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SAGE Publications Inc.
2024-07-19

Pöyry, E, Holopainen, J, Parvinen, P, Mattila, O & Tuunanen, T 2024, 'Design Principles for Virtual Reality Applications Used in Collaborative Service Encounters', Journal of Service Research. https://doi.org/10.1177/10946705241266971

http://hdl.handle.net/10138/584356
10.1177/10946705241266971

Scholarly Article

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Journal of Service Research
2024, Vol. 0(0) 1–17

DOI: 10.1177/10946705241266971
journals.sagepub.com/home/jsr
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Abstract

Immersive technologies like virtual reality (VR) provide new opportunities to augment service encounters by supporting customer–service agent collaboration and problem-solving. Guided by the value cocreation and service technology infusion literature, a design science research (DSR) study is carried out with three iteratively developed versions of a VR application used to make decisions about forest management services. The aim is to develop design principles (DPs) for physical VR technology-infused service encounters. DSR produces unique knowledge on how a VR solution affects customer–service agent collaboration. In each development cycle, the problem–solution fit is evaluated, and emerging problems are addressed in the following DSR cycles. Based on interviews (N = 127) with customers and service agents of a forest management service company conducted during the DSR cycles, we show that VR technology solutions support collaboration and problem-solving in knowledge-intensive service encounters by invoking dialogue difficult to generate otherwise—especially when decision-makers are novices and service outcomes are physical and irreversible. We present three new DPs that help conceptualize how collaborative service encounters can be improved by using a developing VR technology: (1) the principle of empowerment, (2) the principle of focus, and (3) the principle of guided decision-making.

Keywords

service encounter, collaboration, design science research, knowledge-intensive services, virtual reality technology

Introduction

Collaboration and problem-solving during service encounters are at the heart of value cocreation (Aarikka-Stenroos and Jaakkola 2012) and essential for selling and buying knowledge-intensive services characterized by exchange complexity (Nordin and Kowalkowski 2010). Research has envisioned augmenting service encounters by service technology infusion (Bitner, Brown, and Meuter 2000; Larivière et al. 2017; Marinova et al. 2017), but in nonroutine knowledge-intensive services particularly, technology is often considered a hindrance to building trust and commitment between the customer and service provider (Röding et al. 2019; Schumann, Wünderlich, and Wangenheim 2012).

Virtual reality (VR) technology provides new opportunities for visualizing multifaceted service solutions in a three-dimensional space and engaging customers in service planning through physical movement and immersion (Boyd and Koles 2019; Pöyry et al. 2020). These possibilities could transform physical service encounters in terms of how services are illustrated and discussed. A media-rich presentation of service information could also be a particularly valuable addition to knowledge-intensive services suffering from information, skill, and commitment asymmetries between customers and service providers (Peffers & Tuunanen 2005; Santos and Spring 2015). VR applications have, however, been scarcely studied in physical service encounters, and little is known about how VR technology affects customer–service agent collaboration and problem-solving.

We study the use of VR technology in a service encounter in the context of wood trade and forest management services—knowledge-intensive services in which customer–service agent

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Received: 1 July 2022; revised: 6 May 2024; accepted: 19 June 2024

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collaboration is central and customer solutions can differ significantly. As the success of new service technologies is often context-dependent and affected by sociotechnical factors related to their use, we use a design science research (DSR) approach. The systematic step-by-step approach of DSR is instrumental in supporting new service development in the face of participatory, human-centric challenges (Grenha Teixeira, Patrício, and Tuunanen 2019) and when immature technologies are utilized (Gregor and Hevner 2013). The goal of the DSR process is to create design principles that support collaborative VR-infused service encounters. Design principles (DPs) are generalizable design guidelines and abstractions that can be applied to develop service-specific solutions and to theorize about and generalize the design of IT solutions (Gregor and Jones, 2007; Hevner et al., 2004; Markus et al., 2002; Tuunanen et al., 2023; Walls et al., 1992).

Our research partner, a large multinational forestry company, has recognized three collaboration and problem-solving challenges involving its clients. First, as the outcomes of forest management decisions do not materialize until decades or even generations afterward, their evaluation is difficult (Food and Agriculture Organization 1999), particularly for inexperienced customers. Second, most decision support tools used in the industry, such as growth model calculations (e.g., Hoogstra and Schanz 2009), are very complex for nonprofessionals. Most customers are private citizens who have, for example, inherited their forest plot, live far away from it, and have no hands-on forestry experience. Third, many customers are unable to state their exact preferences and priorities, which might lead to unsatisfactory service outcomes. The company is developing a VR application to respond to these challenges.

Our goal is to investigate how to use VR technology to enhance customer–service agent collaboration and problem-solving in knowledge-intensive services and to specify DPs for that purpose. The paper is structured as follows. First, we present the theoretical background and draw on the value cocreation, service technology infusion, and VR technology literature to develop the initial DPs for the VR solution. We use Aarikka-Stenroos and Jaakkola's (2012) dyadic problem-solving framework to evaluate and guide our DSR process. We develop versions of a VR solution and investigate how they affect customer–service agent collaboration. Then, we discuss our findings, revise the DPs accordingly, and consider our research's implications and future research avenues.

Theoretical Background

Collaboration in Knowledge-Intensive Services

Knowledge-intensive services are characterized by exchange complexity and challenges in communicating value, usually caused by information asymmetry and customers' difficulty in defining their needs, resulting in intricate and time-consuming customer–service agent collaboration (Nordin and Kowalkowski 2010; Tuli, Kohli, and Bharadwaj 2007). Therefore, the ability to create and manage customer knowledge is crucial. Customer knowledge management concerns how organizations create customer knowledge to develop better customer solutions (Hakanen 2014). Customer knowledge management requires knowledge revealing, sorting, and leveling (García-Murillo and Annabi 2002) and is enhanced when the parties trust and depend on each other (Park, Lee, and Lee 2015).

As much customer knowledge management is about searching for and creating new knowledge, socialization activities are needed (García-Murillo and Annabi 2002; Nonaka, Takeuchi, and Umemoto 1996). Meetings, interviews, and problem-solving sessions are common ways of supporting socialization (Li and Calantone 1998), but arguably, more creative methods support participants' reflexivity to tap into previously uncovered knowledge (Vink and Koskela-Huotari 2022).

The value cocreation literature also highlights the role of customer–service provider interaction (Prahalad and Ramaswamy 2004). The literature posits that value can only be created through service exchanges with customers (Vargo & Lusch, 2004; Vargo, Koskela-Huotari, and Vink 2020). Grönroos and Voima (2013) argue that there needs to be a joint value co-creation sphere between involved parties so that value can be cocreated. These value exchange instances are also called value interfaces (Kundisch and John 2012). Ballantyne and Varey (2006) suggest that, in practice, relationship development, communicative interaction, and knowledge renewal enhance value cocreation. In customer–service agent interaction, Baumann and Le Meunier-FitzHugh (2015) propose that value cocreation occurs when customers disclose their value systems and value-generating processes and when salespersons understand and participate. This interaction is driven by commitment, common goals, dialogue, and shared interests (Baumann and Le Meunier-FitzHugh 2015) and hampered by ignorance and overconfidence (Aarikka-Stenroos and Jaakkola 2012).

