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THE PROCESS AUGMENTABILITY CANVAS - HOW TO FIND THE SWEET SPOT FOR AUGMENTED REALITY

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Research Paper

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Abstract

The adoption of augmented reality (AR) has been one of the defining technological trends of the past decade. While AR has experienced significant growth in consumer electronics, its potential for professional use still needs to be explored. Despite the growing interest in AR, determining its feasibility and potential to satisfy business needs remains challenging. To address this gap, we used a mixed-method research approach to create a guiding framework called the process augmentability canvas. Drawing on a comprehensive case study of a major European maintenance, repair, and overhaul service provider, as well as state-of-the literature, we present a canvas that allows scholars and practitioners to evaluate AR's applicability for a given process thoroughly. By providing a structured approach to analyzing AR solutions, the process augmentability canvas contributes to a better understanding of how AR can be used efficiently in organizational settings.

Keywords: Augmented Reality, Canvas, Service Innovation, Service Design.

1 Introduction

Digital technologies have transformed the possibilities available to organizations in improving service provision and operational efficiency. However, assessing the applicability and usefulness of digital technologies in organizational contexts remains challenging. This is particularly true for augmented reality (AR), which has already become a commodity from a customer's perspective. Especially through the use of AR on mobile devices, as demonstrated by popular mobile applications like Pokémon GO (Lintula *et al.*, 2017) and IKEA Place (Ozturkcan, 2021), AR has become popular. In services, AR provides benefits through process support, enabling hands-free working and training possibilities (Klinker, Wiesche and Krcmar, 2019; Placencio-Hidalgo *et al.*, 2022; Bräker *et al.*, 2023). Despite the enormous potential of AR for digitization in industrial settings, its adoption in these areas remains scarce. This scarcity may, in part, be due to a lack of understanding regarding the key challenges and success factors involved in implementing AR technologies (Masood and Egger, 2020). While previous research has explored the challenges and requirements in specific services (Hobert and Schumann, 2017; Prilla, Janßen and Kunzendorff, 2019; Zubizarreta, Aguinaga and Amundarain, 2019; Osterbrink *et al.*, 2021; El-Shamandi Ahmed, Ambika and Belk, 2023), little attention has been paid to identifying services that benefit from AR (Steffen *et al.*, 2019; Bräker and Semmann, 2022). In particular, small and medium-sized enterprises (SMEs) with limited resources and knowledge require more decision-making assistance. As such, guidance is needed to help organizations identify services best suited for piloting and implementing AR. To bridge this gap, we propose a mixed-method approach to answer two research questions:

RQ1: What criteria determine the suitability of AR for services?

RQ2: How can processes be identified that benefit from AR?

To achieve this, we introduce the process augmentability canvas. It is a framework that supports practitioners and scholars in identifying the sweet spot of AR by defining process characteristics and environmental variables that influence the suitability of AR. Our canvas proposes a representation of decisions needed to identify, assess and realize the potential of AR in practice. We build on the wide acceptance and application of such canvas tools as prominently introduced with the business model canvas (Osterwalder and Pigneur, 2010; Antunes and Tate, 2022).

In the following sections, we first introduce related work to lay the foundation regarding AR and the effects of aligning task and technology characteristics. We then describe our research design, which is based on a comprehensive case study at a large European maintenance, repair, and overhaul (MRO) service provider in the aviation sector and a literature review. Afterward, we present the result, the process augmentability canvas. Finally, we discuss the implications of our findings and conclude the paper.

2 Related Work

Augmented reality, blending virtual computer-generated overlays with reality (Milgram and Kishino, 1994), has been extensively studied for decades (Sutherland, 1968). AR has three main characteristics: First, it "combines the real and the virtual" (Azuma, 1997, p. 2), usually by extending or overlaying virtual elements onto reality. Reality and computer-generated virtual objects are perceived simultaneously in this manner. Second, AR is "interactive in real time" (Azuma, 1997, p. 2), enabling real-time interactions with the system. Finally, virtual content is "registered in 3-D" space (Azuma, 1997, p. 2). Virtual objects have a registered location in the real world. They can be controlled through interactions and behave similarly to real objects. AR applications can be implemented using different hardware technologies, such as head-mounted displays (HMDs) or hand-held displays like tablets or smartphones. Spatial AR uses hardware detached from the user's body, like projection-based spatial AR that overlays real objects using projectors (Bimber and Raskar, 2006).

In IS research, various models have been developed to determine whether a technology is suitable for a task. The task-technology fit (TTF) model (Goodhue and Thompson, 1995) and the technology acceptance model (TAM) (Davis, 1985; Davis, Bagozzi and Warshaw, 1989) are examples of such models that aim to explain technology usage. The unified theory of acceptance and use of technology (UTAUT) is an extension of the TAM, which provides more specific factors affecting technology use and their moderators (Venkatesh *et al.*, 2003). Four factors influence the behavioral intention to use a system, and hence the actual user behavior: (1) performance expectancy, meaning that the system supports job performance, (2) effort expectancy, which is accordingly to ease of use of TAM, (3) social influence, and (4) further facilitating conditions. Moderating factors such as gender, age, experience with the technology, and the voluntariness of use also play a significant role. The TTF model has also been applied to determine the feasibility of AR for specific use cases, such as in the architecture, engineering, and construction industries (Shin and Dunston, 2008). Therefore, to ensure high process performance, user acceptance, and adoption, as well as efficient system usage, aligning task and technology characteristics is critical when evaluating the suitability of AR for processes.

