developed against the background of the post-war reconstruction of industry during this period. A core message was that coping with the transformation challenges and reaching higher productivity as an issue of public interest in access to energy resources (the parallel to the current situation in our economy is depressing) requires more than a renewal of the technical infrastructure but needs to face characteristics of the social system and labour conditions. This was the starting point to conceptualize the complementarity between technical and social job characteristics and to include both in job description and analysis while also facing important public concern. It was initial to give more emphasis to working groups and group dynamic, to consider the benefit of autonomy and discretion. Labour was no longer conceptualized as a pure cost factor supposed to be replaced by technology but understood as potential and valuable resource to higher outcome and reliability. In the further development there was a new inquiry in research to treat the social and the technical system as an integrative unit of analysis instead of two separated spheres. Moreover, a whole research program and movement all over Western Europe emerged as a new paradigm (Fischer 1978). This was in hand with a specific set of research methodologies with longitudinal approaches and an extended operationalization of outcome factors, e.g., including indicators for individual well-being (Haring et al. 1984).

The idea of STS was transferred into design processes by socio-technical design principles, that aim at a balanced integration of technological and social aspects (Ghaffarian 2011). These principles were highly acknowledged and further developed especially within the field of information systems but also in engineering science (Ropohl 1978). This led to the academically well-known system development methodology ETHICS (Munford/Weir 1979). Despite its promising principles, STS design failed to proliferate in practice. During the challenging business environments in the 1990s, companies tend to use methods like business process reengineering and lean management, both seeing the human being as a source of failure and taking little consideration of social factors or societal and ecological side-effects of cost-cutting strategies. Consequently, they were not considered anymore as a prerequisite for economic prosperity (Ghaffarian 2011).

It became obvious, that the STS approaches used so far, had focussed too much on a micro level and have thus excluded organisational boundary conditions and contextual factors. The dialogue was not connected to the mentioned management concepts. Grounded in this criticism, a new STS-research stream emerged also during the 1990s (Ghaffarian 2011), that was based strongly on the theory foundations of social sciences. Herein, the social system is not (just) an extension with an additional field of variables but conceptualized as inseparable from the technical system by origin (Orlikowski/Scott 2008).

2.2. Sociomaterial oriented understanding of STS in work science

Work science or ergonomics explores different approaches of STS-theory – some are more related to physical ergonomics, others to cognitive or organizational ergonomics (see Federation of European Ergonomics Societies https://www.ergonomics-fees.eu/node/7). Cognitive ergonomics emphasises the human-technology-interaction (HTI) and considers a set of variables on individual level (e.g. Abdel-Halim 1981; Thüring/Mahlke 2007; Sundar 2020). Sociomateriality is an STS understanding rooted in organizational ergonomics that goes beyond and explores a deeper understanding of the contextual embeddedness. It treats the interplay of organizational properties, technological artefacts, and human behaviour as unit of analysis when facing digital transformation (Orlikowski 1992; Iveroth 2011; Sesay et al. 2017). Technology, people, and organization are not three separable entities, but their entanglement is of key concern. According to this perspective, materiality does not exist separately from its social context and meaning (Orlikowski/Scott 2008) as the technological artefact is a social construction (Orlikowski 1992). This research direction became its further specification in the movement on sociomateriality (Leonardi 2011; Orlikowski 2007). Technical artefacts are not ascribed as objectifiable properties but are intertwined with the social practices in which they are used. Already existing specifications and interpretations lead to path dependencies and thus might cause a narrow scope for digital transformation (Panourgias et al. 2014; Wilkens et al. 2021c) or unfold different meanings to different user groups (Wilkens et al. 2021b).

The sociomaterial perspective in STS research typical leads to a research methodology that refers to real-life phenomena in qualitative case-based field work. Qualitative process analysis is very common leading to a distinctive description how the entanglement of technology, human interpretation and behaviour as well as organizational context factors look like (Orlikowski 1992; Orlikowski 2007; Orlikowski/Scott 2008; Scott/Orlikowski 2013). The explanatory power is to better understand inhibitors of digital change.