As a key tenet of value cocreation is problem-solving, customer–service agent collaboration is needed (Aarikka-Stenroos and Jaakkola 2012; Lindgreen et al. 2009; Sawhney 2006). Regarding knowledge-intensive service exchange, Aarikka-Stenroos and Jaakkola (2012) identified five distinct but usually parallel collaborative activities: (1) diagnosing needs, (2) designing and producing the solution, (3) organizing the process and resources, (4) implementing the solution, and (5) managing value conflicts. To be effective, collaborating parties need to develop "platforms and procedures that invoke dialogue concerning the objectives of collaboration, facilitate identification of misunderstandings, and avert the development of unwanted or inadvisable solutions" (Aarikka-Stenroos and Jaakkola 2012, 23). We argue that new technologies can provide distinct support for selling and buying parties to reach a common understanding and make well-advised, long-term decisions.

Service Technology Infusion

Technology use in services and service encounters has long been studied, including how service technologies are accepted by service agents (e.g., Schillewaert et al. 2005) or customers (e.g., Bhappu and Schultze 2006). Typically, the perspective or aim of these studies has been to substitute or replace some tasks previously carried out by service agents to save costs (Hilton, Hughes, and Marandi 2013; Lin and Hsieh 2011; Rancati and Maggioni 2022). However, as Marinova et al. (2017) suggest, technology's effect on service encounters varies along a substitute–complement continuum. Technologies may substitute service agents, complement, or augment their abilities, or fall in between. In complementary temporal services, service agents and bots take turns (e.g., Schmid et al. 2022), while augmentation refers to when technologies are used in synchrony with human service agents (e.g., Dolata et al. 2020; McLeay et al. 2021; Wu, Fan, and Mattila 2015).

As service technologies can support many goals and tasks, particular attention should be paid to why and how different technologies or systems are used in service encounters. For example, a self-service kiosk and a high-end VR technology application are not comparable in their roles in and effects on the service experience. In this study, we focus on VR technology used cooperatively by the customer and service agent in a physical space to augment human-to-human service encounters. De Keyser et al. (2019) described these kinds of service encounters as technology-facilitated encounters in which a customer and a service agent maintain direct contact, and the technology facilitates the service encounter in a physical space.

The effectiveness of a service encounter can be evaluated based on how well customer needs are met and what the encounter provides beyond expectations (Bitner, Brown, and Meuter 2000). In technology-infused services, these parameters can include opportunities for customization, flexibility, or effective service recovery, for example (ibid.). While these considerations reflect typically positive effects of technology infusion, negative effects also occur. As technology infusion challenges the typical script of a service encounter and interrupts natural human-to-human interactions, customers can react unfavorably. For example, Röding et al. (2019) found that technology infusion in service encounters can hamper customers' information disclosure behavior, while Kilic, Dolata, and Schwabe (2016) reported that using an IT system during a face-to-face service encounter could negatively affect certain conversational elements, such as signals about the listener's state.

These findings highlight the need to design the technology and the service encounter so that customer–service agent interaction is not damaged. Successfully designed service technology infusion can empower service agents by improving their problem-solving skills (Giesbrecht, Schenk, and Schwabe 2015; Giesbrecht, Schwabe, and Schenk 2017) and enhance customers' perceived control and trust in the service provider and increase their service satisfaction (Dolata et al. 2020; Inbar and Tractinsky 2012). Embracing existing processes, practices, and social rituals, allowing collaborative use of technology (e.g., shared or double screens), and offloading service agents' cognitive loads have been found to support effective and purposeful interpersonal communication when technology is used in a service encounter (Dolata et al. 2020; Giesbrecht, Schenk, and Schwabe 2015; Giesbrecht, Schwabe, and Schenk 2017; Inbar and Tractinsky 2012; Schmid et al. 2022). In other words, designing technologies that do not hinder meaningful human-to-human interaction but act as aids that bring in useful information have been found to create value in physical technology-infused service encounters.

Virtual Reality Technology Infusion in a Service Encounter

While collaborative service encounters in which IT systems are used on a computer screen have been studied (e.g., Giesbrecht, Schenk, and Schwabe 2015; Giesbrecht, Schwabe, and Schenk 2017; Inbar and Tractinsky 2012), the sociotechnical aspects of VR technology remain little studied. VR is an immersive computing technology that absorbs users in a responsive virtual world (Berg and Vance 2016). A head-mounted display is a popular VR solution, allowing the position, orientation, and visual and auditory stimuli to change with the user's movements (Meißner et al. 2019). Distinctive VR qualities include a first-person view in a three-dimensional space, enabling an immersive experience of presence like physical reality (Berg and Vance 2016; Torro et al. 2022), and interactive data visualizations, enabling informative and educational experiences (Boyd and Koles 2019; Pöyry et al. 2020). Both qualities have also been found to induce playfulness and entertainment value (Hsu, Chen, and Chen 2020; Loureiro et al. 2019; Willems, Brengman, and Van Kerrebroeck 2019).

The immersive features of VR technology reflect the high media richness and information synchronicity of the platform (Daft and Lengel 1986; Dennis, Fuller, and Valacich 2008). Media richness refers to its capability to carry complex, multidimensional information and cues that help recipients understand the intended message (Daft and Lengel 1986). Information synchronicity addresses the need for the conveyance of data and the convergence of a shared understanding to accomplish meaningful action and communication that supports both (Dennis et al. 2008; Dennis and Valacich 1999). The conveyance of sufficient information enables reaching correct conclusions, while convergence is necessary for groups of people to act together with synchronicity and a common understanding (Dennis, Fuller, and Valacich 2008).

In service research, however, VR technology has mainly been regarded from the perspective of how it affects communication and the experience of service qualities (Hudson et al. 2019; Itani and Hollebeek 2021; Pleyers and Poncin 2020). Regarding social interaction and collaboration in VR environments, research has scrutinized how interacting with other people within a VR environment affects one's personal experience (Hudson et al. 2019) and how collaboration is affected by multiuser VR applications (Olt et al. 2024; Tea et al. 2022). The research results vary: Hudson et al. (2019) found that interacting with other people in a VR environment could hinder their immersion and decrease satisfaction, while Olt et al. (2024) and

Tea et al. (2022) found that collaborating on a joint goal was enhanced with an immersive VR application compared to conventional methods (e.g., online conferencing).

Understanding how VR technologies are used during interactions with service providers is also needed. Current evidence suggests that VR technology's greatest potential lies in using it for selling complex and hypothetical services (Boyd and Koles 2019; Pleyers and Poncin 2020) in which a supporting service agent's role is significant. In this study, therefore, we investigate how joint problem-solving and collaboration are supported by VR technology offering high media richness and information synchronicity. We thus aim to push service technology infusion research forward by linking it to the value cocreation literature and to provide detailed and empirical information about VR technology-facilitated service encounters.

Design Principles Development for Virtual Reality-Infused Collaborative Service Encounters

Our research interest lies in how a developing VR system enhances collaboration and problem-solving in knowledge-intensive services—forestry services in our case. We approach this question by proposing DPs derived from previous studies that are intended to be prescriptive statements that can guide system design (Nguyen et al. 2021). The key phases of collaboration and problem-solving in knowledge-intensive services (Aarikka-Stenroos and Jaakkola 2012) are used as a template for the DPs; we propose three DPs that follow aspects of collaboration that need to be covered to ensure mutually beneficial value cocreation.

