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Verse: A Virtual Environment For Research On Social Experiences - Theory, Co-Design and Evaluation Of A Researcher-Centric Social Vr System

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VERSE: A VIRTUAL ENVIRONMENT FOR RESEARCH ON SOCIAL EXPERIENCES – THEORY, CO-DESIGN AND EVALUATION OF A RESEARCHER-CENTRIC SOCIAL VR SYSTEM

Completed Research

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Abstract

Virtual Reality (VR) has long been recognized as holding significant promise for research on social interaction across fields such as HCI, social psychology, and cognitive (neuro)science. Yet the application of VR systems in research projects remains difficult, largely due to inadequate attention to researchers' specific needs in existing systems, a lack of VR-specific technical skills, and insufficient design guidance. This limits the technology's practical impact. Following a design-oriented approach, we introduce the VERSE framework to tackle these challenges, providing a threefold contribution to both social interaction researchers and the IS discourse: (1) a ready-to-use artifact instantiation; (2) generalized affordances of researcher-centric VR systems derived from our artifact; and (3) a conceptualization of researchers as facilitators of interaction within socio-technical VR information systems, grounded in Affordance and Role Theory. Our results show how facilitators can configure, rather than develop, virtual experiences to meet analytical needs, enabling effective virtualization of study designs.

Keywords: Social Virtual Reality, Social interaction, Experiments, Immersive Research, HCI.

1 Introduction

Virtual Reality (VR) technology holds significant potential for research, not just as an object of study across its various applications, but also as a research method or supporting tool (Fox et al., 2009). Accordingly, scholars across fields such as social psychology, cognitive (neuro)science, and organizational behavior have discussed how VR can be used to study human behavior and have increasingly adopted the technology (Pan & Hamilton, 2018; Parsons et al., 2017; Yaremych & Persky, 2019). For researchers studying social interaction in the behavioral sciences, the unique virtualization of face-to-face interaction (F2FI) through social VR (SVR) is particularly appealing, and we focus on this subgroup of researchers in the following. Because F2FI is inherently multimodal and relies on rich perceptual and communicative cues, SVR's rich sensory impressions make it a compelling medium for such studies. Further, advances in head-mounted displays (HMDs) over the last decade have enabled high-quality, immersive experiences at affordable prices while also reducing the risk of cybersickness,

thereby greatly reducing adoption barriers (Pan & Hamilton, 2018; Yaremych & Persky, 2019). Despite this potential and these advances, however, the actual adoption of VR in social interaction research remains relatively low (Neveu et al., 2025), and many scholars report substantial barriers to realizing VR's benefits in their own work: they struggle with limited resources and expertise, or encounter commercial systems that do not fit their work practices (Rubo, 2025; Pan & Hamilton, 2018). VR has been approached in research and design primarily from two perspectives: a technical and an experiential one (Dörner et al., 2022). The common ground between these perspectives is the characterization of VR systems through their unique user interfaces—as a new frontier of human-computer interaction (HCI), where research and design focused primarily on users' immersion and presence (Dörner et al., 2022). A broader perspective on VR systems as socio-technical infrastructures has been largely neglected, despite calls for such a research program emerging over two decades ago (Walsh & Pawlowski, 2002). Thus, there is no strong conceptualization and, consequently, no technical support for user groups beyond those directly immersed users and their roles within such infrastructures.

Against this backdrop, we identify researchers as a notable example of such neglected user groups. Their goals and challenges differ fundamentally from those typically prioritized in SVR system design in terms of tasks, activities, and obligations: Most social interaction researchers do not use SVR systems to immerse themselves in virtual worlds; instead, they use them to facilitate social experiences for *others*. They play a fundamentally different *role* than their participants, who represent a more typical *immersed user* group in this context. Multimodal, high-fidelity communication affordances allow researchers to reproduce and manipulate F2FI cues in controlled yet ecologically rich, realistic settings (Menck et al., 2023b). At the same time, the value of these virtualized interactions, e.g., in experimental contexts, is created primarily for the researcher and the wider academic community, not for the immersed participants themselves. We conceptualize these scholars as *facilitators of interaction*—actors who shape SVR experiences from "outside" the virtual world for others to experience. They share this form of use, or obligation, with the group of *VR developers*. Yet, since VR developers typically build systems for others, they are often not considered as a user group themselves in design research. Consequently, most SVR system design has implicitly assumed that the users most affected by it are the immersed interactants (such as participants), while experience creation falls solely to non-users (i.e., developers). However, developers and researchers play different types of facilitator roles, with overlapping but also diverging needs, obligations, and skill sets. As a result, this forces behavioral researchers interested in VR into a dual 'researcher-developer' role, requiring them to develop in-house solutions (Rubo, 2025). Researchers lacking these specific skills face barriers to adoption.

We argue that to reduce these barriers, researchers require a dedicated interface to the shared virtual space (SVS) and a corresponding role within SVR systems that allow them to create or facilitate, control, and observe immersive social situations and to collect multi-layered data about these interactions. Social interaction research can fully leverage VR's potential only if SVR systems explicitly support this "facilitator" perspective (Walsh & Pawlowski, 2002, p. 301). We aim to overcome current shortcomings by creating an artifact that meets our following overarching design research goal: *Implement a researcher role and associated functionality that facilitates immersive virtual social interactions, thereby helping social interaction researchers effectively leverage VR technology's potential.*

In this paper, we address this objective by applying a Role Theory (Galletta & Heckman, 1990; Mirbabaie & Marx, 2024) lens that foregrounds the researcher's role and its implications for system design (Zhu & Zhou, 2008) in combination with Affordance Theory (Gibson, 1986; Volkoff & Strong, 2017) to the intersection of social interaction research and SVR technology. To guide our inquiry, we follow the Design Science Research Methodology (DSRM) as our core process model (Peffers et al., 2007), complemented by a systematic literature review of VR research tools and a multi-method evaluation of the resulting artifact. As a solution, we present VERSE (Virtual Environment for Research on Social Experiences), an SVR research platform centered on the researcher as interaction facilitator. Our work offers three contributions. First, we provide a ready-to-use artifact instantiation, the VERSE tool, which enables researchers to configure and run various controlled social interaction scenarios in VR, including a dedicated researcher interface for configuration, intervention during interactions, and recording of detailed socio-spatial data. Second, in line with Steffen et al. (2019), we derive generalized

affordances of researcher-centric SVR systems from our artifact, offering guidance for future design research and tool development. Third, we develop a theoretically grounded conceptualization of researchers as facilitators of interaction in socio-technical VR systems, thereby contributing to a broader information systems (IS) perspective that recognizes facilitators as a distinct user role in SVR. We position VERSE as one component within a broader research infrastructure ecosystem for VR-based social interaction research, enabling researcher-centered orchestration, configuration, and multimodal data capture. The paper proceeds as follows: Section 2 outlines our design-oriented methodology; Section 3 constructs the knowledge base, covering SVR theory, VR affordances, Role Theory, and a review of existing tools; Section 4 presents the VERSE artifact; Section 5 reports the two-stage evaluation; Section 6 provides a discussion of the findings; and Section 7 concludes the paper.