Current research elaborating on sociomaterial thinking claims to give more emphasis to the entities themselves – the IT artefact and agency – in order to capture the key characteristics of the entangled system (Weißenfels et al. 2016). This might be especially important if one considers the pervasive nature of new digital technologies such as artificial intelligence (AI) (von Krogh 2018). If technology gains decision making authority (von Krogh 2018) and becomes more and more flexible (Leonardi 2011) this is on the one hand side a strong argument for treating the concept of sociomateriality seriously. But on the other hand, it becomes obvious that there might be new characteristics of the technological entity which somehow challenge how to reflect on the interaction in the sociomaterial system (Scott/Orlikowski 2014) and to better frame new practices.

The critical debate also shows that a sociomaterial perspective often leads to an overemphasis on social aspects and an underemphasis on materiality (Cecez-Kecmanovic et al. 2014). The overall societal discourse is also neglected even though the reflection of trade-offs could adapt such criteria. Despite these critical points, the sociomateriality perspective has gained influence as it counteracts an (unintended) technology-dominated view and offers a consideration of organizational practices which are often underestimated, e.g., in studies interested in HTI.

2.3. Understanding of STS in mechanical engineering science

In mechanical engineering science, there is also a variety of STS understandings, which are related to how the discipline has changed over the past 15 years. Firstly, the need for an STS approach was articulated by Ropohl in 1978 within his influential systems theory of technology (Ropohl 1978). Herein he describes the empirical observation of the “insufficiency of socio-technical practice” that shows itself e.g., in the deterioration of psychosocial work conditions and negative ecological effects. Therefore, he proclaims, that technology cannot be understood without the context of social systems. Furthermore, he elaborates, that this higher (socio-technical) understanding can only be achieved by describing the human-technology system within a model (Liggieri/Müller 2019). Ropohl developed a system-theoretical modelling approach, which is continuously evolved towards today's industrial widespread approach of Systems Engineering (SE) (Bursac 2016). The cybernetic nature of SE is useful for integrating heterogeneous disciplines in the context of mechatronic design tasks but goes along with the abstract description of systems in such a way, that phenomena in both social as well as technical systems are modelled with equal elements, e.g., in-formation processing, control loops and mathematical functions (Liggieri 2019). This comes along with several shortcomings and reductions related to the representation of human and organizational behaviour as well as individual wellbeing and satisfaction, which are brought to light when transferring scientific knowledge from modelling in computational and laboratory settings to organizational practice. At that point of time the prescriptions are combined with taken for granted social practices of companies primarily dedicated to cost savings as an issue of lean management (see e.g. the case study from Dombrowski et al. 2017). This also leads to a reinterpretation of the prescriptions as the basic understanding of the social in modelling and the social in the implementation context differ. Furthermore, the prescriptive nature neglects the subjective perspective of how individuals construct technology for their own (see 2.2). It does not explicitly include societal norms such as ecological sustainability but the approach would be suitable to adapt related variables.

Furthermore, product innovation nowadays is much more multifaceted and associated with smart systems, data-based services as well as new kinds of business models (Spath/Dangelmaier 2016). This leads to an increasing demand to adapt the cybernetic STS understanding mentioned above.

On the one hand, technical systems become increasingly intelligent. The use of advanced information processing and AI not only enables a higher degree auf autonomy and cooperation among technical systems, but furthermore changes the way technology and humans interact. Thus, there is the need to overcome the shortcomings and reductions in the representation of human and organizational behaviour, mentioned above. For this purpose, mechanical engineering science tends to adopt methods and concepts from other disciplines. E.g., approaches such as human-centred design and human factors engineering (HFE) became more present in engineering practice lately, both originating in psychology-oriented work science (Bubb et al. 2016).

On the other hand, the use of AI also amplifies servitization by enabling the exploitation of available data (Thomas et. al 2016). Therefore, the scope of systems design is extended towards integrated services like e.g., predictive maintenance, product-service systems (PSS) and new as-a-service or platform-oriented business models (Matzner et al. 2021). Despite still having the prescriptive design-oriented and modelling driven view on the system (business model), the associated design methodologies of service design, design thinking and business model innovation intensively highlight the user and call for a deep understanding of user needs and their role in the creation of value. Especially the toolset of design thinking ensures, that the subjective view of different stakeholders is included into the design of technologies, e.g., by methods like personas, user stories or empathy mapping (Marcus 2015). Furthermore, when designing business models, engineering science must take organizational contexts into account. Therefore, methods like maturity evaluations and competence models are more likely to be used, originating in information systems science and economic-oriented work science (e.g., Rübel et al. 2018).