The first DP concerns the need to be able to diagnose customer needs and determine goals for the exchange. Previous research suggests that service agents should use their specialist knowledge to identify customers' needs, as customers may experience barriers to participating and sharing their thoughts, particularly if they lack expertise (Aarikka-Stenroos and Jaakkola 2012; Santos and Spring 2015). While knowledge-intensive services usually require some sort of digital decision support tools and visual aids (Aarikka-Stenroos and Jaakkola 2012; Elhajjar, Yacoub, and Ouaida 2023), many are centered on numbers, charts, and figures. Thus, they may be perceived as only highlighting the knowledge the customer does not possess. Research has shown that customer passivity and inhibitions could be tackled by allowing customers to use the technology, creating enticement, empowerment, and a sense of control (Dolata et al. 2020; Giesbrecht, Schwabe, and Schenk 2017; Inbar and Tractinsky 2012). We argue that using VR technology, which provides a compelling way of visualizing service solutions (Hsu, Chen, and Chen 2020; Loureiro et al. 2019; Willems, Brengman, and Van Kerrebroeck 2019), encourages knowledge sharing between the parties.

Previous research suggests that VR solutions with a natural user interface should base their design on immediate understanding, natural engagement, and compatibility between the user's task and domain (Regazzoni, Rizzi, and Vitali 2018). The user should intuitively understand how the system works and what it gives them. In addition, research recommends that VR solutions should design for tangibility in how products and service elements are presented in a virtual environment, utilizing the three-dimensional spatial sensation VR can provide (Jain et al. 2023). Taken together, we propose the following:

> **DP1. Principle of engaging visualization:** The VR solution should visualize service solutions in an intuitive, tangible, and compelling manner so that it helps customers articulate their needs.

The second DP concerns collaboration phases that require specifying the problem and optimal value proposition and organizing the required resources (Aarikka-Stenroos and Jaakkola 2012). To do this, service providers should illustrate their value propositions and provide information that allows the customer to understand their realistic options. The visualized service offerings should also fit customer needs by providing customer-specific information about the services or otherwise communicating the unique and contextualized qualities of the proposed service solution and its outcomes (Aarikka-Stenroos and Jaakkola 2012; Bitner, Brown, and Meuter 2000).

Immersive VR technology enables dynamic first-person visualizations, creating a sense of presence for the user (Berg and Vance 2016). This can be achieved by maintaining faithful viewpoints, meaning that a change in the virtual environment display should conform to the user's motion and expectations (Sutcliffe et al. 2019) and allow for various motions and movements (Schjerlund, Hansen, and Jensen 2018). In addition, the more realistic the user's interaction with the environment (e.g., achieved through natural hand gestures), the more they will feel a sense of presence (Sutcliffe et al. 2019). To create a consistent user experience, the user should be able to control the direction and timing of the interaction up to the achievement of their goal and to individualize the experience according to their needs (Regazzoni, Rizzi, and Vitali 2018). Moreover, Jain et al. (2023, 18) recommend that a VR system should allow flexibility or customization to put the user "in charge." So, to help customers to thoroughly understand the central elements of different service options and their outcomes, we propose the following DP:

> **DP2. Principle of information immersion:** The VR solution should visualize service solutions so that it allows customers to interact with service options in an immersive and individualized manner.

The third DP concerns what is usually the final step of a collaborative endeavor between a customer and a service provider—assessing the implementation of a service solution. This requires ensuring that all necessary decisions have been made, that divergent views have been reconciled, and that potential value conflicts have been managed (Aarikka-Stenroos and Jaakkola 2012). Service agents are usually more knowledgeable than customers about the service delivery process and the required steps and decisions, but they should engage customers in the entire decision-making process (Aarikka-Stenroos and Jaakkola 2012; Santos and Spring 2015). However, customers might lack the expertise, role clarity, or resources to maintain interaction with the service provider (Santos and Spring 2015) or have unrealistic expectations about the service and its benefits (Aarikka-Stenroos and Jaakkola 2012). Santos and Spring (2015) suggest strategies to increase customer participation in the service delivery process, including keeping the customer active and informed, proactively engaging them in preventive actions, and solving problems that arise during the process.

Similar strategies have been reported in technology-augmented service research. Giesbrecht, Schwabe, and Schenk (2017) and Schmid et al. (2022) point out that infusing technology into a service encounter requires seamless integration of technologies and conventional processes (Dolata et al. 2020), and a service agent must play an advisory role. To achieve these goals in VR design, research suggests that systems should pay attention to the narrative of the user experience. Schjerlund, Hansen, and Jensen (2018) argue that a strong narrative explains why the user interacts with the system, and that the more detailed narrative elements become, the higher the degree of interactive freedom the user expects. Similarly, Regazzoni, Rizzi, and Vitali (2018) suggest that a natural VR user interface should be based on progressive learning, meaning that the applications is easy to start to use and uncovers more details as the user progresses. Therefore, to ensure a well-advised decision-making process, we propose the following DP:

> **DP3. Principle of guided decision-making:** The VR solution should contain a clear narrative so that it allows customers to interact with all service decision steps in an advised order and that it shows progress.

Methodology and Data

Our research concerns forest management services that are increasingly produced using digital aids and tools and new technologies. Traditionally, personal service and visits to forest sites have been an important part of the service process. However, as most customers live far from their forest plots, the need for remote service planning is more common (Pynnönen, Haltia, and Hujala 2021). In addition, while it is relatively easy to find forestry information online, forest owners' level of expertise limits their awareness of forest management practices and service options.

Research Approach

The research approach for the study is DSR, which aims to create and evaluate IT solutions to solve real-world organizational problems and advance a field's knowledge base (Hevner, March, and Ram 2004; Grenha Teixeira, Patrício, and Tuunanen 2019). DSR outputs are new constructs, models, methods, or instantiations that offer a research contribution (Hevner, March, and Ram 2004). DSR has been applied in the development of new service design methods (Sudbury-Riley et al. 2020; Grenha Teixeira et al. 2017; Grenha Teixeira, Patrício, and Tuunanen 2019). We iteratively developed versions of a VR technology solution for customer use during a service encounter with the help of a service agent for decision support. Consequently, we created new DPs to improve service encounters using VR technology.

We applied a DSR methodology (DSRM; Peffers et al. 2007) to conduct the study. A DSRM is a solution-driven, systematic knowledge development process that classically consists of six steps: (1) problem identification and motivation, (2) definition of the objectives for a solution, (3) design and development, (4) demonstration, (5) evaluation, and (6) communication. A DSRM is well suited for studies aiming to form and scrutinize DPs to support system development (Tuunanen and Peffers 2018), as here. It is typically applied using DSR cycles in which a solution is iteratively developed, demonstrated, and evaluated (Tuunanen and Peffers 2018).