2 Methodology

This study follows the DSRM as proposed by Peffers et al. (2007), with minor modifications to account for practitioner involvement in the design and development process. Thus, we also adopt elements of Action Design Research and participatory design to strongly involve our target users in shaping the artifact (Sein et al., 2011; Robertson & Simonsen, 2012). In our context, the 'practitioners' or target users are themselves researchers, which mitigates typical participatory challenges, such as maintaining commitment and bridging language or expectation gaps, and makes them especially effective co-designers for a research-oriented information system such as VERSE (Cook et al., 2017).

This meant involving a social interaction researcher not only as an evaluator but also as a co-designer and co-researcher, and ultimately a co-author on our team. The fifth co-author is a cognitive scientist with more than a decade of experience in VR- and non-VR-based studies examining human social behavior, who acted as a practitioner–co-designer, articulating research needs, shaping and challenging design decisions from the user perspective, and reflecting on VERSE's suitability for studying social interaction. The other authors, all from the field of IS, also contributed prior experience with designing and running SVR systems and conducting VR-based research (e.g., Rehmer et al., 2025; Rose et al., 2025; Trier et al., 2024a), and they assumed primary responsibility for the design and technical implementation of VERSE. This configuration created a semi-internal, semi-external practitioner view that foregrounded overarching research goals and real-world applicability over purely technical considerations. Since a Design Science Research (DSR) project moves through different stages or phases as per the DSRM, including problem formulation, defining requirements or solution objectives, artifact design and development, and evaluation, different methods will often be employed at each step to ensure the validity of these "intermediate artifacts" (Tuunanen et al., 2024). Our specific methodological configuration of the process is depicted in Figure 1.

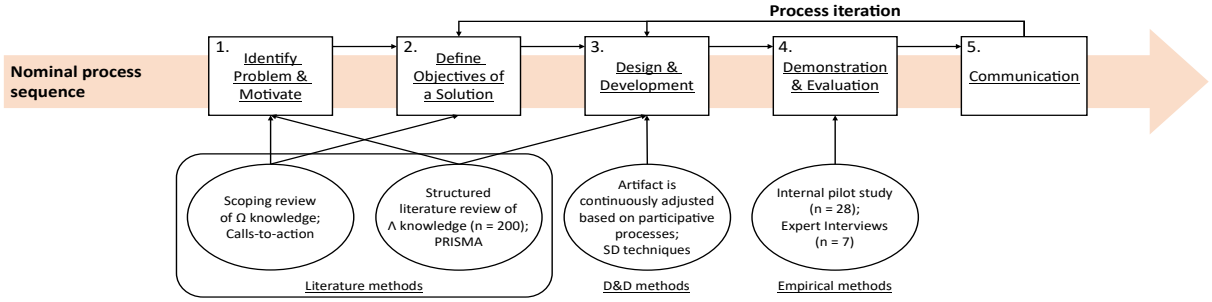

Figure 1. DSR process adapted from Peffers et al. (2007) and sub-methods for each step.

Following the DSR guidelines of Gregor and Hevner (2013), we structured the knowledge base, which provides the foundation for both the design and the justification of our artifact, into descriptive knowledge (denoted Ω) and prescriptive knowledge (denoted Λ). Accordingly, in this paper, a dedicated knowledge base section—divided into subsections for Ω and Λ—replaces the traditional literature section. To build the knowledge base, we conducted a two-step literature review in line with established IS guidelines (vom Brocke et al., 2015; Webster & Watson, 2002). First, a scoping review (Arksey &

O'Malley, 2005) was conducted to map how VR is used across disciplines concerned with social interaction, such as social psychology, social neuroscience, and behavioral economics, through iterative database searches and snowball sampling. Second, we carried out a systematic review of the scientific databases Scopus and Web of Science in accordance with the PRISMA guidelines (Page et al., 2021). We began with a keyword search to identify articles presenting VR-focused design artifacts, such as design frameworks, toolkits, or full software applications, intended to support research. We then screened the first 100 results from each database based on title and abstract and, where necessary, full text. Subsequently, we conducted forward citation searches on the retained articles to identify more recent artifacts using the same inclusion criteria. An explicit representation of the screening process is provided in Figure 2. The scoping review primarily informed the problem space, VR applications, and theoretical background (Ω), while the systematic review primarily consolidated the design state (Λ); however, both contributed to both sides of the knowledge base.

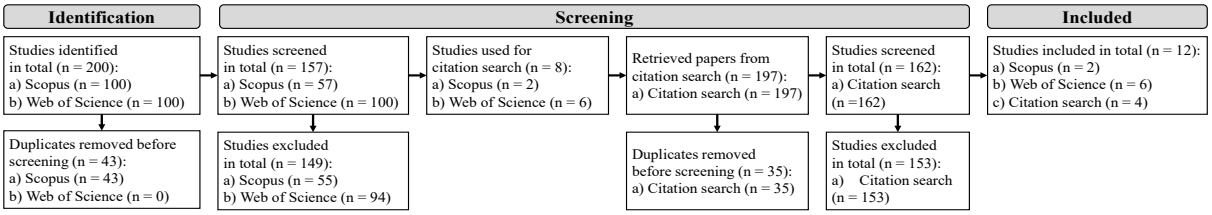

Figure 2. Adapted PRISMA flow diagram.

The artifact was created in accordance with the DSRM through an iterative design process. The collaboration in our interdisciplinary team to design and implement VERSE unfolded over three years through a series of development sprints and internal workshops. Building on the combined knowledge base and co-researcher feedback, we aimed to design a platform that offers researcher-oriented affordances through role-based features. We ran through multiple development cycles in which the system architecture was drafted, tested against tentative objectives, and refined as needed. Our iterative co-design process unfolded in three main phases: (1) an initial core-feature phase, in which we implemented and stabilized basic researcher/participant roles, session management, and tracking pipelines; (2) an interface and workflow phase, where we iteratively refined the researcher interface in recurring co-design meetings; and (3) an extension phase, in which we added advanced configuration, remote, and extensibility features based on meetings with other social interaction researchers and insights from the internal pilot study, reviewing each sprint's changes in realistic study scenarios. This iterative and participatory approach enabled continuous alignment with the identified requirements, culminating in a consolidated set of design decisions that adequately addressed the research goal. The artifact instantiation (VERSE tool) was developed using established software engineering techniques. The evaluation of the artifact followed a two-stage procedure to assess its value across different project stages and contexts:

(1) Use-in-practice and piloting: The artifact's basic functionality, correctness, and operational stability were tested in a series of internal test runs, during which we reconstructed previous study designs in VERSE and worked closely with a loosely affiliated team under the fifth author's supervision. This allowed for an assessment of usability, ease of use, and comprehensibility outside the development context. Regular feedback sessions with this team helped capture their experiences and identify challenges and opportunities in the tool's practical application that went unnoticed. A pivotal element of this phase was a controlled internal pilot study with students (n = 28). As this stage primarily aimed to evaluate system functionality and operational stability under typical experimental conditions, students constituted an appropriate sample representative of common participant populations in social interaction research. Participants engaged in dyadic coordination tasks that required verbal and nonverbal communication and offered a realistic interaction scenario for evaluating the system's qualities and performance. Throughout this phase, any issues, breakdowns, or notable observations were systematically documented.