When new technology is introduced, it often results in the virtualization of processes. The process virtualization theory (PVT) (Overby, 2008) seeks to examine the virtualizability of processes. Virtualizing a process involves removing physical interaction between the user and other objects or individuals. Virtualizability is measured by the quality of outcome or user acceptance. According to PVT, four key constructs negatively impact process virtualizability. The first aspect, sensory requirements, involves the user's sensory experiences during the process, including human senses such as sight, smell, hearing, touch, and taste. Virtualizing the process reduces the experience's richness, negatively impacting the process virtualizability. The second construct, relationship requirements, refer to the degree of interaction with others. Social interactions with other people lead to knowledge acquisition and personal ties. The need for physical in-person interaction negatively influences the process's virtualization ability. The synchronism requirement refers to quickness and allowed delays in the process. A process with a high demand for synchronicity is less amenable to being virtualized.

Lastly, identification and control requirements refer to the need for unique user identification. If the process requires control through secure user identification, the process is less virtualizable. A thorough analysis of the process is necessary to determine which processes are suitable for AR. A recent study has investigated the extent to which conventional process modeling approaches and tools are suitable for modeling AR processes and concluded that there is still a research gap regarding the applicability of AR in practice (Bräker and Semmann, 2021).

3 Research Design and Methodology

In this research, we adopt a mixed-method approach (Venkatesh, Brown and Bala, 2013; Venkatesh, Brown and Sullivan, 2016) to identify criteria that describe the suitability of AR. Our approach combines quantitative and qualitative data to validate that our findings are relevant for practitioners and researchers. We combine specific knowledge from a use case with generalized knowledge from literature (Greene, Caracelli and Graham, 1989).

Our case study is based on a leading European MRO service provider in the aviation sector with its own logistics service provider. Specifically, we focus on a use case in their logistics warehouse – the inventory process. This process represents one of the typical processes in a warehouse (ten Hompel and Schmidt, 2007). The inventory is performed daily to check the current stock levels. Mobile hand-held scanners record the inventory and transfer the counted quantity to the warehouse management system. Depending on the storage location, employees have to walk further distances within the warehouse or – in the case of smaller materials – can request that all materials are delivered directly to their workstations. Our focus was on the suitability of the inventory process for utilizing AR, the criteria that determine the suitability, and what we can learn from this example to make more general statements about the applicability of AR. Through observations, interviews, a user study, and workshops, we explored how AR can enhance this process and what criteria determine its suitability. Figure 1 illustrates our research design, which consists of five steps.

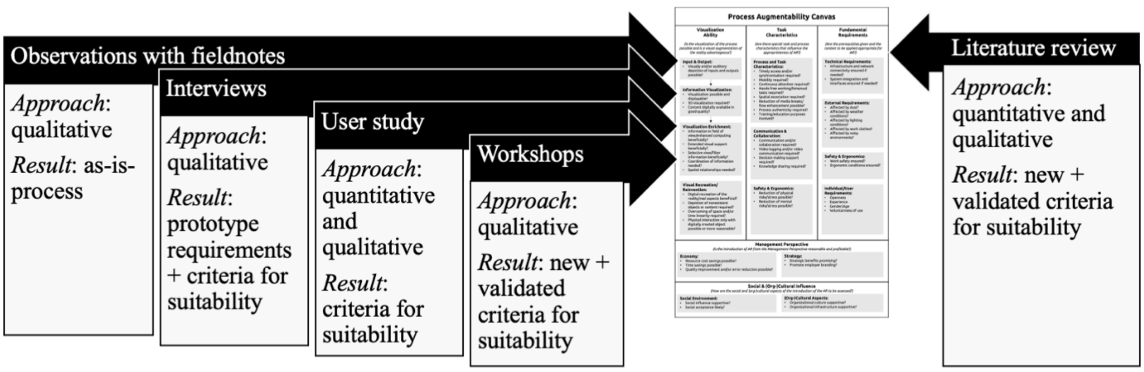

Figure 1. Research design.

3.1 Literature review

We began our research by reviewing the literature to establish an initial theory-driven framework version. In order to draw on fundamental knowledge from previous research, we conducted a structured literature review (Brocke *et al.*, 2009). The primary goal was to identify existing models or frameworks that outline which processes are suitable for AR digitization. We performed a keyword search, which included several high-quality information systems journals, including the "Senior Scholars' Basket of IS Journals". We added the "International Conference on Information Systems" and the "European Conference on Information Systems" as IS conferences. Additionally, we searched through human-computer interaction-focused outlets, including the "AIS Transactions on Human-Computer Interaction", "ACM Transactions on Computer-Human Interaction", and the "CHI Conference on Human Factors in Computing Systems", as AR is a prominent research topic in this field. We did not restrict the time frame and examined all articles related to AR, along with models or frameworks in the title, keywords and abstract. Our search query was: ("augmented reality" OR "virtual reality" OR "mixed reality" OR "smart glass*" OR "data glass*" OR "extended reality" OR "assisted reality") AND ((digitisation OR digitization OR digitalisation OR digitalization OR digitizing) OR (criteria OR model OR concept OR design OR framework OR "design principles" OR process)). We reviewed a total of 270 papers and narrowed it down to ten relevant to our research as they discussed models or frameworks that guide the application and requirements for AR implementation (see table 1). Two independent researchers were involved in the review process. Additionally, we added two papers by Klinker et al. (2018) and Venkatesh et al. (2003), covering a broad range of relevant aspects, to serve as valuable additions to the relevant papers.

	AIS Electronic Library	EBSCO Business Source Complete	ProQuest	ACM Digital Library	ScienceDirect	Sum
Hits	43	34	3	190	0	270
Relevant	8	2	0	0	0	10

Table 1. Literature review.

