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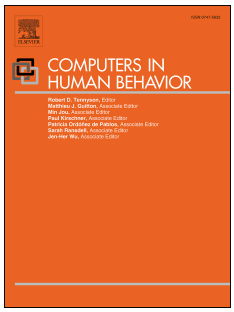

Exploring approachability in social virtual reality: Scaffolding social translucence

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Title

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Abstract

Approachability in social virtual reality (sVR), a technology with growing relevance for education and knowledge work, remains underexplored, particularly in relation to novice users. Drawing on social translucence theory and Vygotsky's Zone of Proximal Development (ZPD), this study explores how affordances for visibility, awareness, and accountability may be realised through avatar-mediated peer-to-peer scaffolding. While scaffolding may not fully explain or ensure approachability, drawing on empirical episodes from a qualitative sVR workshop with novices, we highlight its role in shaping early user experiences. This encourages attention to strategies that may help novices 'fail forward together', leveraging the inherently social nature of sVR for approachability as a developmental experience.

Keywords

Approachability; Social virtual reality; Affordances; Scaffolding; Social translucence; Zone of Proximal Development

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Competing interests

The author declares no competing interests relevant to the content of this article.

Ethics Approval

Ethical approval for this study was granted by the Ethics Committee of the University of Bristol Business School, UK (01/2022). The University of Bristol's research ethics framework adheres to international ethical standards, including the principles outlined in the Declaration of Helsinki.

Written informed consent was obtained from all individual participants included in the study, covering their participation and the publication of their data and photographs.

Exploring approachability in social virtual reality: Scaffolding social translucence

Approachability in social virtual reality (sVR), a technology with growing relevance for education and knowledge work, remains underexplored, particularly in relation to novice users. Drawing on social translucence theory and Vygotsky's Zone of Proximal Development (ZPD), this study explores how affordances for visibility, awareness, and accountability may be realised through avatar-mediated peer-to-peer scaffolding. While scaffolding may not fully explain or ensure approachability, drawing on empirical episodes from a qualitative sVR workshop with novices, we highlight its role in shaping early user experiences. This encourages attention to strategies that may help novices 'fail forward together', leveraging the inherently social nature of sVR for approachability as a developmental experience.

Keywords: Approachability; Social virtual reality; Affordances; Scaffolding; Social translucence; Zone of Proximal Development

1. Introduction

Social virtual reality (sVR) is increasingly recognised as a promising medium for collaboration across contexts such as education and knowledge work (Dey et al., 2024; Jin et al., 2022; Petersen et al., 2023; Scavarelli et al., 2021). Technologically, sVR enables avatar-mediated interaction in immersive environments, potentially reshaping how users engage with content and one another (Oumaima et al., 2023). Yet, how this potential is realised in practice, especially by novices, remains underexplored (Eugy & Bailenson, 2024; Petersen et al., 2023).

This study adopts an exploratory, qualitative approach grounded in multimodal analysis (Mondada, 2011), using video-recorded episodes of avatar-mediated interaction. Rather than aiming for generalisability, we focus on theory-building from situated encounters. While

much research addresses VR affordances (Poretski & Tang, 2022; Shin, 2017), fewer studies examine which affordances matter, for whom, and in what contexts (Jeong & Hmelo-Silver, 2016), particularly for novices outside of specialist labs and without trained facilitators (McGill et al., 2015; Spangenberger et al., 2024; Sykownik et al., 2023).

Though sVR enables rich social interaction (Hennig-Thurau et al., 2023), early encounters are often fraught with difficulty (Khurana et al., 2024; McGill et al., 2015). Novices struggle to seize promised affordances (Jetter et al., 2020), yet these formative experiences are rarely analysed in detail (Scavarelli et al., 2019; van Dijk & Rietveld, 2017). Moreover, the concept of approachability, while important, remains under-theorised in sVR contexts (Poretski & Tang, 2022; Wiberg et al., 2007).

Existing definitions of approachability are drawn from other domains. In game design, it refers to the ease with which novices begin to play without discouragement (Desurvire & Wiberg, 2015); in education, it often describes the friendliness of a tutor (Denzine & Pulos, 2000). Both emphasise 'the other', i.e., designer or teacher while overlooking the resourcefulness of the learner. This one-sidedness is limiting when inquiring into social technologies (Hemmi et al., 2009), particularly amid avatar-mediated interaction possibilities (McVeigh-Schultz et al., 2019), which shift attention from individual engagement with technology to peer-to-peer interaction.