(2) Expert interviews: The summative evaluation of VERSE as a research tool was the explicit purpose of the second stage. To complement the team's internal insights from the first stage, we assessed the

perceived usefulness and relevance of the artifact to scholars' activities among a wider range of domain experts. We therefore conducted semi-structured expert interviews with seven researchers from social neuroscience, social psychology, cognitive science, and information systems. The sample comprised two full professors, three postdoctoral researchers, and two PhD researchers, most of whom had prior experience designing or deploying VR-based studies on social interaction. The experts were invited to participate in live demonstrations of the system. During these sessions, they were introduced to all core functionalities, shown anonymized example recordings from the pilot study, encouraged to ask questions, and to engage in discussions with the developers. We collected their assessments through semi-structured interviews with experts. The interview guide, execution, and analysis followed established guidelines for expert interviewing (Bogner et al., 2009). We analyzed the data via a structured qualitative content analysis based on Mayring's (2014) tradition, tailored to expert interviews, to gain insights into the tool's relevance, utility, and potential for research. Based on the empirical data of each evaluation phase, the artifact was reviewed against the solution objectives (see Section 4) and adapted accordingly. The insights of both evaluation phases, along with the modifications derived from them, are presented in Section 5.

3 Knowledge Base

3.1 Ω-Knowledge - Theoretical Background

SVR systems. The term VR is used inconsistently and overlaps with notions such as virtual environments or virtual worlds (Wohlgenannt et al., 2020). We understand VR as a computer-generated digital environment that can be experienced, at least in part, as if it were real through immersive, interactive hardware such as HMDs (Jerald, 2015). On a more abstract level, VR applications virtualize experiences (Steffen et al., 2019) and can induce robust illusions of altered situations and identities in which people behave "as if" they were exposed to real scenarios (Gonzalez-Franco & Lanier, 2017).

SVR denotes a subclass of VR systems that virtualizes social interactions (Trier et al., 2024a). SVR applications are relevant when social activities are to be digitally represented. Users are (partially) embodied as avatars that support verbal communication and non-verbal communication (NVC). NVC, including facial expressions, gestures, and spatial positioning, accounts for a large share of interpersonal communication in dyadic interactions (Antonijević, 2013). Because SVR supports both verbal and non-verbal cues, it can give rise to an illusion of F2FI, defined as the perception of communicating with virtual social actors, both verbally and non-verbally, as if the interaction were non-mediated (Jerald, 2015). This illusion rests on telepresence, self-presence, and social presence (Oh et al., 2018).

Defining SVR solely in terms of such subjective illusions, however, offers limited guidance for system design. Drawing on Goffman's interactionist theory, Trier et al. (2024a) therefore conceptualize SVR around co-presence and three basic interaction units: social occasions (events viewed as a unit to which people look forward and back), gatherings (sets of mutually co-present actors), and situations (the full spatial environment in which actors become co-present). Together, these units form the social situation and capture the core social structures that SVR systems need to represent.

VR affordances and virtually assisted activities. Steffen et al. (2019) conceptualize VR as a technology that supports virtually assisted activities, focusing on why specific aspects of an activity are virtualized, which is particularly relevant to our context. The authors propose a classification framework, based on empirical studies and drawing on Affordance Theory (Gibson, 1986), that groups VR application goals into four overarching affordance clusters. First, *recreating* real-world aspects aims to virtualize hard-to-access, costly, or scarce environments (e.g., by visiting distant locations virtually). Second, *enhancing* positive real-world aspects means making activities easier, more effective, or more productive in VR by adding or modifying elements (e.g., augmenting meetings with additional context). Third, *diminishing* negative real-world aspects aims to mitigate risks or burdens, such as dangerous training scenarios or emotionally stressful situations. Fourth, *creating new*, non-existing aspects concerns experiences that are impossible or currently unfeasible in physical reality.

The value or usefulness of virtualization depends not only on these motivations but also on the extent to which sensory intensity and physical context are significant to the focal activity (Steffen et al., 2019). Importantly, virtually assisted activities need not fully replicate the original physical experience or functionality to be meaningful. Affordances focus on how users perceive and intend to use an action possibility (e.g., the "accessibility of online educational material"), placing greater weight on subjective perception compared to other approaches (Thapa and Zheng, 2019). Consequently, affordances are an appropriate concept for investigating how specific user groups intend to use VR.

Role Theory in IS. Following the discussion of VR affordances, Role Theory offers a complementary perspective, focusing less on action possibilities themselves and more on the socially structured positions, expectations, and responsibilities through which technology use is organized in IS contexts (Volkoff & Strong, 2017; Schulz-Schaeffer, 2021). Roles are commonly conceptualized as bundles of socially shared expectations, rights, and obligations attached to positions within a social structure rather than as fixed individual traits, which makes the perspective relevant for analyzing heterogeneous actors in information systems (Galletta & Heckman, 1990; Zhu & Zhou, 2008). Galletta and Heckman (1990) conceptualize organizational roles not as monolithic entities but as configurations of multiple subroles, each representing specific bundles of expectations and norms. In the context of end user development, these subroles expand as responsibilities traditionally assigned to developers are transferred to end users. This shift leads users to assume activities such as design, coding, and testing without formal assignment or sufficient expertise. As a result, several problems arise. *Role overload* occurs when individuals take on too many subroles, leading to stress and reduced quality. *Role ambiguity* and *role conflict* emerge from unclear and conflicting expectations. Moreover, insufficient training contributes to control and quality issues, including poor documentation, weak data integrity, and inadequate security mechanisms.