3.2 Case study

Observations with fieldnotes: Preliminary qualitative research was undertaken to investigate the inventory process at the logistics service provider. This research involved six field observations in four different warehouses and an inventory coordination office, whereby ethnographic fieldnotes were taken (Emerson, Fretz and Shaw, 2001, 2011). Each observation session lasted approximately one hour. We assumed a relatively passive observer role in the environment to avoid any interference with the logistics service provider's employees. The main objective was to observe and document how the actual inventory process is carried out to identify potential areas for improvement. As a result of this initial step, we have documented and analyzed the actual inventory process and gained insights into performance challenges.

Interviews: Ten qualitative interviews were conducted to explore additional insights, collect requirements, and identify relevant criteria when utilizing AR. The interviewees comprised logistics employees from the warehouse and inventory coordination, healthcare management, workers' council, coordinators responsible for communication between the MRO service provider, as well as unit members technically responsible for AR and virtual reality (VR) technologies and logistical applications. The non-standardized interviews were based on guiding questions and lasted approximately 30 minutes each. We documented them with handwritten notes (Rubin and Rubin, 2011). The insights from the interviews provided preliminary requirements for an AR prototype. We identified specific criteria that are critical for the successful implementation of AR in the inventory process.

User study: We developed a prototype for the inventory process using Microsoft Hololens. The prototype facilitates wayfinding in the warehouse, correct materials identification, and inventory stock entry into the warehouse management system. We conducted a user study acquiring qualitative and quantitative data to evaluate the use of AR within a concrete example. The study employs the thinking-aloud method during prototype use (Van Someren, Barnard and Sandberg, 1994; Boren and Ramey, 2000). We additionally used established questionnaires to gain more quantitative data, including the NASA task load index (NASA-TLX), to evaluate subjective workload and stress levels (Hart and Staveland, 1988). The system usability scale (SUS) (Brooke, 1996) and the short version of the user experience questionnaire (UEQ-S) (Schrepp, Hinderks and Thomaschewski, 2017) were used to evaluate usability and user experience. A questionnaire was used to measure technology acceptance using the TAM model (Davis, 1989; Davis, Bagozzi and Warshaw, 1989) and the UTAUT model (Venkatesh *et al.*, 2003). Open questions were included to solicit participants' feasibility estimations and feedback qualitatively. The objective was to gain further insights into the AR application's suitability, identify strengths and weaknesses, and thus determine criteria that influence the suitability of the AR technology. Our study included 33 manufacturer and logistics service provider employees, with a heterogeneous age distribution and male and female participants. The study lasted four days, with each participant spending 15 to 20 minutes on average using the prototype. We instructed the participants to use the AR prototype for the inventory process and communicate their thoughts loudly according to the thinking-aloud approach (Van Someren, Barnard and Sandberg, 1994; Boren and Ramey, 2000).

Workshops: We leveraged the design-thinking approach to conduct two workshops to identify additional practical criteria for implementing AR (Brown, 2008). Seven participants attended the workshops, including employees from the logistics service provider and the manufacturer's IT department. Each workshop was designed to last approximately 1.5 hours. To guide the workshops, we posed two central questions: (1) Which process steps or tasks would most benefit from AR integration? (2) Which existing processes can be digitized using AR technology? The workshop began with a diverging brainstorming phase, during which we aimed to collect all of the appropriate processes and subtasks for utilizing AR. Next, we structured the ideas by clustering them and evaluated them in a converging phase to identify three core ideas. In the following diverging phase, we collected and documented criteria for these core ideas. The documentation was done in the form of a process profile. The participants recorded the technology's requirements, advantages, risks, interrelationships, and support capabilities to develop this process profile. Finally, we re-clustered the criteria and used them as input for the following stages of the study.

3.3 Data analysis and framework development

To develop the framework, we conducted a data analysis combining the literature review findings with our case data. We began by reviewing the literature to establish an initial theory-driven version of the framework. Two independent researchers coded relevant publications by searching for keywords that described the applicability and suitability of AR. This process allowed us to derive 42 criteria from the literature, which we supplemented with data from our case study. We analyzed the data from the case study by coding the empirical material analog to the literature coding. In addition to keywords describing the applicability and suitability, we mainly looked for requirements, challenges and improvement possibilities in the empirical data. Based on this, we developed 24 criteria shaped by practical experience. Of these 24 criteria, 17 confirmed or extended the findings from the literature, while seven entirely new criteria shaped by the practice were discovered. The same two researchers thematically clustered these criteria to create the final framework. After removing duplicates and merging similar criteria, the framework's foundation consists of 49 criteria divided into 15 groups. To make the canvas useful for organizations assessing their processes and making decisions regarding the use of AR, we aimed to build the canvas with a process-oriented approach. We expand the process characteristics to include preconditions for AR and a more abstract view of the management and the social and organizational culture perspective. We conducted a second clustering to summarize the groups further, resulting in five primary categories. The final framework is described in section 4.

4 Result – Guiding Framework to Assess Processes for the Applicability of Augmented Reality

The resulting framework, called process augmentability canvas (see figure 2), provides guidance and decision support for the application of AR in service contexts. The canvas format offers immediate access to all categories, groups, and criteria without imposing a strict order for user exploration. The five main categories of the canvas align with the analysis results. The first category, *(1) visualization ability,* deals with visual representations and requires vision enrichment as a precondition. AR is effective only when information is visualizable, and this ability involves three interdependent sequential phases. These include, at first, the depictability of visual and auditory inputs and outputs. Second, the information needed for the process should be analyzed to determine whether visualization is achievable. The visualization should also enrich the user's experience in the third step.