To develop the VR solution, we applied the DSRM with three iterative DSR cycles (see Table 1). Each development version addressed problems stemming from practice and the solution created in response. Table 1 details the key design features of each solution, including general service conditions. Each DSR cycle was evaluated against the same criteria and the service's intended purpose (Venable, Pries-Heje, and Baskerville 2016). The solution was demonstrated to the study participants in each cycle and evaluated based on interview data collected from the solution's users. The interviews focused mainly on the user experience of the solution, its implications for customer decision-making, and comparisons with other decision support tools.

The solution was tested first with industry experts, then with customers and service agents in laboratory conditions, and finally with customers and a service agent in field conditions. The customer (or industry expert in DSR cycle #1) used the VR solution and headset, with the service agent (or research assistant in DSR cycle #1) guiding the use by monitoring the customer's view on a computer screen. The focal company recruited the participants by inviting customers and partners on their mailing list. The participants varied in terms of age, gender, size, and distance to their forest estate.

DSR cycle #1 focused on the fact that many customers are not sufficiently knowledgeable about identifying and determining their needs, but the selling company can propose viable solutions. Therefore, the VR solution (HTC Vive) was created to visualize key information about forest management operations in a tangible, illustrative, and compelling manner (DP1) that allowed the customer to interact with service options (DP2) in an advised order (DP3). Forty-seven forestry and technology industry experts tested the solution with a researcher's assistance. The solution functionalities included moving around in a simulated forest, earning money by removing trees, and comparing the result to the starting point. The user could also see a point cloud and a 360-degree image of a forest site and compare it to a simplified interactive model. The solution's visual quality was fairly simplistic. The solution addressed core VR design features, including playfulness (e.g., Loureiro et al. 2019),

Table 1. Overview of the VR Solution Versions (DSR Cycles) and Research Data.

DSR Cycle	Problem	Solution	Key Design Features (Incremental)	No. of Interviews	Sample	Use Situation
1	Many customers not sufficiently knowledgeable to identify and determine their needs	VR solution that demonstrates key information about forest management operations and visualizes them	Playfulness, dynamic visualizations, first-person view in a three-dimensional space	47	Industry experts	Laboratory
2	Using the VR solution time-consuming and might create misunderstandings; customer expectations about service solutions sometimes unrealistic	Integrating the VR solution into customer meetings; improved and more realistic visuals and decision scenarios	Synchronized customer and service agent views, interactive and user-controlled exploration of additional information	64	Service agents and customers	Laboratory
3	Use of the VR solution not aligned with usual service processes; creating customer-specific models expensive	Integrating the VR solution in parallel with existing service processes and decision support tools	Service option comparison, combining generalized visualizations and customer-specific data	16	Customers and a service agent	Field

interactive and dynamic visualizations (e.g., Pöyry et al. 2020; Regazzoni et al. 2018), and first-person view in a three-dimensional space (e.g., Jain et al. 2023; Torro et al. 2022) (see Online Appendix 1).

DSR cycle #2 addressed the weaknesses of the VR solution identified during DSR cycle #1: using the solution was time-consuming, caused some misunderstandings, and gave rise to unrealistic expectations. The graphics and decision scenarios were made more realistic and comparable, and more detailed information was provided about the land area and its contents, including a map. The forest area was enlarged from a few acres to several hectares. The possibility of switching to a point cloud view was replaced by easy browsing between ready-made solutions the user could still modify. The improvements to the decision scenarios and usability aligned with DP3 by creating a more guided decision-making process. The solution was tested in face-to-face meetings with 55 customers and 9 service agents, but the use was simulated. DP1 and DP2 remained. In addition to the previous design features, the solution incrementally addressed synchronized customer and service agent views in VR and on a computer screen (e.g., Pöyry et al. 2020) and allowed interactive and user-controlled exploration of additional information (e.g., Regazzoni, Rizzi, and Vitali 2018; Zhang, Bowman, and Jones 2019) (see Online Appendix 2).

DSR cycle #3 concentrated on the problems that emerged in the previous cycles and interviews. Overall, the VR solution's use was not aligned with the usual service processes. The solution was thus integrated with existing service processes and decision support tools utilizing an existing database on natural forest resources in Finland (Mäkisara, Katila, and Peräsaari 2022). Therefore, our VR solution and an existing online service with all available information on the customer's forest management operations were used in parallel (see Online Appendix 3 for details of the existing online service). A possible solution involving fully personalized content was attempted, including VR models with drone-collected customer data, but it was too costly for the focal company. Consequently, the existing forest database was taken as a usable starting point. The customer–service agent collaboration involved showing general visualizations with the VR system, along with accurate customer data in the existing decision support tool.

Further, instead of a more fixed solution (HTC Vive), the VR solution was made stand-alone (Oculus Quest 2), enabling portability in customer meetings. The VR solution's functionalities remained the same as in DSR cycle #2. Cycle #3 shifted the focus to how to support collaboration in real-life situations. Altogether, 16 interviews were conducted with customers and a service agent who worked for the focal company. In addition to evaluating the effects of the solution on collaboration and problem-solving, attention was given to how the new VR solution could function alongside other existing service process elements and systems. For further details, including a business and systems process model and an activity diagram for the system design, see Online Appendices 1–2 and 4–5.

Interviews and Data Analysis

Altogether, 127 interviews were conducted during the three DSR cycles, providing data on how well the VR solution performed against the service's intended purpose (Venable, Pries-Heje, and Baskerville 2016). The evaluation criteria were based on Aarikka-Stenroos and Jaakkola's (2012) conceptualization of collaborative activities in joint problem-solving:

- **Diagnosing needs.** Identifying and articulating the needs and goals for the exchange.
- **Designing and producing the solution.** Specifying the problem and optimal value proposition for resolution and communicating value-in-use expectations.

- **Organizing resources for the solution.** Organizing problem-solving and identifying, activating, collecting, and integrating required resources.
- **Implementing the solution.** Launching and supporting the implementation of the systems, reports, processes, etc. required for the value in use to materialize.
- **Managing value conflicts.** Reconciling divergent views regarding optimal value in use, creating smooth interaction, and managing value conflicts.

The interviews were recorded, transcribed, and imported into Atlas.ti for analysis. Directed qualitative content analysis was used to code the data (Assarroudi et al. 2018; Hsieh and Shannon 2005). The main steps of our analysis were getting immersed in the data, theoretically defining and testing the main categories and their coding rules, performing the main deductive data analysis, inductively abstracting new generic categories from the preliminary codes, and establishing links between the main categories (first-order abstractions) and new generic categories (second-order themes) (Assarroudi et al. 2018).

The first deductive data analysis round resulted in 50 codes (DSR cycle #1), 197 codes (DSR cycle #2), and 45 codes (DSR cycle #3), which were summarized and sorted under the initial main categories. New generic categories were elicited and linked under the main categories using contextual interpretation (Ahuvia 2001). Three researchers (with expertise in forest management and sales management) performed the coding and analysis.

Open coding was used when pretesting the categorization. These preliminary codes were grouped based on their meanings, similarities, and differences under the main categories for inductive abstraction. The inductive so-called generic categories were constantly compared to the theory-based main categories to develop a conceptual link between the generic and main categories and to nest the generic categories into the preexisting main categories. No new main categories were created.

Results

The DSR cycles aimed to determine how each version of the VR solution affected the participants' ability to collaborate and solve service-related problems. The findings are illustrated using interview quotations.