Zhu and Zhou (2008) complement this view through a technology-focused perspective. They review role-based approaches across multiple IS domains and show that roles have become a recurring organizing principle across modeling, software design, access control, agent systems, and CSCW. Their review suggests that roles in IS are used to structure interaction, authorization, coordination, and responsibility, even though no single universally accepted definition exists (Zhu & Zhou, 2008). Across these domains, roles may specify both *rights* and *responsibilities* and may function either as relatively abstract interfaces or as more concrete process structures that guide behavior (Zhu & Zhou, 2008). This positions Role Theory in IS not only as a lens for analyzing social expectations, but also as a design-relevant perspective for differentiating actor positions in socio-technical systems (Zhu & Zhou, 2008). More recently, Mirbabaie and Marx (2024) extended role-theoretical thinking in IS by focusing on role transitions in digital transformation contexts. They define such transitions as physical and psychological movements between roles and identify three technology-related patterns: *role conflation*, *role emancipation*, and *role confinement* (Mirbabaie & Marx, 2024). Their findings show that digital technologies can either soften or solidify role boundaries, thereby shaping how actors move between, combine, or remain constrained within particular role constellations (Mirbabaie & Marx, 2024).

VR as a research method in the social sciences. VR is used across social psychology, social neuroscience, economics, and organizational behavior to study social interaction under controlled yet lifelike conditions (e.g., Fox et al., 2009; Pan & Hamilton, 2018; Parsons et al., 2017; Yaremych & Persky, 2019; Innocenti, 2017; Pierce & Aguinis, 1997). Across these domains, the core motivation is methodological: researchers seek designs that balance reproducibility, internal validity, and ecological validity. For instance, Caruana et al. (2024) demonstrate that SVR, combined with eye- and hand-tracking, enables the controlled study of multimodal nonverbal behaviors, such as gaze and pointing gestures, during dyadic interactions.Similarly, Trier et al. (2024b) use an SVR commerce environment to study avatar-mediated customer-seller consultations, analyzing how immersion, socio-spatial setting, and avatar communication influence customer satisfaction.

In practice, social scientists juggle partly conflicting goals: (1) ecological validity and realistic social context, (2) controllability of stimuli and confounds, (3) rich behavioral data, and (4) unobtrusive data collection that does not itself distort behavior. Classical methods force trade-offs between these aims. Laboratory and online experiments facilitate control and randomization but typically rely on simplified, non-embodied stimuli. Field experiments and naturalistic observations provide realism and context but

make it difficult to manipulate conditions systematically, access rare situations, or instrument them with sensors without becoming intrusive (Pan & Hamilton, 2018; Yaremych & Persky, 2019). VR, and SVR in particular, can partially relax these trade-offs. For online and lab experimenters, SVR offers a path 'outwards' toward more realistic, embodied face-to-face interaction while retaining standardized procedures and precise control over scenarios. For field researchers, SVR offers a path 'inwards' toward repeatable access to otherwise costly, risky, or ethically sensitive situations, while preserving key multimodal cues such as gaze, gesture, interpersonal distance, and turn-taking and enabling detailed yet unobtrusive behavioral measurement (Parsons et al., 2017; Pan & Hamilton, 2018; Menck et al., 2023b).

Realizing this potential requires SVR systems that treat the researcher as a distinct user role. Researchers must (re-)create social situations, monitor and intervene, and collect detailed data while participants experience a natural face-to-face encounter. Existing general-purpose SVR platforms (e.g., VRChat, Spatial) offer rich social interaction but little experimental control or data export, whereas dedicated VR experiment tools emphasize control and logging but rarely support fully embodied interaction (Steed et al., 2022; Wölfel et al., 2021). This gap motivates the design of researcher-centered SVR systems that align methodological goals with the affordances offered to different roles.

3.2 Λ-Knowledge - An overview of extant tools

To extract relevant prescriptive knowledge to guide our design, we focused on two contribution types in the literature: (1) frameworks and design guidelines for the development of VR research systems, and (2) IT artifacts, i.e., ready-to-use tools or software resources (e.g., libraries, toolkits, SDKs) for creating new VR research tools. These artifacts were examined both conceptually (design rationales, intended purposes) and practically (hands-on feature testing). Table 1 presents a subset of the screened literature selected for relevance.

Authors	Description
Bebko & Troje, 2020	**bmlTUX:** Unity system automating condition combinatorics, counterbalancing, randomization, and block/mixed designs with minimal manual setup.
Brookes et al., 2020	**UXF:** Behavioral-study toolkit managing experimental structure, independent variable, and data capture while relying on Unity for stimuli.
Grübel et al., 2017	**EVE:** Experiment framework handling logic control, logging, sensor sync, database storage, questionnaires, VR events, replay, and R-based analytics.
Lee et al., 2022	**RemoteLab:** Remote-VR toolkit for cross-machine state sync, multimodal recording, data aggregation, and experiment replay.
Liu & Chen, 2022	**SkyBXF:** Skyrim-VR mod adding controlled session–block–trial sequencing for in-game behavioral experiments.
Menck et al., 2023a	**VR experiment design principles:** Six design principles for VR Experiments emphasizing immersion, reproducibility, data capture, and customizability.
Oliva et al., 2022	**QuickVR:** Unity library for embodied avatars with synchronized full-body motion.
Rose et al., 2025	**SVR Data Canvas:** Framework unifying physiological, perceptual, and socio-spatial data via unobtrusive virtual sensors in VR.
Schuetz et al., 2023	**Vexptoolbox:** Python/Vizard toolkit for structured trial control, standardized logging (eye/body tracking), and data export.
Steed et al., 2022	**Ubiq-exp:** SVR toolkit offering networking, avatars, voice, and extensions for distributed mixed-reality studies.
Vasser et al., 2017	**VREX:** Tool for procedural multi-room generation with auto-placed objects and manual scene-editing options.
Wölfel et al., 2021	**VRSTK:** Toolkit for developing, running, and analyzing VR experiments with sensing, stimulus/scene control, data management, and standardized workflows.

Table 1. Overview of VR-based design artifacts for research.

The reviewed artifacts included frameworks and guidelines, but the majority were toolkits for the Unity engine that support researchers in programming in-engine setups to run VR experiments. The authors of these artifacts highlighted that leisure-oriented consumer SVR platforms do not sufficiently address the specific needs of researchers. Following this, they argued for dedicated research-oriented applications, concluding that while consumer applications can provide appropriate virtual social experiences for study participants, they lack native support for research-specific functionality such as session–block–trial models or other experiment-oriented utilities. Offering such features was thus seen as a primary way to add value for researchers.

Still, our investigation identified several valuable features beyond that in the IT artifacts. For example, VREX automatically generates randomly furnished rooms based on predefined settings. VRSTK offers asymmetric normalization of avatar height, which ensures participants see all avatars as matching their own body height, which has unique methodological value in VR. Ubiq-exp provides many manipulation and intervention functions. It enables researchers to control environmental parameters and participant states, and even automate remote, unsupervised experiments.