This raises a central question: How can approachability emerge in sVR?

To explore this, we integrate two theoretical lenses. First, social translucence theory, which highlights visibility, awareness, and accountability as interaction-enabling affordances (Erickson & Kellogg, 2000; Kellogg & Erickson, 2002). Second, Vygotsky's Zone of Proximal Development (ZPD) frames learning as an interactional and socially scaffolded process (Chaiklin, 2003; Doolittle, 1997). This combination sensitises us to ways in which

novices may leverage these affordances in avatar-mediated interaction and the potential of peer-to-peer-to-peer scaffolding playing a part in this.

Empirically, we conducted an sVR workshop with novice users in a standard seminar room (Ørngreen & Levinsen, 2017), observing their interaction via head-mounted displays. Using our integrated lens as a sensitising device (Blumer, 1954), we examined micro-level episodes to trace how social translucence affordances were enacted, challenged and adapted through peer-to-peer scaffolding (Ackermann et al., 2018; Knoblauch et al., 2006).

Although our data cannot establish causal relationships, the episodes illustrate how developmental moments of approachability appear to be linked to peer-to-peer scaffolding. In particular, we propose considering how 'failing forward together' may inform approaches for social support for novices in sVR.

In this way, rather than focusing solely on long-term technical redesign of sVR platforms, our study draws attention to what users can do now with the systems available to them. Peer-to-peer-to-peer scaffolding may offer a low-threshold, socially grounded pathway for supporting early sVR use.

The following section presents the theoretical background.

2. Theoretical background

2.1 Affordances for social translucence

Affordances, i.e., possibilities for action provided by technology design, are central to understanding interactions in context (Evans et al., 2017; Scarantino, 2003). Amidst a plethora of VR affordances (Shin, 2017), social translucence theory posits that visibility, awareness, and accountability appear important for creating the conditions for effective interaction supported by social technologies (Erickson & Kellogg, 2000; Kellogg & Erickson,

2002). While initially applied at macro and organisational levels (Gilbert, 2012; Treem & Leonardi, 2013), the theory is equally applicable to micro-level interaction, including multimodal collaboration (Echeverria et al., 2019; Goyal & Fussell, 2016).

Indeed, visibility, awareness and accountability appear foundational in enabling users to perceive, interpret, and respond to one another (Erickson & Kellogg, 2000). Visibility refers to perceiving others' presence, such as via online status indicators (Stuart et al., 2012; Szostek et al., 2008). Awareness, which builds on visibility, involves interpreting others' actions within shared contexts (Echeverria et al., 2019). Finally, accountability entails a sense of mutual responsibility for sustaining joint activity (Barreto et al., 2011; Schultze & Brooks, 2019; Szostek et al., 2008).

In sVR, these affordances are partly supported by avatar embodiment, gestures, and spatial audio, which help signal presence and interpret intention (Freeman & Maloney, 2021; Petrakou, 2010). For example, avatar proximity or gestures, such as waving, may indicate readiness to engage (Szostek et al., 2008), while movements and spatial cues foster mutual understanding (Maloney et al., 2021). These features can enable joint problem-solving and exploration (Huang et al., 2023; Silseth et al., 2024). Moreover, affordances may also be cascading (Michael, 2000; Overhill, 2012); for example, a gesture gains meaning when reciprocated, thereby realising awareness and enabling accountability (Pentzold & Bischof, 2019).

Yet, affordance realisation is not automatic. Rather, it is effortful and often challenging for novices (Goncharov et al., 2023; Poretski & Tang, 2022; Scarantino, 2003). This highlights the need to examine how such affordances are realised in practice (Gaver, 1992; Yakhlef & Rietveld, 2020). On the one hand, in VR, structured tutorials have traditionally been proposed to assist novices (Tusher et al., 2024), but in practice, such structured resources appear to be

often underused (Carroll & Rosson, 1987) and potentially also poorly suited to the emergent, unpredictable nature of social interaction (Kiani et al., 2020; Poretski & Tang, 2022)

Educational research, on the other hand, may provide complementary insights into how people engage with new contexts, even when these are fully mediated by technology (Chaiklin, 2003; Hua Liu & Matthews, 2005; Oumaima et al., 2023). We, therefore, turn next to the concept of scaffolding within the ZPD to explore how affordance realisation may be socially supported in sVR.