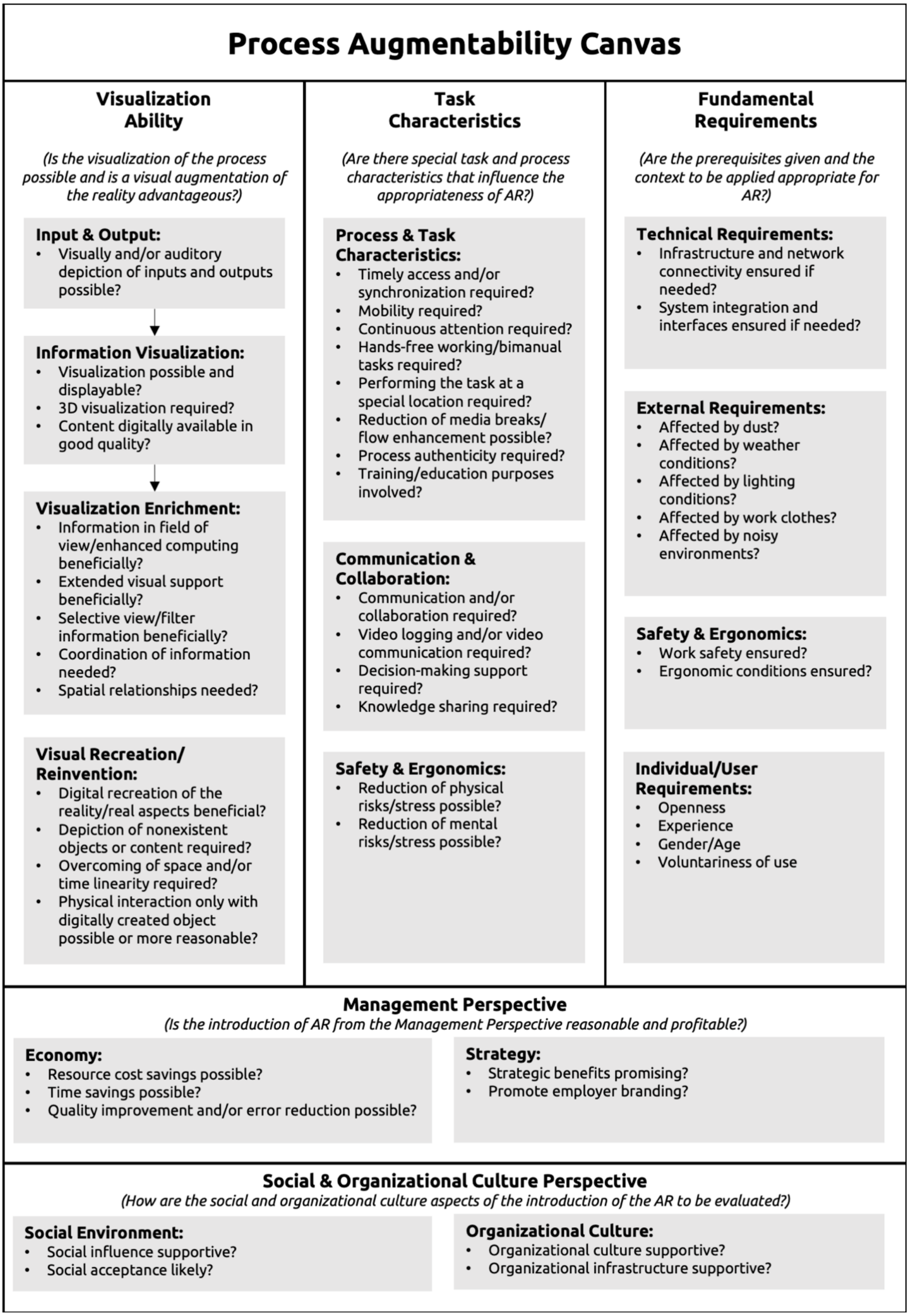

Figure 2. The process augmentability canvas.

The second category, *(2) task characteristics*, represents the outcome of the activities and processes and serves as the canvas's fundamental goal. Therefore, this category occupies the central position of the canvas. Processes meeting one or more of the process and task criteria are well-suited for initial AR application. AR also supports communication and collaboration activities by enabling remote collaboration through AR devices. Moreover, AR can help reduce physical and mental stress. The third category, *(3) fundamental requirements*, refers to technical and environmental aspects and constitutes a precondition for AR use. This category includes technical and external requirements, work safety and ergonomics, and individual and user requirements. We suggest evaluating technical and external requirements and assessing safety and ergonomic benefits if the preconditions are achievable. Finally, we recommend analyzing the user target group to ensure technology acceptance. Two additional perspectives abstracted from a strict process perspective are included at the lower part of the canvas. The *(4) management perspective* provides insights into economic and strategic benefits, such as profitability. In contrast, the *(5) social and organizational culture perspective* encompasses the impact of social environments and organizational culture on AR assessment. Detailed descriptions of the different areas of the canvas and their sources are presented in the following.

4.1 Visualization ability

Visual representations play a significant role in AR applications. In order to augment a process, it must be ensured that the relevant information and data can be visualized and that the visual augmentation of reality provides benefits. Hence, the visual representation of inputs and outputs should be possible (Klinker *et al.*, 2018). Moreover, audio elements such as voice commands can be incorporated to enrich the visual elements. Once it is confirmed that the inputs and outputs of the system or application are represented, the necessary information must be visualized and displayed (Klinker *et al.*, 2018; Kortekamp *et al.*, 2019). If the process requires or benefits from 3D information, AR is a viable option (Yeo, 2017; Kortekamp *et al.*, 2019). High-quality digital content is a prerequisite for visualization (Klinker *et al.*, 2018).