4 IT Artifact

4.1 Problem and Solution Space

Building on the knowledge base and the participatory co-design process, we conceptualized the problem and solution space in line with Maedche et al. (2019). We derived eight solution objectives that specify the required properties of researcher-created social experiences in SVR: *ecological validity*, *controllability*, *reproducibility*, *participant safety and well-being*, objective *capturability*, technical *reliability*, *remote accessibility*, and continuous *mutability and extensibility*. Together, these objectives define the methodological and experiential conditions under which SVR can serve as a viable research instrument.

To translate these objectives into an actionable design space, we adopt an affordance perspective to examine how an artifact could enable the fulfillment of the solution objectives. Although the affordance perspective proposed by Steffen et al. (2019) is useful, it does not distinguish between those who *benefit* from the virtualization of an activity and those who *experience* it immersively. SVR systems used in research must support two distinct roles: participants immersed in social interaction and researchers, who orchestrate, monitor, and control virtual experiences from outside the immersive environment. They represent the primary users of a research SVR system. Moreover, the affordances perceived and required by researchers differ substantially from those perceived and required by participants. This requirement reveals a critical gap in existing SVR systems. Current commercial platforms aimed at consumers primarily optimize the experience of immersed end users and therefore provide only limited support for researchers' needs, such as situational control, procedural oversight, and systematic data capture. Existing research-oriented artifacts address this gap only partially. They either remain highly abstract at the level of design goals or focus on technical building blocks such as trial structures and logging utilities, while leaving the creation and management of socially meaningful SVR experiences to external tools or custom in-house development (Rubo, 2025).

Consequently, researchers are often pushed to engage in end-user development activities that exceed their primary research role. By playing a dual role as a VR developer and researcher, they risk role overload, which, as Galletta and Heckman (1990) noted, increases the burden and may reduce research quality. Following Zhou and Zhu's (2008) view that technical roles should support the enactment of social roles, we argue that an SVR artifact should enable researchers to exercise the rights and fulfill the obligations associated with their role toward participants, namely, to provide and manage a suitable virtual experience in which participants can engage naturally as research subjects. In this sense, and in line with Mirbabaie and Marx (2024), the proposed artifact may help to induce a role emancipation from researcher as developer to researcher as facilitator, thereby addressing an unmet stakeholder need and defining the overarching design goal of this study: to enable SVR facilitators to create and manage virtual social experiences that satisfy methodological and experiential requirements without being overburdened by development related subroles. In our project, the affordances engineered into the

system serve as the central mechanism that links this facilitator-centered problem space to the corresponding solution space (see Figure 2).

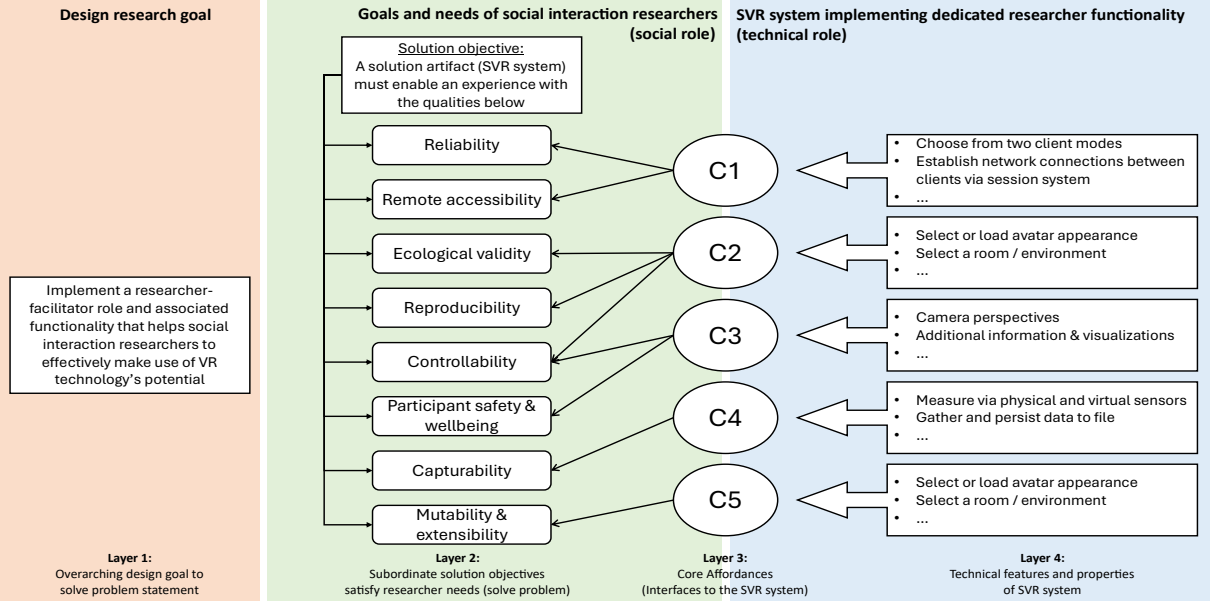

Figure 3. Problem and Solution Space are connected through five core affordances.

4.2 Artifact Design, Affordances, and Implementation

The following section details the features and properties of VERSE and the resulting researcher-perceived affordances, as well as how the enactment of these affordances contributes to the subordinate solution goals outlined above:

VERSE enables researchers to **(C1) connect with participants and join the shared virtual environment as non-immersive users**. This feature ensures that virtual social experiences created with VERSE are remotely accessible and do not require the researcher to be physically present in the laboratory setting. To support this, VERSE provides two distinct user modes: a Participant mode, designed according to established principles for immersed users of SVR systems, and a Researcher mode, which operates through a non-immersive desktop interface. All users can connect to a shared session through a session–code–based networking system, in which individuals enter their identifier along with a pre-agreed session code to join the environment. In VERSE, the shared virtual environment is hosted on the researcher's client, which functions as the ground truth reference for the experience. To ensure high system reliability, VERSE includes several recovery mechanisms. For example, if the researcher temporarily loses connection, one of the participants automatically assumes the host role and maintains the ground-truth state of the session until the researcher successfully reconnects.

VERSE enables researchers to **(C2) create tailored virtual social situations for specific research goals** with greater ecological validity than conventional laboratory settings. It supports the construction of situations that are unsafe, unethical, or impossible to implement physically, thereby facilitating the examination of behavioral responses under realistic yet fully controllable conditions. The virtual social situations can be precisely specified across multiple dimensions, enhancing both experimental control and reproducibility. Researchers can define interaction types by selecting social actors and configuring individualized actor profiles (see Figure 4, label 2). These profiles include selecting custom avatars using the ReadyPlayerMe avatar creator and adjustable action capabilities such as locomotion, verbal communication via voice chat, and hardware-tracked nonverbal behaviors (e.g., facial expressions, eye movements, gestures). The virtual environment can likewise be configured by selecting from curated scenes and modifying objects or features to match study requirements (see Figure 4, label 1). Finally,

each actor profile is positioned within the environment and assigned to a connected participant, who then enacts the role during the interaction.