2.4. Comparing different understandings of STS

It becomes obvious that there are certain understandings and quite different views of STS (for an overview, see table 1). All directions refer to and elaborate on the initial research from the Tavistock Institute. Even though they do not have a specific focus on SMEs they can be applied independently from firm size. So far, these perspectives rather co-exist instead of learning from each other. The research community referring to sociomateriality benefits from field study analysis and a thoughtful reflection of phenomenon while engineering studies is much more sophisticated in modelling on a large-scale basis. This research serves as a conceptual backbone for system design and defines outcome factors on technical and social level (normative). Nevertheless, latest developments show a more holistic view, going beyond the cybernetic understanding of SE and adopting methods and concepts from other disciplines. This is a promising trend, because a comprehensive view might be important when facing the challenges of using AI in digital transformation as technological and human agency increasingly merge within organizational constraints.

STS perspective and key authors	**Typical research methods**	**Focus of analysis**	**Criticism**
Sociomateriality: The technological artefact can only be understood from the social context and is subjectively constructed (Orlikowski 1992; Orlikowski/Scott 2008; Leonardi 2011)	Field study analysis with emphasis on development processes, primarily qualitative approaches for exploring phenomena and patterns	digital transformation and design tradeoffs on system level	Neglecting the description of entities; pure process description without prescriptive design principles
Cybernetic, design driven perspective: Modelling social systems with mechanical principles respective information processing logic (Ropohl 1978)	Model based problem solving, simulation, experimentation / design of experiments or design science research	SE, HTI, HFE	Computational models of individual and group behaviour de-coupled from practice; organizational properties rather neglected
Customer design science: Focus on the customers perspective various stakeholder. Consideration of organizational and network capabilities (Marcus 2015; Boßlau 2014).	Model based problem solving (e. g. business model canvas), Design Thinking toolset (persona, empath map), empirical testing of solutions with stakeholders	Business Model Engineering	Resource based mapping of business models not considering the transformational processes and limitations of understanding organizational dynamics

Table 1: Overview of the outlined STS perspectives

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3. Analysing STS-understandings within different case studies

Implementation projects facing the digital transformation explore various translations and applications of STS-theory. Maturity models are most likely to support the transfer of academic knowledge to practice and to monitor the overall digitalization process. Differences result from the project involved disciplines and research perspectives but also from already established interpretations in companies. This is what we further illustrate by deeper analysing two research initiatives of digital transformation projects, both with emphasis on SMEs. The first case study is taken from a project on digitalization in agriculture and is primarily driven by work science. The second case study comes from a project on digitalization in mechanical engineering. By comparing these two cases in their strengths and weaknesses we refer to our basic assumptions that are different interpretations of what dimensions of STS-theory matter and that this creates shortcomings with respect to a holistic approach as an overall deficit and inhibitor of successful transformation. Learning from existing approaches and their limitations allows us to derive a proposition for a holistic framework and underline the advantages but also existing challenges while referring to the interdisciplinary digitalization project HUMAINE.

3.1. Case 1: Experimentierfeld Agro-Nordwest

The first case relates to the BMEL-funded project "Experimentierfeld Agro-Nordwest" (funding code 28DE103D18). Within this project there is an example of how researchers analyse technological change from the perspective of sociomateriality (see paragraph 2.2; Leonardi 2011; Orlikowski 2007). The examined use case are agricultural businesses, both SMEs as well as large farms (5 ha up to more than 1000 ha). The maturity model (de Bruin et al. 2005) was developed during the process of analysis and derived from the empirical data gathered from quantitative and qualitative field analysis. The model (see figure 1) monitors (1) the individual skills of the farmers (competencies and mindset of digital transformation), (2) the organizational framework and decision making (coping and dealing with internal and external demands) and (3) the technological potential in terms of the use of digital technologies. Most relevant dimensions are explored from field analysis and not based on prescriptive concepts. The sources of information are interview and questionnaire statements from farmers. Exploratory factor analysis was used to form categories within the dimensions. The analysis shows that farms are good at combining human and technical dimensions but are less good at indenting them with organizational management. The use of digital technologies such as precision farming, for example, not only requires individual skills in professional use, but also new perspectives in organizational decision making.