Design Science Research Cycle #1

Diagnosing Needs. In the interviews with industry experts, the VR solution was generally described as a unique approach to visualizing forestry operations. The feeling of "being present in a forest" was mentioned often as an integral part of the experience. Some also said that the service felt personal and intimate when experienced with the VR solution. Visualizing the expected service operation outcomes was seen as encouraging customers to start thinking about their actual needs and go beyond the VR solution's technical details. Seeing the results of different operations also acted as a conversation starter, and many participants thought it could improve collaboration and problem-solving by reducing the knowledge gap between the parties, as shown in the following quotation:

> If you think about the people to whom or with whom these things are planned, then I think this helps the parties talk about the same things and begin to understand what the customer needs. (A1: Industry expert)

Designing and Producing the Solution. Using the VR solution required no specific knowledge about the service. It allowed users to explore and test various service operations directly after putting on the VR headset. The participants felt the ability to test irreversible forest management operations in real life was impressive and a novel addition to forest management planning. Some also thought that the solution would increase the acceptability of the outcomes and lower barriers to making decisions. The following quotation reflects how an illustrative visual experience, together with rapid feedback, increased the user's understanding of the service operation outcomes:

> The most impressive thing was that I was able to quickly select the trees that I wanted to log. And I was able to see so fast, like, immediately, what the forest would look like after. (A2: Industry expert)

Organizing resources for the solution. Regarding critical resources related to using the VR solution as a service planning and decision-making tool, many industry experts stressed the importance of the source data. Many were skeptical about whether the available source data would be detailed and reliable enough, particularly if the solution was intended for planning operations at a single-tree level. Therefore, instead of using the solution as a tool to support decision-making, some proposed other use cases, such as general training and education or presales planning, both for customers and service agents:

> [This kind of VR solution] could be used to become familiar with a new customer site and plan before any customer meeting. (A3: Industry expert)

Implementing the Solution. The VR solution's feasibility in terms of visualizing forest management operations was a key discussion point with the industry experts. Many thought that features such as removing single trees and seeing a point cloud were interesting but not necessarily useful in practice. Many interviewees proposed that browsing through ready-made customer solutions would be more meaningful than making real-life plans in the solution. Still, increasing the service planning convenience was considered a strength, and it was noted that the VR solution could prompt customers to become more active in managing their forest plots, as opposed to staying passive. As one expert stated:

> I'd say that the benefit is that it can be fun and exciting. It may motivate one to start doing something with one's forest. (A4: Industry expert)

Managing Value Conflicts. Some participants proposed that the solution could help manage value conflicts and misunderstandings by enabling early-stage service discussions. However, they also expressed worries about giving an overly positive image of service outcomes if the VR solution was to be used in actual customer decision-making. Some industry experts assumed that inaccurate data and service promises based on solution visualizations could also make customers dissatisfied by setting unrealistic expectations. Others still thought that even rough visual estimations would be helpful, as one said:

> Having all the trees in their right locations is probably unnecessary. You'll see the change in a landscape if the density and that kind of stuff are correct. When you start thinning out the forest, you'll see how it changes. (A5: Industry expert)

Summary of the DSR cycle #1 findings. Cycle #1 uncovered opportunities for improved customer–service agent collaboration and highlighted the importance of providing detail to support problem-solving. Many participating industry experts believed that the fact that the VR solution highlighted the first-person experience would encourage customers to consider complex problems, better understand solutions proposed by service agents, and progress in their decision-making. Opinions about whether the visualizations should resemble reality or if generalizations would suffice were divided. However, the participants generally agreed that a concrete, customer experience-oriented way of presenting service solutions would improve collaboration and problem-solving, by helping the parties better understand each other.

A new version of the solution was developed by adding a more versatile selection of tree species and undergrowth, more realistic decision scenarios, and a larger forest area. After these improvements, the solution was considered comprehensive enough to be evaluated by real customers. Additionally, as it was expected that most future users of the solution would be inexperienced with the technology, attention was given to developing a more straightforward user interface, providing the most important service information, and removing any irrelevant information.

Design Science Research Cycle #2

Diagnosing Needs. Next, customers of the focal company were invited to test the improved version of the VR solution. Most liked the visual illustration of the service, as they thought it helped increase their understanding of the basic premises of the service and provided an understanding of the possible service scenarios. Many also paid attention to the financial estimates attached to different forest operation options and said that they helped establish more informed objectives for the service. While some industry experts interviewed in DSR cycle #1 thought the revenue estimates were too detailed, customers typically thought that showing the financial value of even small operations was illustrative, as the following quotation shows:

> I have not yet taken part in the wood trade. But I do believe that if I saw the financial value like this [at a single-tree level], I would understand better. I always understand better if things are concrete. (B1: Customer)

Designing and Producing the Solution. Most participating customers considered the possibility of receiving immediate visual feedback about different service solutions a strength. Normally, forest management operations are planned using maps and data sheets requiring context-specific knowledge, and the operations' outcomes can only be seen after implementation. The solution enabled customers to compare outcomes visually, determine whether they liked them without knowing expert terminology, and adjust as needed. Consequently, many customers thought that misunderstandings and disappointments with the results would be less common.

> With this, it is super easy to see those few scenarios of what the forest looks like after logging. It is otherwise hard to illustrate. (B2: Customer)

However, some customers found the solution irrelevant, arguing that their forest management experience helped them imagine the consequences of different operations and that VR visualizations offered nothing new.

Organizing Resources for the Solution. During the evaluation of DSR cycle #1, discussions about required resources mainly related to data sources. During the evaluation of DSR cycle #2, discussions shifted to where and by whom should the VR solution be used. Some customers emphasized the benefits of flexibility and avoiding going to the forest plot to make decisions:

> It brings the forest closer to you; you don't need to go to the forest. I mean, for many people, it takes an entire day to visit one's forest plot. (B3: Customer)

The possibility of augmenting a physical service encounter in an office space was also frequently discussed. Relatedly, the importance of personal connections was emphasized. Fully independent use raised concerns about losing personal contact with a service agent. Discussion also occurred about how the solution could engage other stakeholders (e.g., family members). Thus, the solution was considered most useful for augmenting, not substituting, personal meetings, as illustrated in the following quotation:

> In this process, there must be a discussion with a forest professional, who will then give their own recommendations. Even though this [the VR solution] adds to how we usually operate, it's still just a visualization. (B4: Customer)

Implementing the Solution. Particularly for the less experienced customers, making forest management decisions was considered laborious, and postponing decision-making was an easy way to avoid the work. The focal company already had an online service that allowed remote planning, but customers generally did not consider it convenient or attractive. On the contrary, many participants thought the VR solution made it easier to understand future scenarios more concretely, which would encourage implementation of the necessary management operations. As one customer stated:

> The possibility of making forestry operations and seeing them was really inspiring. It would increase activity in forests, and even more, you could see what would happen if you did nothing. (B5: Customer)

Managing Value Conflicts. Visualizations were seen as promising for evaluating the proposed service solution's value. Many customers thought the VR solution would help them better understand what service agents were proposing and be more integrated in the problem-solving process. Consequently, some participants thought that improved customer understanding would support service discussions and enable them to express important, yet possibly conflicting, values, such as aesthetics. This was particularly evident in the case of less experienced customers, as the following illustrates:

> I know I might make decisions that I would regret after seeing the results. So, this provides an interesting alternative to make decisions. This would also help me understand the consequences of my decisions or, should I say, give more informed consent. Until now, I've only received some papers that I'm not sure about what they really mean, like "cutting off hold-overs." (B6: Customer)

Summary of the DSR Cycle #2 Findings

Cycle #2 highlighted the need to tackle complexity. The customer interviews revealed that information relevant to customers occasionally differed from what the industry experts expected, with the level of information detail being one of the most notable differences. For many customers, building their understanding from a rudimentary level enabled them to proceed to more complex solutions. Visualizations also supported interactions by providing concrete aspects they could refer to without knowing expert terminology. The improvement was not necessarily about making communication less formal, as suggested in DP1. Rather, the VR solution enabled customers to better recognize and express their needs. Moreover, customers became more aware of the key decisions they needed to make, not only because of the first-person experience, as suggested in DP2. Instead, it seemed the key to increased understanding was the limited set of information provided to the customer in a digestible visual format. Also, due to the difficulties in absorbing service information and the risk of remaining inactive, the solution's guiding the customer through the decision-making journey was found useful, in line with DP3.

Next, the VR solution was developed for use on the sales organization's premises. The functionalities remained the same, but the hardware enabled more flexible and mobile solution use, as required in actual wood trade negotiations. Consequently, improvements were made to the service encounters, and the evaluation focused on integrating the solution into existing service processes and systems. Customers who had contacted the company to start wood trade negotiations were recruited as participants.

Design Science Research Cycle #3

Diagnosing Needs. In addition to the VR solution, existing online services and decision support tools were discussed during DSR cycle #3. The company's existing online service starts with an overview of the customer's forests using maps and tables. Many customers thought the amount and nature of information in the online service was overwhelming and uninviting. The perspective and way of presenting information differed drastically in the VR solution, which started by showing information regarding small land lots or even single trees. One customer spoke about the difference:

> When you know nothing about the topic, you become fearful. You feel like you don't understand anything. Instead, when starting from the virtual experience, small steps can be taken to become familiar with the topic. (C1: Customer)

Consequently, the participants thought the VR solution helped the parties understand each other. Financial calculations were focal in the online service, but the experience-oriented approach of the VR solution helped customers think and communicate other aspects related to the service and approach the financial discussions. For a few customers (particularly inheritors), the financial calculations were viewed as contradictory to their own, typically environmental values, making discussions with service agents challenging.

Designing and Producing the Solution. As noticed during DSR cycle #2, the solution helped present service operations in a more easily understandable way. For example, visually comparing different service scenarios was a compelling way of approaching service decisions. Whether this was considered useful and important depended on how competent customers felt about the problem. The VR solution would add less value to the existing online system if forest management decisions were made routinely. However, the less experienced customers found the VR solution useful in designing the service solution compared to using only the online service:

> It felt like… real! It is a completely different thing to see an area on a map compared to seeing it as a landscape like this. (C3: Customer)

Organizing Resources for the Solution. Most of the focal company's customers make forest management decisions infrequently. They mentioned different ways of preparing for decision-making when necessary. Some customers said they tended to use photos and calculations from earlier management operations to refresh their memories and become oriented. Thus, they viewed the VR solution as beneficial for engaging in operation planning and focusing on value-creating subproblems, as the following example illustrates:

> There's a village road going through my forest. In situations like that, I often think about the landscape, and this [the VR solution] would be valuable in cases like that. (C4: Customer)

Implementing the Solution. The expectation that the VR solution would activate customers' decision-making was strengthened during DSR cycle #3. Still, comparisons with the existing online service did not reveal any significant new insights regarding implementing a service, indicating that the research data had reached a saturation point. As in the previous cycles, playfulness and seeing the eventual outcomes were helpful in the implementation process, as shown in the following quote:

> I would engage to play with different options for sure. This would enhance the thinking process, for example, scaling if clear-cutting is necessary or if there are other options. (C5: Customer)

Managing value Conflicts. The interviews revealed multiple value conflicts between customers and the service provider. Many customers suspected or observed that companies propose the most profitable solutions and remain silent about other options. Interestingly, our interview with the service agent who assisted customers supported the view that customer values are sometimes ignored when proposing solutions. Using the VR solution in a real use situation revealed the negotiation pressure service agents encounter, which was not expressed in previous DSR cycles in laboratory conditions. For instance, letting customers participate in the planning process with the help of the VR solution was considered whimsical and even threatening. One service agent explained their skepticism about marking single trees for cutting, an option the VR solution offered:

> It's easy to infer that if you're managing 1000 m^3 of wood a week, there's no time to mark single trees. Nowadays, if the landowner has no specific requirements, nothing will be marked. It's the forest machine driver at the site who decides. (C6: Service agent)

The conflict was based on the differing opinions mentioned earlier. More experienced participants regarded the VR solution as too detailed, whereas less experienced customers perceived this way of presenting information as illustrative. This finding underlines the tensions present in customer–service agent collaboration. Not every solution is optimal for all parties, and compromises are needed to satisfy the realities of addressing service and customer values and information needs.

Summary of the DSR cycle #3 Findings. Cycle #3 revealed shortcomings in the existing online service. The threshold to even start discussions with a service agent was considered high by some customers, especially if they expected their values to conflict with the service agent's. Although limiting the amount of information shown in the VR solution originally related to usability, it helped the service agent present solutions in a form that customers perceived as more relevant and understandable. Improvements in communication related more to finding a common language than to making the situations informal. Thus, DP1 needed to be revised, as suggested earlier. Furthermore, by starting with something a customer was familiar with, problems became easy to approach. In parallel with DSR cycle #2, an increased understanding of the problem enabled customers to consider solutions with conflicting values instead of immediately rejecting or involuntarily accepting them. Supporting DP3, it was found that service agents are needed to guide customers throughout a complex service process and keep them involved. Table 2 summarizes the results from DSR cycles 1–3.

Discussion

General Discussion and Revised Design Principles

This paper documents the development process of a VR solution intended to augment a service encounter. We aim to investigate how we can use VR technology to enhance customer–service agent collaboration and problem-solving in knowledge-intensive services. We apply the DSR approach to solve this problem and specify DPs for this purpose.

We show that enhanced customer–service agent collaboration can be regarded as a positive outcome of service technology infusion, in line with human–computer interaction research (Giesbrecht, Schwabe, and Schenk 2017; Inbar and Tractinsky 2012). According to our findings, VR technology brings distinct benefits to the service encounter from the perspective of value cocreation. This finding emerges from the theoretical argument that both the service provider and the customers provide valuable resources for collaboration and problem-solving (Aarikka-Stenroos and Jaakkola 2012). Our study shows that VR technology provides distinct means to surface and integrate those resources. In line with Wilson et al. (2016), we provide a triadic perspective on the joint problem-solving process by accounting for the resources and capabilities of service providers, customers, and VR technology. These findings are reflected in the revised DPs discussed and depicted next.