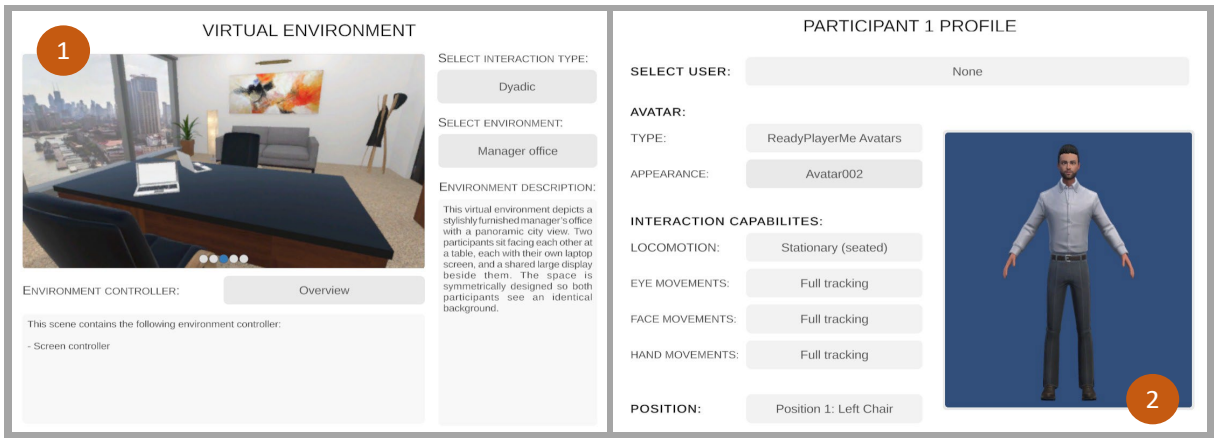

Figure 4. Experiment Setup View.

VERSE empowers researchers **(C3) to control the virtual environment and the social interactions among participants**, thereby ensuring that targeted social dynamics can be reliably induced while safeguarding participant well-being. Its real-time monitoring tools enable observation from multiple freely positionable or predefined camera perspectives, including views synchronized to participants' head movements (see Figure 5, label 1). Additional visualization options (e.g., name tags and gaze indicators) support detailed situational awareness. During active sessions, researchers can modify the environment through dedicated control interfaces, for example by displaying images on screen objects within the virtual environment (see Figure 5, label 2). They can also intervene directly at the participant level by muting users, toggling their visibility, regulating object-interaction capabilities, or repositioning them within the scene (see Figure 5, label 3). Built-in voice communication further enables immediate guidance or corrective intervention.

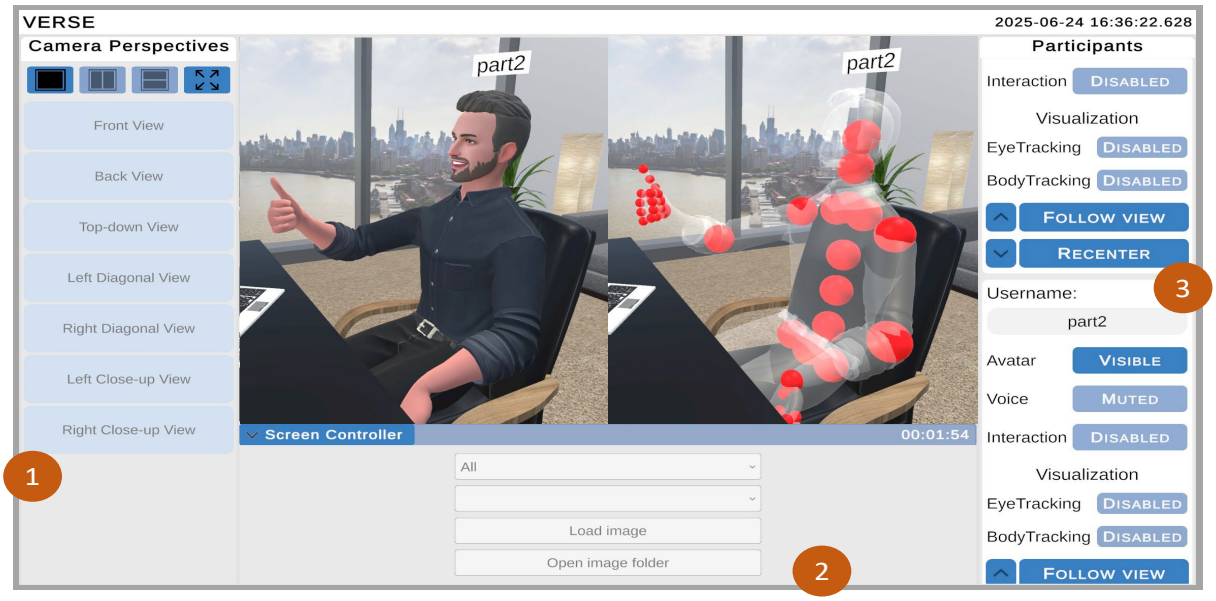

Figure 5. VERSE researcher view.

VERSE also provides researchers with the option to **(C4) collect extensive data of virtual social interactions in an unobtrusive manner**, enabling analysis without reducing ecological validity. To this end, VERSE includes functionality for continuous tracking of multiple behavioral data streams. Building on the framework of Rose et al. (2025), these include physiological and behavioral data captured by the HMDs hardware sensors (e.g., eye movements, facial expressions, hand and body

gestures, or recorded voice), as well as socio-spatial behavioral data recorded within the virtual environment using virtual sensors. The latter comprises participants' positions and movements in the virtual space, their eye gaze direction, and their interactions with other participants or with elements of the virtual environment. In addition to these continuous behavioral measures, VERSE supports comprehensive event logging. The system automatically records all system-level events (e.g., the completion of environment loading) as well as all researcher-initiated manipulations and interventions executed during the session. All collected data is processed and stored locally on the researcher's PC. At the end of the experiment, the data can be exported as CSV files and event-log text files, containing all selected behavioral and system-level variables chosen for recording.