Provided that the first two requirements are met, the visualization should be advantageous and regarded as enrichment, allowing the process to profit from AR. Visual enrichment can be accomplished by enriching the user's field of view with additional (Steffen *et al.*, 2017, 2019) or filtered information (Steffen *et al.*, 2017, 2019; Kortekamp *et al.*, 2019). Additionally, AR is helpful when a process involves coordinating a significant amount of complex information (Oesterreich and Teuteberg, 2017; Steffen *et al.*, 2019) or when visualizing spatial relationships is beneficial (Yeo, 2017; Steffen *et al.*, 2019). AR also permits the visual recreation and reinvention of objects. When real objects are recreated in a virtual environment, they mimic reality (Steffen *et al.*, 2017, 2019), which can serve various purposes, such as cost reduction or risk reduction. If the necessary objects do not exist in the real world, reality must be reinvented (Steffen *et al.*, 2017). In some cases, such as time travel or empowering physically disabled persons, spatial or temporal linearity must be overcome (Steffen *et al.*, 2017, 2019). AR is recommended when the process refers to non-existent elements or when it is simpler to mimic reality. This is also true if the process benefits from interacting with digitally created objects (Steffen *et al.*, 2019). However, a simplistic augmentation of reality can still hold significant value.

Table 2 summarizes the criteria mentioned above and provides a brief overview of their sources. To improve readability, we have included the sources within the description where *I* are interviews, *L* is literature, *O* is field observations, *U* is user study, and *W* is workshops.

4.2 Task characteristics

The task characteristics play a critical role in determining the suitability of AR as an appropriate technology solution (see table 3). While AR can support generic process tasks, certain task characteristics provide enhanced benefits when using AR. For instance, when timely access to information is required, or specific information needs to be synchronized in real-time, AR can be recommended (Yeo, 2017; Klinker *et al.*, 2018).

Group	Criterion	Description
Input & output	Visually and/or auditory depiction of inputs and outputs possible?	Is it possible to visually or auditory depict the inputs and outputs of the process? Possible inputs could be photos, videos, text, or speech commands. Possible outputs could be photos, videos, text, or audio. (*U; W; L* (Klinker *et al.*, 2018))
Information visualization	Visualization possible and displayable?	Is content visualization possible, and can the required information be displayed? (*U; W; L* (Klinker *et al.*, 2018; Kortekamp *et al.*, 2019))
	3D visualization required?	Is the 3D visualization of the information required? (*L* (Yeo, 2017; Kortekamp *et al.*, 2019))
	Content digitally available in good quality?	Is the required content digitally available? Is it available in good quality? (*U; W; L* (Klinker *et al.*, 2018))
Visualization enrichment	Information in field of view/enhanced computing beneficially?	Does the process benefit from representing the information in the user's field of view? (*L* (Kammler *et al.*, 2019; Steffen *et al.*, 2019))
	Extended visual support beneficially?	Does the process benefit from extended visual support, e.g., by enriching additional information? (*L* (Steffen *et al.*, 2017, 2019; Kammler *et al.*, 2019; Kortekamp *et al.*, 2019))
	Selective view/filter information beneficially?	Does the process benefit from a selective view, e.g., in the form of filtered information? (*L* (Steffen *et al.*, 2017, 2019; Kortekamp *et al.*, 2019))
	Coordination of information needed?	Does the process coordinate many or complex information? Does the process benefit from improved structuring and a better overview of this information? (*L* (Oesterreich and Teuteberg, 2017; Steffen *et al.*, 2019))
	Spatial relationships needed?	Does the process benefit from a visualization of spatial relationships and spatial positioning? (*L* (Yeo, 2017; Steffen *et al.*, 2019))
Visual recreation/ reinvention	Digital recreation of the reality/real aspects beneficial?	Does the process benefit from a recreation of existing aspects to mimic reality? (*L* (Steffen *et al.*, 2017, 2019))
	Depiction of nonexistent objects or content required?	Does the process benefit from the possibility of creating aspects that do not exist in reality? (*L* (Steffen *et al.*, 2017))
	Overcoming space and/or time linearity required?	Does the process require going beyond time and space, e.g., traveling back in time or visiting other places? (*L* (Steffen *et al.*, 2017))
	Physical interaction only with digitally created object possible or more reasonable?	Does the process benefit from interacting with digitally created objects? (*L* (Steffen *et al.*, 2019))
	I = interviews, *L* = literature, *O* = observations, *U* = user study, *W* = workshops	

Table 2. Visualization ability.

Mobility is another factor that influences the appropriateness of AR, particularly when users are required to be mobile due to changing or flexible workplaces. AR is also appropriate when continuous user attention is required, such as driving a vehicle or performing bimanual tasks (Klinker *et al.*, 2018; Kammler *et al.*, 2019). The spatial allocation of virtual objects is an important consideration, especially when the process performance is location-based (Yeo, 2017). AR can be highly recommended when virtual objects or information can be arranged spatially or related to a specific location. AR can also be used to reduce media breaks and improve workflow.