Previous research suggests that customer inhibitions should be removed to support articulation of their needs (Aarikka-Stenroos and Jaakkola 2012), which was also reflected in original DP1. However, in addition to just engaging the user with powerful or compelling visualizations, which are typically the initial associations of VR design (Loureiro et al. 2019), the VR solution empowered and activated customers to discuss their service needs and challenges more openly, arguably because the solution made complex problems easier to approach. With the help of the VR solution's dynamic visualizations, customers who were hesitant about getting started with forest management operations learned about their service options and the attached trade-offs.

Table 2. Summary of Results.

Analysis Codes	New Generic Categories	Quotations in Text
Diagnosing needs		
Seeing the big picture	Visual scenarios	B1
Complex scenarios		
Visual information		
Gap identification		
Customer education	Teaching and learning	A1
Find common ground		
Understand development needs		
Learn new perspectives		
Motivating customers	Customer activation	C1
Activate passive customers		
Inexperienced customers		
Remote owners		
Designing and producing the solution		
Understandable visualization	Visual guidance	B2
Guidance		
Feedback		
Prototyping	Comparison of solutions	A2
Rapid testing		
Digital twin from a real site		
Value of alternatives		
Organizing resources for the solution		
Need for up-to-date information	Data management	B4
Databank		
Human knowledge		
Checking to-dos	Scheduling	A3; B3; C4
Mentally preparing		
Avoiding physical disturbances		
Implementing the solution		
Fun and exciting	Encouragement	A4; C5
Encouragement to get started		
Reality enhancing		
To-dos with expected outcomes	Showing progress	B5
Historical log data		
Ready-made solutions		
Completed tasks		
Managing value conflicts		
Current conditions	Supporting agreements	A5; B6
Agreements		
Notes on changes		
Budgeting		
Accounting for expectations	Risk analysis	C6
Emotions attached to forest		
Quality control		

Furthermore, the media-rich nature of the VR visualizations differentiated the VR solution from more conventional decision support tools, which are typically based on a data-oriented approach to service planning. Previous research argues that, in e-commerce, using richer media encourages consumers to explore and consider more options than when using leaner media platforms (Maity, Dass, and Kumar 2018). Our findings suggest that VR technology makes it easier for customers to understand various service scenarios and articulate their service needs, empowering them to participate in value and service discussions without knowing professional terminology or financial models. Moreover, customers started to create new knowledge because the VR-based forest model made it simple to grasp, for example, what one's forest plot looked like and how new pieces of information connect to that knowledge. Thus, increasing customer understanding of the service and empowering them facilitated customer–service agent collaborative problem-solving, leading to a revised DP1.

> **DP1. Principle of empowerment:** The VR solution should provide compelling and dynamic service visualizations that teach about service dimensions, trade-offs, and outcomes. This activates and empowers customers to better articulate their needs.

Second, the visual and media-rich nature of VR technology also relates to DP2, which initially stated that information immersion would help envision value in use. While intuitive interaction with the VR system and the consequent sense of presence and immersion seemed to add to many customers' understanding of the service, as suggested by earlier VR DPs (Schjerlund Jonas et al. 2018; Sutcliffe et al. 2019), this was not only because the person could interact with the system and see how different forest management operations affected the virtual forest. The fact that the VR solution limited the customer to only a defined set of visual and sometimes textual information at a time seemed to lead to increased comprehension. Unlike the company's existing online service, the VR solution's user interface restricted the amount of information that could be displayed, allowing the service agent to prompt discussions on the most central aspects and proceed to more nuanced and detailed matters if needed. By designing a solution based on the process of customer knowledge creation instead of expert knowledge dissemination, service information became easier for customers to absorb. While customers preferred the idea that the VR solution used their own forest data, they accepted working with parallel data systems with a service agent.

We argue that displaying information in an understandable and restricted format is beneficial, particularly in knowledge-intensive services where customers with limited topic expertise depend on the service agent's advice (Baumann and Le Meunier-FitzHugh 2015). By displaying service information in a way that highlights the most important service features and outcomes—while allowing the customer to freely interact with objects they find interesting and complementing the general service information with customer-specific data—customers are better informed about service options and can make more informed decisions.

> **DP2. Principle of focus:** The VR solution should visualize a limited set of key service information and enable exploration of additional information and service comparisons as the use progresses. The system or the service agent can complement the use by providing relevant customer-specific information. This helps the user to build knowledge about the service and make more informed decisions.

Third, because service agents affect the overall perception of what a service entails and how it is implemented, their role in guiding customers throughout the process is central, as suggested in the original DP3. Our findings support the importance of managing customer knowledge creation by guiding customer activation and attention in a subtle and timely manner using a predefined narrative, as Schjerlund, Hansen, and Jensen (2018) suggest. Indeed, as knowledge-intensive services are based on the service provider's contextual knowledge and process understanding (García-Murillo and Annabi 2002; Santos and Spring 2015), customer–service agent information asymmetry cannot be entirely removed. Our results, however, suggest that with the VR solution's help, the service agent can help the customer make progress and visualize expected service outcomes to support making agreements and analyzing risks. To make customer service agent collaboration less intricate and time-consuming, yet collaborative and driven by customer knowledge, we refined DP3 to reflect our findings regarding customer–service agent collaboration and joint problem-solving.

> **DP3. Principle of guided decision-making:** The VR solution should contain a clear narrative, show progress, and visualize service outcomes. This allows customers to interact with required service decision steps in an advised order and supports them to recognize risks and make agreements about service implementation.

While our study focused on VR technology and service solutions in forest management services, with DPs developed for this context, other services share similar qualities. These service qualities are also why we believe the developed VR solution supported customer–service agent collaboration in our case. In simpler consumer services or routine B2B purchases, for example, the need for dynamic visualizations, teaching about service dimensions, or guiding the decision-making process with both the VR solution and a supporting service agent would probably not be necessary or useful. We believe the findings apply to services with similar characteristics as forest management services; (1) services that are purchased irregularly, (2) services that are purchased by novices, and/or (3) services with physical, irreversible, and long-term service outcomes (Pynnönen, Haltia, and Hujala 2021).

For example, in construction and real estate development, a similar VR solution could be beneficial, both in business to consumer and business to business (Pleyers and Poncin 2020). Similarities can also be found in urban planning and infrastructure services (van Leeuwen et al. 2018). Other possibilities are large, expensive, and/or critical products and services requiring customization, where customer cases vary and would thus benefit from collaborative VR-infused service encounters; for example, selling customized vehicles, machinery, or spatial concepts (Choi, Jung, and Noh 2015; Lin et al. 2017). In the case of industrial services, VR-infused service encounters could be useful in services that aim at creating or developing customer processes or product function, and thus require customer knowledge to produce an effective service solution (Lehtonen and Kostama 2014). Examples of such services include prototype design and system modification service (ibid.). In the case of immaterial knowledge-intensive services that have long-term effects on customers, such as financial services, VR-infused service encounters could support decision-making by displaying service options and constellations using immersive data visualizations (Dolata et al. 2020).