VERSE is designed to encourage researchers to **(C5) customize and continue the system** by adding functionalities required for highly specific or emerging research questions. This extensibility is enabled by its open-source codebase and component-based architecture, which allow new environments, environment controllers, or data measures to be integrated with minimal effort. Built in the freely accessible Unity engine and compatible with standard assets, VERSE is accompanied by comprehensive documentation that further facilitates adaptation. Technically, VERSE is implemented as a standalone application. It supports Meta Quest devices, building on the Meta XR SDK, but full feature availability (particularly eye and face tracking) requires Meta Quest Pro devices. Virtual environments were built from Unity Asset Store assets; avatars were generated with the ReadyPlayerMe SDK and animated with FinalIK. Multi-user networking relies on Photon Fusion for synchronized movement, tracking, and interaction data, while voice communication is provided through Photon Voice 2. VERSE is released as a ready-to-use PC application and as open-source software. Due to licensing restrictions, external licensed assets cannot be redistributed; however, the documentation explains where to acquire and how to integrate any required assets. Nearly all external assets (except for the 3D environment assets) are available at no cost. The application, source code, and accompanying detailed documentation, including a dedicated section on ethics and data governance, are available at: https://spatialytix.org/verse.

5 Evaluation

As outlined in Section 2, the evaluation process comprised two stages: (1) a reflection of our internal use practices and observations from a pilot study, and (2) the collection of expert feedback through interviews conducted following a live demonstration of the tool. However, this is just a schematic representation of the continuous, iterative evaluation loops that occurred in the participatory design process. The integration of diverse methods and stakeholder involvement generated a rich and multifaceted body of evaluation data, exceeding what can be comprehensively examined within the scope of this paper. Accordingly, the following section provides a focused synthesis of the most relevant findings in relation to the research goal.

Evaluation results from practical use: The pilot study validated the system's operational stability and its core features in a realistic interaction scenario. Overall, the system afforded the intended research use: researchers could configure dyadic scenarios, monitor sessions, and export rich behavioral data without additional programming effort. Post-experiment questionnaires indicated high levels of social presence and a convincing face-to-face interaction illusion, suggesting that VERSE can support ecologically valid social experiences while preserving experimental control, remote accessibility, and comprehensive data capturability in line with our solution objectives. At the same time, this naturalistic evaluation exposed several design gaps. Unstable institutional networks caused occasional participant disconnects, prompting the implementation of a reconnect mechanism to improve technical reliability. Usability feedback also revealed that avatar selection via external links was cumbersome; in response, we integrated an in-tool avatar gallery with visual previews to streamline session preparation. Finally, reflecting jointly with the collaborating research team led us to refine and prioritize the initially literature-based solution objectives, elevating ecological validity, controllability, reliability, and extensibility as central design foci for subsequent iterations of VERSE.

Evaluation results from expert interviews: Overall, the experts expressed a highly positive perception of VERSE and unanimously emphasized its relevance for their own research contexts. As one expert

noted, *"I really like that it's built with a focus on what the researcher needs, and I can see that in the design"* (Researcher 2). Multiple researchers highlighted the potential of VERSE to enhance, streamline, and in some cases entirely transform existing study procedures by replacing traditional stimuli with immersive virtual social experiences. One expert illustrated this by reflecting on previous work: *"I would just replace that whole experimental setup. Anytime I'd be trying to create a real-world environment on screen, I'd replace all of that with VR. There'd be no need to do the basic one anymore"* (Researcher 3). Key advantages identified by the interviewees included the platform's comprehensive data-export functionality, particularly the integrated eye-tracking features. These capabilities were described as highly valuable for behavioral research, offering greater precision and accessibility than many conventional laboratory setups. Participants also emphasized the utility of the platform's extensive control features for conducting remote and multi-user experiments, noting that these functions help address common challenges related to participant safety and technical support. As one expert remarked, *"I really liked the key features that we need—muting participants, recentering them, and all of that is really easy and very on the ball"* (Researcher 6). Beyond its functional strengths, the tool's high usability was repeatedly acknowledged. Several interviewees contrasted VERSE positively with the typically limited usability of existing research software, describing it as considerably more intuitive and supportive of efficient study execution. When asked about possible extensions, experts emphasized the value of recording and replaying avatar-based interactions, noting that live sessions leave little capacity for real-time analysis. Retrospective review using the full visualization features was therefore considered highly beneficial and potentially useful for new study designs, such as external observer evaluations. Two researchers also expressed interest in integrating virtual AI agents as additional social actors.

6 Discussion

Insights from our pilot study using VERSE and the external evaluations obtained through expert interviews indicate that our design artifact successfully addresses its overarching design goal: to support researchers in the investigation of social human behavior and to enable them to realize the advantages that VR technologies promise for empirical work. Notably, all interviewed researchers identified clear value in VERSE for their respective fields and expressed the intention or willingness to integrate VERSE into their research practices. This convergence suggests that our design strategy, which emphasizes the researcher's ability to shape, observe, and measure virtualized F2FI rather than focusing on highly domain-specific experimental paradigms, is well aligned with the cross-disciplinary needs of social behavior research. This cross-disciplinary alignment is further illustrated by two ongoing studies that leverage VERSE's core capabilities: First, building on VERSE's infrastructure, a dedicated prototype for more inclusive job interviews for autistic adults examines how sensory reduction, algorithmically maintained eye contact, and asymmetric individualization of the virtual environment can reduce social complexity and stress in interview situations (Rehmer et al., 2025). Second, an ongoing study on prosocial behavior varies the perceived human-likeness of interaction partners and beliefs about human vs. AI control to examine cooperative behavior in virtual environments. Beyond these application scenarios, the evaluation results are encouraging, yet the long-term success of VERSE will depend on its adoption and long-term use in full-scale studies conducted by researchers beyond our immediate research team. At the same time, the extent to which researchers will fully leverage VERSE's customization and extensibility remains an open question. VERSE was intentionally designed as an invitation to co-creation, enabling researchers not only to run studies but also to adapt and extend the system through modular components. Realizing VERSE's full potential, therefore, depends on whether non-technical or semi-technical researchers perceive such customization as accessible and meaningful for their work. If this occurs, VERSE may evolve beyond a research tool into a community-developed research platform, collaboratively expanded by a broad research community. Such a trajectory would continue the participatory ethos that underpinned VERSE's original design process.

In terms of the DSR knowledge contributions (Gregor & Hevner, 2013), we primarily position our instantiation artifact, the VERSE tool, as an improvement, as it consolidates and extends the fragmented functionality of existing VR experiment systems into a coherent, researcher-centered SVR

infrastructure. At the same time, our theorizing of the researcher/facilitator role in SVR systems, drawing on Role Theory, constitutes an exaptation, transferring an established theoretical lens to a new technological and organizational context. Taken together, the VERSE framework and artifact instantiate an invention, providing a novel combination of architecture and affordances for virtually assisted activities, such as controlling and capturing F2FI, that can be applied in real-world research settings. This categorization is underscored by VERSE's low application domain and solution maturity, as defined by the Knowledge Contribution Framework.