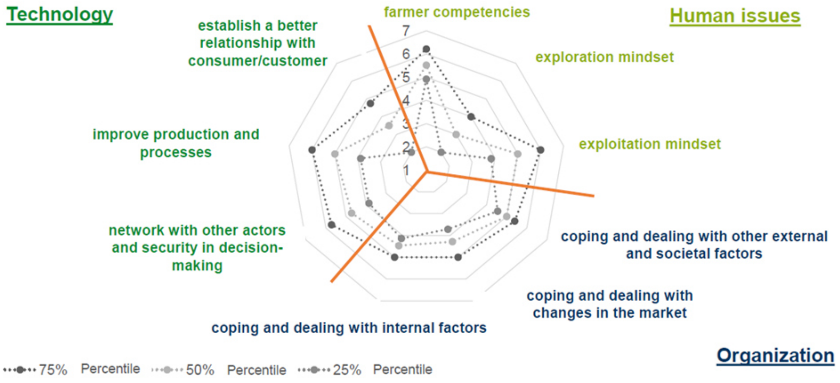
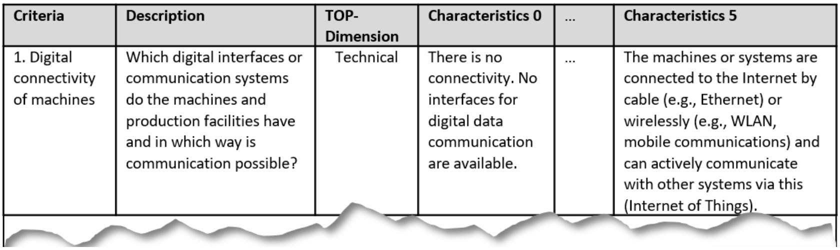


Figure 1: Digital maturity model for agriculture

The case study from the “Experimentierfeld Agro-Nordwest” project features a sociomaterial STS perspective as it explicitly integrates farmers’ subjective interpretation of the meaning of digitalization (see table 1). The demonstrated approach is helpful to explore the challenges in practice from a sociomaterial perspective and to explain shortcomings in digital transformation but it is less likely to change the dominant interpretations and path dependencies in farming firms. This also includes farmers’ interpretation of what sustainability means. Additional interview studies explored that considerably changes could only be observed when the farm is transferred to the next generation (Wilkens 2021c). The model helps to understand the entire system dynamics and why change is not a pre-designed step by step further development.

3.2. Case 2: Digital Coach

The second case originates from the Digital Coach project, which is funded by the European Union in the program "Erasmus plus – Strategic Partnerships" (funding code E10209466). The aim of the project is to understand the needs and to help with the digital transformation of manufacturing SMEs from Southeast Europe. The methodological core of the project is a maturity model, which was developed in a previous research project called ADAPTION. The model can be used to determine and define the actual and target state regarding the implementation of digital technologies in production, so called cyber-physical production systems (CPPS), using predefined classes (Morlock et al. 2017). The focus is always on a defined area, which serves as a pilot project. In total, there are 47 criteria, each has several maturity levels. The criteria are based on the dimensions of technology, organization, and individual competencies and skills as well as their intersections. To give an impression, the following figure shows the structure of the model and an exemplary criterion with the associated characteristics. It is a scientifically deduced framework of relevant categories.



Criteria	Description	TOP-Dimension	Characteristics 0	...	Characteristics 5
1. Digital connectivity of machines	Which digital interfaces or communication systems do the machines and production facilities have and in which way is communication possible?	Technical	There is no connectivity. No interfaces for digital data communication are available.	...	The machines or systems are connected to the Internet by cable (e.g., Ethernet) or wirelessly (e.g., WLAN, mobile communications) and can actively communicate with other systems via this (Internet of Things).