Implications for Service Encounter Literature

Our study contributes to the literature by showing how the VR solution can augment the service encounter to allow the creation of customer knowledge that would not otherwise have been created, as proposed similarly in the smart technologies field (Marinova et al. 2017). In particular, the study shows that the VR solution contributed to collaboration and problem-solving by helping diagnose customer needs (through visual scenarios, teaching, and learning activation), designing the solution (through visual guidance comparisons), organizing resources (through data management and scheduling), implementing the solution (through encouragement and showing progress), and managing value conflicts (through creating agreements and analyzing risk). Although some outcomes could have been achieved without VR technology, the findings point to the VR solution's explicit role in invoking dialogue, helping the parties better understand each other, and finding common ground (Aarikka-Stenroos and Jaakkola 2012). VR technology-infused service encounters can thus be regarded as a unique value interface supporting value cocreation (Kundisch and John 2012; Prahalad and Ramaswamy 2004).

The study also illustrates which VR technology features are the most decisive in terms of customer–service agent collaboration and value cocreation (see Table 1 and DPs). Unlike existing service tools, the solution empowered customers through its compelling and dynamic visualizations (as discussed by, e.g., Willems, Brengman, and Van Kerrebroeck 2019). Information processing-related features, particularly user-controlled information exploration and comparison of solutions, were found to be important in terms of a concrete understanding of the customer's options. Previous research suggests that interactivity with objects in a virtual world enhances user learning and satisfaction (Hudson et al. 2019;

Zhang, Bowman, and Jones 2019), in line with the current findings.

Essentially, these design features manifest the role of media richness and thus improved conveyance of information (Daft and Lengel 1986; Dennis, Fuller, and Valacich 2008). However, infusing VR technology in a physical service encounter and using it in synchrony with a service agent could also be seen to support the convergence of meaning and shared understanding (Dennis, Fuller, and Valacich 2008), which are core goals when collaborating and solving problems in knowledge-intensive services. We thus highlight that VR technology should not be regarded only for its ability to convey multidimensional information but also for its support in converging and processing that information. Synchronizing customer and service agent screen views, complementing general service options with customer-specific data, and structuring the VR experience based on clear tasks helped enhance the service process and cooperation between the parties.

Similar features have been found useful in other collaborative service technologies for which research has proposed establishing shared information spaces, integrating existing tools and information resources, and creating a structure customers and service agents can follow (Dolata et al. 2020; Giesbrecht, Schenk, and Schwabe 2015). Previous research has also suggested that VR technology would be especially beneficial in buyer–supplier relationships characterized by high task complexity because they require involvement from both parties (Boyd and Koles 2019). Our findings support this idea: the new technology was welcomed because it allowed a novel way to approach a complex service offering in a field that frequently suffers from inexperienced and passive customers.

Implications for Service Designers and Managers

As various service encounters have been digitalized, automated, and made self-service, many remaining face-to-face service encounters will be geared toward a better understanding of customer needs and how the service provider can best serve those needs. This requires platforms and procedures that enable more meaningful service-related interactions between the parties. Our VR-infused forest management service depicts how immersive VR environments can combine the interaction benefits of meeting on site and having discussions with the help of a visual aid in a controlled meeting environment. A similar goal has driven for example the development of Apple Vision Pro, Apple's augmented reality headset. The software used allows the user to see their physical environment and stay connected to people around them, aiming to serve business use cases such as collaborative product design and immersive training (Miller 2024).

While other tools or solutions, such as interactive tablet applications, could provide immersive service visualizations while maintaining a dialogue with the customer, some distinct benefits can be achieved using a VR solution. While the case company's existing online service (see Table 3) offers the means to understand the detailed qualities of one's forest estate and the costs and benefits of different forest management options, the VR solution offers new ways to visualize the service and enhance customer–service agent collaboration. Key features to achieve the new benefits were playfulness in using the solution, realistic and dynamic service scenarios and 360-degree images of real forest sites, and the ability to experience the service from the first-person perspective in a three-dimensional virtual space. The user was also able to learn more about the service using an interactive map, modifying scenarios, and comparing service options. We argue that VR technology increases experiential and communicative depth during service encounters, demonstrating that VR is a viable technology for augmenting service encounters aimed at activating and educating customers, planning service solutions, and making decisions.

Since we studied forestry services, our findings are particularly applicable to designers and managers of other knowledge-intensive services that contain physical service elements that are difficult to illustrate with traditional methods (see, e.g., Tuunanen et al. 2019). Further use cases concern service encounters when multiple decision-makers, stakeholders, and interests are involved. When decision-making requires the ability to justify plans and activities to others and when decisions involve high financial, social, and

Table 3. Summary and Comparison of the Existing Online Service and the VR Solution.

Existing Online Service (See Also Appendix 3, picture 1b, Appendix 4)	VR-Infused Forest Management Service (See Also Appendices 1–2, Appendix 3, picture 1a)
• Online portal with forest site statistics (forest stand names and codes, hectares, and volumes) • Description of forest management service options • Digital forest management plan with costs and benefits • Forest stand maps • Forest management plan and cost and benefit charts	• Playfulness (teleporting and earning money by removing trees) • Immersion (three-dimensional space, realistic scenarios, and 360-degree images of real forest sites) • Dynamic visualizations (interactive map and comparable decision scenarios) • User-controlled information exploration (ability to modify scenarios by removing single trees) • Synchronized customer and service agent screen views • Augmenting general service options with customer-specific data • Customer's perspective (first-person view) with the support of a service agent

emotional stakes, it is worthwhile to visualize different service solutions and scenarios, for which VR technology is well suited.

Finally, our findings showcase that infusing technology in service encounters has two-way benefits. Some benefits, such as customers' increased comprehension of the service due to the visual aids, are dyadic, meaning they relate to the customer's relationship with the technology. However, other benefits, such as the possibility for guided decision-making, are triadic and are realized when the customer, the technology, and the service agent interact. The design and development of VR solutions should therefore maintain both avenues to enable multiple use cases.

Limitations and Future Research

Certain research limitations need to be addressed. This study accumulated knowledge about how different versions of a developing VR solution affected collaboration and problem-solving in a knowledge-intensive forest management service. Analyzing only iterative versions of a single service solution has both strengths and weaknesses. The most evident concerns relate to the generalizability of the results and how they apply to other contexts and technologies at different stages of maturity. However, the DSR process's iterative nature provides evidence of the realities organizations might face when designing and deploying a novel and immature technological solution (Hevner, March, and Ram 2004). Moreover, interview data provide only a limited view of the solution's qualities and effects, and participatory observation or ethnography could be used to collect detailed interaction data.

Further, as VR is a specific kind of technology, it is unknown whether other technologies, visualization techniques, and collaboration methods would have similar design features and lead to similar outcomes. Future research should investigate the use of VR technology by comparing it to other technologies and methods. Regarding VR technology, multiuser applications offer avenues for future research on collaborative service planning. It would also be valuable to know when immersive and complex technology is unnecessary and when simpler technologies would suffice. As new technologies develop and become more accessible to a broader range of organizations, the possibilities described here will become more commonplace and achievable. While this study focused on a service based on long customer relationships, valuable service contracts, and physical service elements, future research could examine more casual service relationships with more hedonic values or intangible components. This study's results also highlight the need to consider the decision between investing in the development of more complex and customized solutions and settling for a less sophisticated yet affordable option. Future research should study this choice and DPs for both high- and low-end technology solutions.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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Supplemental Material

Supplemental material for this article is available online.

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