Authenticity is another critical factor determining AR's appropriateness for specific processes (Yeo, 2017). AR can be useful when training situations or educational aspects are involved (Kohn and Harborth, 2018; Sommerauer and Müller, 2018; Kortekamp *et al.*, 2019; Steffen *et al.*, 2019). AR can assist communication and collaboration processes (Kortekamp *et al.*, 2019; Steffen *et al.*, 2019; Weigel *et al.*, 2021), particularly in instances such as video logging, video communication, or remote support (Klinker *et al.*, 2018; Kortekamp *et al.*, 2019; Steffen *et al.*, 2019). AR can aid in decision-making processes (Chaturvedi, Dolk and Drnevich, 2011; Oesterreich and Teuteberg, 2017) and knowledge sharing (Chaturvedi, Dolk and Drnevich, 2011; Sommerauer and Müller, 2018; Kortekamp *et al.*, 2019; Weigel *et al.*, 2021), and promote empathy (Steffen *et al.*, 2019) in all of these instances. Additionally, AR can reduce physical, mental, or emotional risks, thus improving safety and ergonomics (Oesterreich and Teuteberg, 2017; Steffen *et al.*, 2017, 2019). This also includes diminishing negative aspects of reality (Steffen *et al.*, 2017, 2019). Therefore, identifying and assessing task characteristics is a critical step in determining the appropriateness of AR in a given context.

Group	**Criterion**	**Description**
Process & task characteristics	Timely access and/or synchronization required?	Is timely access to the information required? Does the information need to be synchronized in real time? (*L* (Yeo, 2017; Klinker *et al.*, 2018))
	Mobility required?	Does the process require the user's mobility? (*U; W; L* (Klinker *et al.*, 2018; Steffen *et al.*, 2019))
	Continuous attention required?	Does the process require the continuous attention of the user? (*L* (Klinker *et al.*, 2018))
	Hands-free working/bimanual tasks required?	Does the process contain bimanual tasks? Does the process benefit from hands-free working? (*U; W; L* (Klinker *et al.*, 2018; Kammler *et al.*, 2019))
	Performing the task at a special location required?	Does the process require performance at a specific location and thus the spatial assignment of the information or the visualized objects? (*L* (Yeo, 2017))
	Reduction of media breaks/flow enhancement possible?	Does the process have many media breaks? (*O; W*)
	Process authenticity required?	How important is the authenticity of the process? To what extent should the process meet the expectations of reality? (*L* (Yeo, 2017))
	Training/education purposes involved?	Does the process involve training or education aspects? (*L* (Kohn and Harborth, 2018; Sommerauer and Müller, 2018; Kortekamp *et al.*, 2019; Steffen *et al.*, 2019))
Communication & collaboration	Communication and/or collaboration required?	Does the process involve communication or collaboration with other people? (*O; W; L* (Kortekamp *et al.*, 2019; Steffen *et al.*, 2019; Weigel *et al.*, 2021))
	Video logging and/or video communication required?	Does the process involve or benefit from video logging or video communication? (*L* (Klinker *et al.*, 2018; Kortekamp *et al.*, 2019; Steffen *et al.*, 2019))
	Decision-making support required?	Do decisions have to be made during the process? Can this decision-making process, e.g., benefit from visualization and coordination of information or supported communication? (*L* (Chaturvedi, Dolk and Drnevich, 2011; Oesterreich and Teuteberg, 2017))
	Knowledge sharing required?	Is knowledge sharing essential for the process, e.g., between different people and departments? (*L* (Chaturvedi, Dolk and Drnevich, 2011; Sommerauer and Müller, 2018; Kortekamp *et al.*, 2019; Weigel *et al.*, 2021))
Safety and ergonomics	Reduction of physical risks/ stress possible?	Is it possible to reduce physical stress or risks? (*U; W; L* (Oesterreich and Teuteberg, 2017; Steffen *et al.*, 2017, 2019))
	Reduction of mental risks/stress possible?	Is it possible to reduce mental and emotional stress or risks? (*U; W; L* (Oesterreich and Teuteberg, 2017; Steffen *et al.*, 2017, 2019))
	I = interviews, *L* = literature, *O* = observations, *U* = user study, *W* = workshops	

Table 3. Task characteristics.

4.3 Fundamental Requirements

The fundamental requirements are critical for the successful implementation of AR in organizations. Such requirements encompass various aspects of the application's context, including technical and external prerequisites, as well as concerns related to safety and ergonomics (see table 4). Individual and user requirements that affect technological acceptance, such as openness, experience, and voluntariness of use, should also be taken into account. In cases where the application requires network connectivity or relies on specific technical infrastructure (Klinker *et al.*, 2018), the required conditions for the use of AR should be thoroughly established. The same applies to interfaces and system integrations.

In addition, external factors that influence the workplace and the environment, such as dust, weather conditions, lighting, work clothing, or noisy surroundings, must be considered (Klinker *et al.*, 2018; Kortekamp *et al.*, 2019). Moreover, compliance with company and legal requirements for work safety and ergonomics should be prioritized (Oesterreich and Teuteberg, 2017).

Specific individual and user requirements that affect technology acceptance and adoption, such as demographic factors like gender and age, should also be considered. For instance, younger people are deemed more likely to use new technologies, and users with greater experience are more likely to embrace the technology, as demonstrated by Venkatesh et al.'s (2003) UTAUT model. Furthermore, voluntary adoption of AR technology is more likely to result in higher levels of acceptance among users. Overall, AR is beneficial if the technical and external requirements, workplace safety and ergonomics guidelines are met, and the potential group appears reasonable.