Figure 2: Structure of the ADAPTION maturity model

By analysing the current and target state, the digitalization potential of a company can be assessed. In particular, the strengths and weaknesses of internal company processes are examined to derive operational and strategic success factors against the normative background. The goal of the use of the model is to derive solutions for digital transformation approaches, that are most useful in the company's specific situation. In this context, it should be noted that the evaluation criteria are not to be understood as benchmarks only. The development of a company towards Industrie 4.0 is not to be understood as a revolutionary and eruptive process, but a continuous procedure that is individual for each company (Hübner et al. 2017). Thus, reaching the highest maturity level of a criterion may not be appropriate in every case. Furthermore, it can be reasonable to downgrade a specific criterion based on cost-benefit considerations regarding the function of the overall system. Regarding implementation, alternative solutions are considered. For this purpose, questions such as how to integrate the envisaged solutions into the operational processes (upstream and downstream processes) as well as if these solutions are compatible with the current job profiles, qualifications, and competencies of the employees, are used. The company's expectations, as well as the capabilities and limits of the maturity model, should be discussed in advance. Basic requirements for the application of the model are the acceptance of change processes and the willingness to train employees. The maturity model was developed by mechanical engineers with the support of social scientists, who contributed content aspects such as codetermination and interdepartmental communication in organizations. In accordance with its engineering origins, the model is characterized by abstraction, formalization, and structure. With the different criteria and the tiered logic, it is intended to map implementation projects in a standardized manner. Due to the high degree of abstraction and standardization, it is possible to use the model for different application contexts and initial situations and to make comparisons.

In correspondence with the prescriptive approach of the model the measurement explores the level of development but cannot demonstrate shortcomings that might result from the interdependence of the dimensions, missing prerequisites or various co-existing interpretations and misinterpretations within the companies. The model does not control for the respondents’ meaning and interpretation of the categories.

The case study of the Digital Coach project features a design-oriented STS perspective with normative pre-designed successive stages (table 1). It supports SMEs while defining a clear guideline for concrete and small digitization steps. However, it cannot explain transformation obstacles out of this framework and why it does not prevent from failure.

3.3. Comparative case analysis

To derive indications for the subsequent synthesis, we conduct a comparative analysis of the use cases introduced before. Within this analysis, we compare the consequences of the underlying STS understanding regarding the general methodological approach, the limitations and the transfer within practice. Table 2 summarizes the characteristics of the two use cases.

	Experimentierfeld Agro-Nordwest	**Digital Coach**
Understanding of STS	Sociomaterial view	Cybernetic view
Unit of analysis	Agricultural businesses	Various manufacturing companies from south eastern Europe
Research method	Self-reported data (quantitative and qualitative)	Self-reported data (quantitative)
Contribution to the digital transformation process	Exploration of drivers and inhibitors in practice (agriculture firm). Agile instrument: development while gathering further data. Monitoring and benchmarking along parameter values of the key characteristics for the sector according to the company's firm size. Identification of interdependencies and shortcoming (from a scientific point of view).	Firm-related self-monitoring of maturity level according to parameter values of the pre-defined dimensions with underlying advices for further implementation.
Limitations in practical application	Measured dimensions do not fully meet farmers interpretation and dominant thinking in human-technologies scenarios, potential for organizational change cannot be fully exploited.	Implementation challenges outside the pre-defined monitoring cannot be identified. Interdependencies tend to be neglected.

Table 2: Comparison of STS-based use cases and maturity models

The maturity model in use in the Experimentierfeld AgroNordwest allows to gain deeper sector-specific insight where are the key challenges or shortcomings in successfully coping with digital change, especially the critical factors for technology acceptance and inhibitors of transformation. But the model is less likely to meet the taken-for-granted interpretation of farmers how to manage digital transformation.