At the heart of VERSE lies the conceptualization that the role of social human behavior researchers in SVR systems is, in most cases, that of a facilitator of social interactions. In other words, rather than interacting with the system in an immersive manner themselves, researchers craft participants' social experiences so that these experiences are (among other things) ecologically valid, controllable, and safe for participants, thereby enabling a valuable approach for studying social human behavior. When abstracting the definition of the facilitator away from context-specific factors that pertain only to the researcher and instead emphasizing the general perspective of a person who deliberately crafts an SVR experience for specific other users, this conceptualization can be applied to users across many domains beyond the research context. Many SVR use cases in other domains similarly rely on facilitator-type users, such as therapists supervising patients in exposure therapy, educators guiding learners in an educational environment, or real estate agents presenting properties to clients. The lack of consideration for the needs of user groups that can also be conceptualized as facilitators in these other domains may, as is the case in the research context, be one of the reasons for the comparatively limited adoption of SVR systems to date. This is particularly apparent in organizational contexts, where, based on the examples described above, it seems plausible that facilitator-type users can serve as proxies for organizational perspectives far more often than typical immersed users of SVR systems.

By analyzing the design of VERSE through a generalized facilitator perspective, a conceptual framework for facilitator-centric SVR systems can be derived (see Figure 5). By abstracting general mechanisms for achieving a facilitator's objectives from the affordances identified during the VERSE design process, it becomes possible to describe a corresponding system architecture, including both its structural components and the interaction patterns between different user groups and the system itself. This framework extends conventional SVR paradigms by introducing a dedicated facilitator instance accessible via a non-immersive interface that provides capabilities for control, oversight, and content authoring. Beyond merely moderating interactions, facilitators can modify the environment, initiate targeted interventions, and extract data generated during interactions. In this sense, facilitators assume a role that is closer to that of creators, and SVR systems designed for such contexts must therefore support meaningful customization and flexible orchestration. Simultaneously, facilitator-centered SVR systems should be designed to enable facilitators to effectively fulfill their role without assuming multiple development-related subroles, thereby preventing role overload.

Drawing on the design knowledge accumulated throughout this project, VERSE can be conceptualized not only as a research tool but also as a blueprint for designing SVR systems that support facilitator-evoked interaction scenarios. This is achieved by deriving two layers of generalizable guidance that extend beyond the specific VERSE implementation. At the first layer, the eight solution objectives (see Figure 3) constitute quality criteria that, although derived from a specific domain, can be adapted to other contexts in which a facilitator orchestrates virtual social experiences. At the second layer, the five general facilitator affordances (C1 to C5) can be translated into concrete design guidelines: (1) implement asymmetric user roles through distinct immersive and non-immersive interfaces; (2) enable facilitator-driven configuration of interaction scenarios without requiring programming expertise; (3) support real-time observability and intervention; (4) integrate unobtrusive multimodal data capture; and (5) ensure modularity and openness through component-based architectures. Figure 6 operationalizes these principles as a reference architecture for facilitator-centric SVR systems across domains.

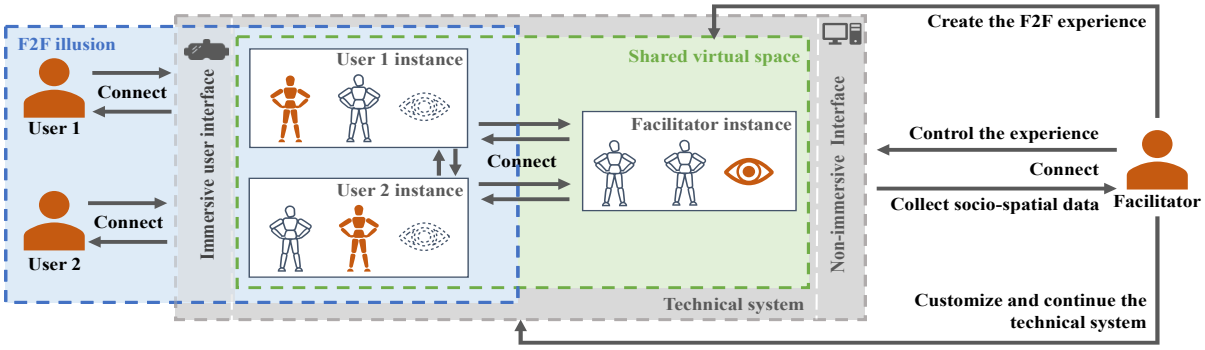

Figure 6. SVR Framework incorporating the Researcher as a Facilitator.

While VERSE helps lower barriers to experiment orchestration, configuration, and multimodal data capture, we acknowledge that it addresses only a subset of the obstacles currently limiting broader VR adoption in research practice. Decisive constraints such as hardware costs and staffing, technical setup and maintenance complexity, participant comfort and cybersickness, interoperability and standardization issues, and stringent privacy and ethics requirements for rich behavioral data remain largely external to our system and must be managed at the level of lab infrastructure and governance. We therefore position VERSE as one component within a wider research infrastructure ecosystem that needs to be complemented by institutional investment, a shared support structure, and clear ethical and technical guidelines.

7 Conclusion

This paper introduced VERSE, a researcher-centric SVR system that addresses barriers to deploying immersive virtual environments for social interaction research. Using a DSR approach and committing to participatory practices, we identified a misalignment between existing SVR systems, optimized for immersed end-users, and researchers' needs as facilitators of virtual social experiences. VERSE addresses this gap with a non-immersive interface allowing configuration, control, intervention, and unobtrusive collection of multimodal behavioral data. The evaluation included a pilot study and expert interviews. VERSE effectively supports ecologically valid, controllable, and safe interaction scenarios while streamlining study procedures and reducing technical burden. Beyond the artifact, we derive generalized affordances for researcher-centric system design and conceptualize facilitators as a core SVR user group. This perspective advances IS discourse on SVR as socio-technical infrastructures and provides a blueprint for SVR applications in domains where users facilitate, rather than experience, virtual interactions. Our evaluation demonstrates the feasibility, perceived usefulness, and usability of VERSE, representing an appropriate first step for a novel artifact of this kind. Further validation with diverse populations is currently being conducted through ongoing VERSE-based studies, including autistic community samples, adolescents with hearing loss, and hiring managers. Future research should build on this by pursuing comparative studies against established VR experiment workflows to quantify efficiency gains (e.g., setup time, configuration errors, data completeness). Regarding cross-lab replications, VERSE is already being implemented in a collaborating laboratory under the leadership of one of the authors; formal cross-lab validation and a broader dissemination strategy remain important next steps. Future work should also examine VERSE's long-term adoption and explore extensions like AI-driven social agents and replay features to expand its methodological utility.

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