Group	Criterion	Description
Technical requirements	Infrastructure and network connectivity ensured if needed?	Does the process require network connectivity? Are all requirements fulfilled regarding the infrastructure? (*W; L* (Klinker *et al.*, 2018))
	System integration and interfaces ensured if needed?	If integration with other systems is necessary, can this be achieved? If interfaces are required, can they be implemented? (*W*)
External requirements	Affected by dust?	Is the hardware exposed to dust or similar? If so, can it be eliminated? (*O, U; L* (Klinker *et al.*, 2018))
	Affected by weather conditions?	Is the hardware exposed to weather conditions? Can these be controlled to ensure the hardware is not damaged? (*I; O; U*)
	Affected by lighting conditions?	Can the lighting conditions be adapted to the hardware requirements? (*O; U; W*)
	Affected by work clothes?	Do users have to wear work clothes? If so, is it ensured that the work clothing does not affect their use? (*O; U*)
	Affected by noisy environments?	Does the process occur in a noisy environment, so the process benefits from visually displaying the information? (*L* (Kortekamp *et al.*, 2019))
Safety & ergonomics	Work safety ensured?	Can work safety be ensured according to business and legal requirements? (*I; O; L* (Oesterreich and Teuteberg, 2017))
	Ergonomic conditions ensured?	Can ergonomic use be ensured depending on the business and legal requirements? (*I*)
Individual/ user requirements	Openness	Are potential users open to new technologies? (U)
	Experience	Are the potential users experienced using new technologies in general or AR in particular? (*U; L* (Venkatesh *et al.*, 2003))
	Gender/age	Can potential users be assigned to specific gender/age groups? (*L* (Venkatesh *et al.*, 2003))
	Voluntariness of use	Do the potential users feel that the use of AR is voluntary? (*L* (Venkatesh *et al.*, 2003))
	I = interviews, *L* = literature, *O* = observations, *U* = user study, *W* = workshops	

Table 4. Fundamental requirements.

4.4 Management Perspective

From a managerial standpoint, the application of AR must be evaluated based on economic efficiency and strategic benefits (see table 5). The decision to adopt AR should be made when it is possible to save on resource costs (Oesterreich and Teuteberg, 2017; Steffen *et al.*, 2017, 2019) or when time savings are expected (Oesterreich and Teuteberg, 2017; Kohn and Harborth, 2018; Kammler *et al.*, 2019). Both short-term and long-term economic gains should be considered. Another facet of economic efficiency is quality improvement and error rate reduction (Oesterreich and Teuteberg, 2017; Kohn and Harborth, 2018). It is also essential to consider the strategic benefits of AR through digitization (Oesterreich and Teuteberg, 2017), which may positively impact employer branding (Dabirian, Paschen and Kietzmann, 2019). Therefore, AR is recommended if economic benefits can be realized and strategic benefits, such as increased employer branding, are anticipated.

Group	Criterion	Description
Economy	Resource cost savings possible?	Is digitizing the process possible to save resources (and therefore costs) in the long or short term? (*I; W; L* (Oesterreich and Teuteberg, 2017; Steffen *et al.*, 2017, 2019))
	Time savings possible?	Is digitizing the process possible to save time (and therefore costs) in the short or long term? (*U; W; L* (Oesterreich and Teuteberg, 2017; Kohn and Harborth, 2018; Kammler *et al.*, 2019))
	Quality improvement and/or error reduction possible?	Is it possible to improve quality or reduce error rates by digitizing the process? (*L* (Oesterreich and Teuteberg, 2017; Kohn and Harborth, 2018))
Strategy	Strategic benefits promising?	Can strategic benefits be achieved by digitizing the process? (*L* (Oesterreich and Teuteberg, 2017))
	Promote employer branding?	Can employer branding be promoted by digitizing the process using AR? (*I*)
	I = interviews, *L* = literature, *O* = observations, *U* = user study, *W* = workshops	

Table 5. Management perspective.

4.5 Social & Organizational Culture Perspective

The final category focuses on the social environment and organizational culture (see table 6). Specifically, the user's social environment plays a vital role in shaping the social adoption of an AR application, with supportive social networks positively affecting acceptance (Venkatesh *et al.*, 2003; Klinker *et al.*, 2018). However, the impact of the organizational culture and infrastructure on AR's appropriateness is likewise significant. For instance, the UTAUT model identifies organizational infrastructure as a facilitating condition for technology adoption (Venkatesh *et al.*, 2003). Thus, using AR to support processes is recommended if user acceptance and social acceptance of the technology can be fostered. Moreover, if the organizational culture and infrastructure are supportive, then optimal conditions for AR adoption prevail.

Group	Criterion	Description
Social environment	Social influence supportive?	Can social influence be expected as supportive? (*L* (Venkatesh *et al.*, 2003))
	Social acceptance likely?	Can the social acceptance of the users and their environment be ensured? (*U; L* (Klinker *et al.*, 2018))
Organizational culture	Organizational culture supportive?	Does the organizational culture support the use of AR? (*I*)
	Organizational infrastructure supportive?	Does the organizational infrastructure support the use of AR? (*L* (Venkatesh *et al.*, 2003))
	I = interviews, *L* = literature, *O* = observations, *U* = user study, *W* = workshops	

Table 6. Social & organizational culture perspective.