The use of the maturity model ADAPTION applied to the project digital coach shows that practitioners tend to relate to scientifically deduced maturity levels and recommendations but reinterpret the relevance of different development fields under cost-benefit considerations leading to a technology-driven work system design. Even if the maturity model also considers organizational input factors (like e.g., abilities of codetermination within companies), these in comparison serve more as boundary conditions than as a concrete design object. This would be the same with overall societal values such as sustainability.

4. Integration of STS perspectives – exemplified with the HUMAINE project

Different STS perspectives and related maturity models explore different strengths and weaknesses, are rooted in unrequested basic assumptions of their underlying disciplines and provide different recommendations for coping with digital transformation challenges.

As there is still a need to overcome transformation obstacles and low technology acceptance – challenges that will further increase when it comes to a broader use of technologies such as AI – it is worth to elaborate on a more integrative STS approach. This is what we will outline in this paragraph.

HUMAINE is an ongoing research project and one of the German competence centres for human-centred work design in the field of AI development and usage. The competence centre is founded by the German Federal Ministry for Education and Research (BMBF) in the program "Future of Value Creation – Research on Production, Services and Work" (funding code 02L19C200). The aim of the project is to make use of the augmentation potential of AI for human-centred work design. The project consortium consists of several academic and industrial partners. On the academic side, the disciplines of work science, work psychology, social science, neuro informatics, cognitive signal processing, service design and production engineering are represented in the interdisciplinary research agenda. The industrial partners are mostly companies from the healthcare sector as well as industrial SMEs (https://humaine.info/).

The methods and tools developed in the project by the scholars from the various disciplines address issues at the interface of AI development and use. Examples include user-centred interfaces for training AI solutions, new standards for workflow descriptions (Thewes et al. 2022) with feedback-loops between AI development and its usage as well as related role development concepts. Further methods aim at improving adaptive and context-sensitive assistance systems, and a model for a human-centred process design including data privacy, trustworthiness, explainability up to personality enhancing job characteristics in AI use fields.

In order to support the digital transformation in adapting AI in work processes of SMEs from manufacturing, health and nursing the research team elaborates on two complementary approaches for enhancing maturity and technology acceptance.

I. The perspective reflecting on the human-centricity in job design (Wilkens et al. 2021a). This is the way to address the transformation challenge from a sociomaterial perspective. It gives especially attention to the users' occupational identity (Wilkens/Langholf 2021).

II. The perspective reflecting on the potential of companies (Bülow et al. 2021) and the identification and definition of maturity levels elaborating on this potential for business model development. This perspective provides access to overall economic rationalities related to AI technology. It gives especially access to the interpretation of actors involved in corporate decision making and project planning.

The approaches are complementary as they both integrate an actor perspective but from different points of view – those who have to work and interact with AI and those who take responsibility for AI decision making and integration in workflows without being individually involved.

The maturity model for human-centred job design (Wilkens et al. 2021a) allows to identify, at an early stage of development, which necessary and sufficient conditions in a concrete AI-enabled workplace are central to guarantee human-centricity in the specific job domain. This determination is made from the perspective of the AI users, focusing on the concrete work process within the actual organizational conditions. Assessments are based on a survey instrument that comprises six dimensions of human-centred design. The result of the analysis is a context-specific configuration of the maturity model that identifies the central aspects of human-centeredness in the work system under consideration. This approach is based on a sociomaterial understanding of an AI introduction as the measurement is related to the enacted reality in the organizational context. This type of diagnosis is a necessary step to approach entangled human and material agency unfolding during the implementation process of AI-enabled systems and to understand why technology is accepted or not.