4.6 Application of the Process Augmentability Canvas

As the proposed framework aids in the augmentation of processes through the utilization of AR, the question arises how the framework can be applied in practice. For a practical application, any business process can be selected, and each canvas section can be explored. The analysis should begin with the upper part of the canvas, emphasizing the visualization ability and fundamental requirements. For each category, the process can be evaluated against each criterion to determine whether the requirements are met or can be met in the future. This enables a comprehensive evaluation of the advantages and disadvantages of using AR. Moreover, it provides a solid foundation for informed decision-making. For instance, if it is determined at the beginning that both the visualization ability and the fundamental requirements are satisfied, we recommend continuing to evaluate the task characteristics. The process selected and its tasks can be examined more closely. This is an advantage if a clear recommendation can already be made based on these characteristics. However, it is not necessarily a disadvantage if this is not possible. Either way, an initial evaluation based on rough prototypes of AR solutions is beneficial. As the maturity of solutions and the potential to become the standard mode of operation increases, the process should be reviewed from the perspectives of management and social and organizational culture. Once the canvas is completed, a solid foundation should be established to determine whether a process can benefit from AR. It is important to note that the canvas is not primarily a checklist that must be completed in its entirety. Rather, it serves as guidance and assistance for the initial assessment of a process's suitability for the application of AR. It is a supplementary tool for practitioners in organizations and serves as a benchmark for comparing different processes. It is important to acknowledge that not every process can satisfy every criterion. Therefore, it is still the responsibility of the respective organization to weigh the suitability of different processes.

5 Discussion

The proposed process augmentability canvas represents a significant step forward in enabling organizations to leverage the potential benefits of AR for services. It provides a structured, criterion-based approach to decision-making, which is particularly relevant given the complexity of the issues involved. We have drawn on existing research in designing the canvas, consolidating fragmented coverage and integrating key insights to create a coherent, comprehensive framework.

Our approach reflects a user-centric perspective, which is critical to overcoming organizational barriers and realizing the intended benefits of AR (Lusch and Nambisan, 2015; Peters, 2016). We have based our canvas on the state-of-the-art concerning technology acceptance and task-technology fit, ensuring that it supports a user-centric approach. Nevertheless, this approach does bear the risk of not leveraging the potential of novel technologies. Thus, a technology-driven approach can be taken to identify areas for application initially. The canvas can contribute to the user-centric design of processes as it tackles all relevant aspects to approach AR solutions.

The canvas enhances communication and collaboration among stakeholders, facilitating alignment of expectations and priorities, reducing misunderstandings and conflicts, and fostering a shared understanding of the benefits and risks of AR. It also supports organizational learning and knowledge management by capturing decision-making rationale and providing valuable insights into the application and limitations of AR. This work contributes to the broader research agenda on digital innovation and organizational change, deepening understanding of the challenges and opportunities of emerging digital technologies. Moreover, the user-centric approach to evaluating AR aligns with the trend toward socially responsible innovation, emphasizing ethical, social, and environmental factors in technology design and deployment. Thus, this work is relevant to practitioners and researchers interested in the implications of digital transformation.

Two main modes of analysis using the canvas are intended to support organizations that aim to pilot AR solutions. The first involves a structured analysis and assessment of all processes using the canvas, allowing organizations to define must-have criteria (e.g., safety and ergonomics) to identify processes that can be augmented. Further analysis should help narrow down potential processes based on the augmentation's expected value, usefulness, and seamlessness. This approach enables organizations to develop a prioritized list of processes and identify processes for piloting that would benefit most from augmentation. Accordingly, as more processes use AR, the economic break-even can be reached more quickly, ultimately leading to organizational changes by shifting towards a more open organizational culture regarding innovation.

The second mode is an approach more driven by business units that seek to explore possibilities of AR or digital units that seek to pilot AR with business partners. Therefore, initial processes can be proposed, and with the help of the process augmentability canvas, areas can be identified that need to be adapted to ensure the criteria are fulfilled to pilot the augmentation. Especially in such a creative exploration mode, guidance to fulfill safety and ergonomics criteria is crucial. At the same time, criteria related to the tasks are assessed by the domain experts themselves. Therefore, a positive assessment within this mode ensures a good task-technology fit. Solely by taking care of these aspects, the results of a piloting phase can lead to applicable and valid results for the organization. Thus, only such results can inform decision-making.

While our work represents a significant contribution to the field, some limitations exist. Our literature review produced relatively few results, and we recognize that broadening the search could increase the number of relevant articles. However, this would potentially decrease the quality and validity of those articles. Additionally, our canvas is based on a single case organization. Thus, the canvas builds on in-depth insights but is nevertheless limited in its transferability. This should be tackled in future research to evaluate the general applicability of the canvas. Finally, while the canvas in its current state focuses on AR, several aspects do indeed apply to VR and mixed reality more broadly. Given the claim to support informed decision-making, further research and validation of the canvas are needed.

6 Conclusion and Outlook

In conclusion, our proposed process augmentability canvas offers valuable contributions to theory and practice by addressing the fragmented literature and limited real-world cases in AR applications. Through consolidation of the state-of-the-art literature in IS and HCI on characteristics of processes to be augmented, we contribute to the ongoing discourse on AR regarding embedding innovations in organizations. Additionally, we propose an example for applying a multi-level perspective to enhance the applicability of innovations in real-world scenarios. Because the process augmentability canvas has been enriched and validated within a real-world organization, it has already proven its applicability and usefulness. Therefore, it enables practitioners to cope with the complex decision-making regarding the application of AR in their organizations and find the sweet spot for AR application. The canvas allows for adapted weightings of criteria and specific, often regulation-dependent, safety and security measures. Even more, the canvas enables an explorative approach to applying AR and experiencing the benefits and potential shortcomings. SMEs that are rather limited in resources can benefit from the canvas in realizing benefits quickly and efficiently.

Based on the process augmentability canvas, various avenues for further research emerge. First and foremost, evaluating the canvas in diverse real-world scenarios would further improve the validity of the artifact. Second, deciding to what extent virtualization and augmentation are the most promising within the virtuality continuum remains challenging. Thus, extending the canvas to guide the decision for the technical degree of augmentation would be important, especially considering broader applicability in SMEs. This includes the type of AR, from HMDs to spatial augmentation and VR.

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