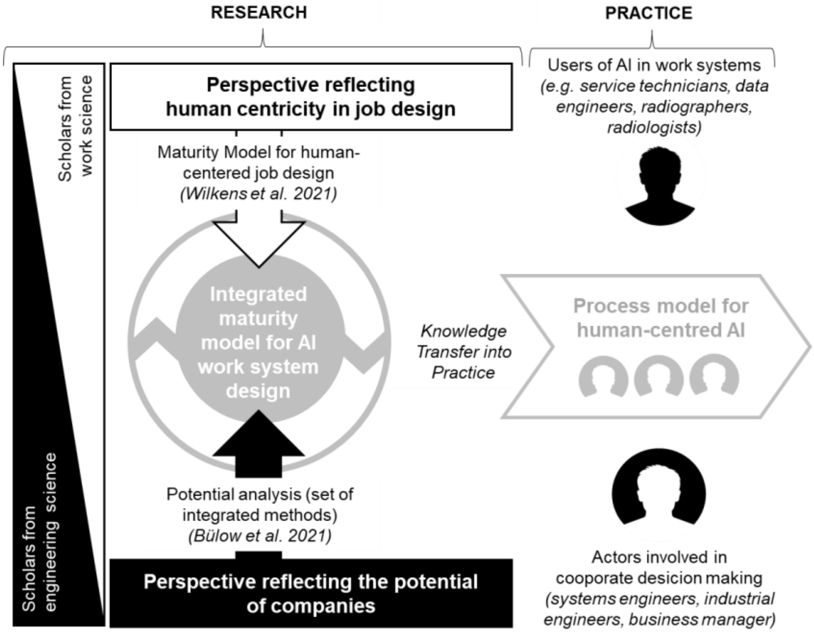


Figure 3: Integrated multi-stakeholder maturity model for AI work system design

With respect to the further development of business models the complementary perspective on STS design that draws more strongly from mechanical engineering science is important in order to reach another group of actors. In this STS approach a potential analysis provides the basis for the outline of a maturity model (Bülow et al. 2021). The development starts with a workshop series to gather enough context-specific understanding to initiate a prescriptive design process. Workshops are carried out with different partners from practice and academia, in which the potentials and challenges related to the use of AI are analysed. Interviews with these actors and their perspective on people, technology, and organization lead to the definition of requirements for the further analysis. A concept for distinguishing levels of digital work systems, which describe aspects such as legal and political constraints, business models, cross-company and work processes, work systems, specific job tasks, and psychological issues related to human-machine interaction (Adolph et al. 2020) serves as further analytical approach.

The selection and use of the different analysis methods is designed in such a way that the dimensions are interconnected across several levels. The method set consists of methods and tools originating from mechanical engineering science, e.g., design thinking methods with focus on business model engineering and lean management methods such as an adaption of value stream mapping focussing on data flows, media discontinuities, and system interfaces. It mirrors the expectation and taken-for-granted practices of project managers taking responsibility for the decision making and the integration of AI in work processes.

This data-oriented technical view on processes is complemented by the task-oriented sociotechnical workflow analysis, which focusses on changes in the human-technology interaction, task shifts, and information flows across organizational units (Bülow et al. 2021).

The two different analysis steps described above will further merge into an innovative multi-stakeholder maturity model that combines different perspectives of STS (see figure 3). This is possible because it is integrated into a process model for human-centred AI and thus combines a more analytical approach to maturity determination with a prescriptive design approach related project management thinking. The holistic STS approach gives a broader picture of how concrete AI systems are interpreted by different actors, enacted at that time of interpretation but can however be aligned for further integration into the overall corporate strategy at external and internal interfaces.

5. Summary and Outlook

Within this paper, the question of why many digitalization projects fail in practice and especially suffer low technology acceptance was approached. The striking point was that even SMEs which have scientific support and may benefit from STS perspective show difficulties in managing digital transformation. We assumed that despite a common theoretical core about socio-technical systems design, different STS perspectives are applied in practice that lead to a variety of interpretation as well as certain limitations. Subsequently, we have outlined typical research perspectives and mirrored on concrete project initiatives why it comes to shortcoming in digital transformation. Elaborating on this step of analysis we demonstrated how different perspectives might be synthesized and integrated into a holistic view with a multi-stakeholder perspective. We proposed an integrated maturity approach for digital transformation projects (for the example of AI-based work systems), bringing together former separated STS-perspectives and by doing so to reflect the digital transformation from different actor perspectives. In the following, it is to be evaluated to what extent this integrated approach now leads to a reduction of the limitations, associated with the earlier projects. Furthermore, interdisciplinary research within the proposed framework is still challenging since there is the problem of translation between the different STS-views and philosophies. So, new methods for a better communication between different disciplines could be of further interest and the project HUMAINE is an appropriate testing ground on a reflexive meta level.

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