2.2 Scaffolding in the ZPD

The Zone of Proximal Development (ZPD) (Doolittle, 1997; Vygotsky, 1997) refers to the space where individuals, through scaffolded social interaction, can accomplish tasks they could not achieve independently (Chaiklin, 2003; Roth & Radford, 2010). Widely used to study novice interactions (Miller, 2011), it offers a valuable lens for exploring sVR interaction.

Central to the ZPD is the process of scaffolding, i.e., temporary and adaptive support that helps novices stretch beyond their current capabilities (Belland, 2014; Van Der Stuyf, 2002; Wood et al., 1976). Rather than rigid instruction, scaffolding involves open-ended, responsive interaction with peers (Roth & Radford, 2010) or tutors (Mercer, 1995; Van Der Stuyf, 2002), shaped by the broader social and technological context (Pea, 2004). For instance, peer-to-peer scaffolding may include vicarious modelling, offering verbal hints, asking questions, and engaging in joint problem-solving, thereby promoting shared responsibility (Belland, 2014; Rogoff, 2008). In this way, peers may bridge the gap between individual ability and collective achievement (Belland, 2014).

In sVR, avatar-to-avatar mediation is a crucial consideration (Mennecke et al., 2010; Procter, 2020; Shih et al., 2023). Avatars signal intent and need through visible actions, enabling

coordination (Biocca, 2014; Pugliese & Vesper, 2022). For example, moving toward a shared object may indicate readiness to collaborate (Freeman et al., 2022; Wu et al., 2021), though misunderstandings are common (Echeverria et al., 2019; Kukshinov et al., 2024). These challenges underscore the need to study how affordances are realised in practice (Paulsen et al., 2024).

Research on avatar-to-avatar scaffolding in sVR remains scarce, suggesting that integrating educational theory with affordance-based perspectives could potentially shed light on how approachability emerges in early sVR use.

2.3 Exploring approachability

Existing conceptualisations of approachability are fragmented. Some treat it as a personal trait, namely how approachable an individual appears (Denzine & Pulos, 2000), while others view it as a feature intentionally designed into systems (Bragdon et al., 2009; Desurvire & Wiberg, 2015). However, these perspectives give limited attention to mediated, real-time interaction between peers, as found in sVR. They also overlook how approachability depends on affordances being actively seized through mutual engagement, especially among novices. This highlights the need for a grounded, interactional account of approachability in immersive, peer-to-peer contexts, such as sVR.

To better understand novices' experiences, we argue for a lens that integrates both technological affordances and the social processes through which they are realised. Social translucence theory and the ZPD offer complementary insights, sharing a focus on interaction and the co-construction of meaning (Echeverria et al., 2019; Fernández et al., 2001). Crucially, affordance realisation and scaffolding are intertwined: affordances must be scaffolded into use, yet scaffolding relies on the action possibilities created by those same affordances (Yakhlef & Rietveld, 2020).

While affordances are central to VR design (Paulsen et al., 2024; Shin, 2017), they are not deterministic. In practice, they are seized or missed through social interaction, including avatar-to-avatar dynamics in sVR (Maloney & Freeman, 2020), which can be messier than design intentions allow (Turner, 2005). Understanding how shared purposes develop in peer-to-peer scaffolding is, therefore, key to grasping how affordances are realised (Pentzold & Bischof, 2019). On this basis, we propose combining both perspectives.

Next, we elaborate on the methodological operationalisation of our integrated theoretical perspective as a sensitising device (Blumer, 1954).

3. Methodology

This exploratory study adopts a qualitative design grounded in an interpretive paradigm (Creswell, 2022).

3.1 Data collection

We conducted an in-person sVR workshop with participants who had no substantive prior experience with sVR and did not own VR headsets. While we could not rule out brief prior exposure (e.g., demos), none had engaged in extended or structured sVR use.

Workshops are well-suited to studying emergent practices in real-world settings (Ørngreen & Levinson, 2017). Our study was conducted in a standard seminar room at a UK university, utilising six Oculus Quest headsets shared among four postgraduate participants, a researcher, and a research assistant, who both served as participant observers (Musante & DeWalt, 2010; Spradley, 1980). Participants were recruited through university mailing lists and represented a variety of disciplines. By coincidence, some were living in the same hall of residence, but the group was not a pre-existing team. The University's ethics committee reviewed the study, and participants gave informed consent. All participant names are pseudonyms.

In the room, we only had the HMD headsets, the participants' laptops, the University's Wi-Fi, and standard tables and chairs. We believe this to be a typical setup in many institutions that lack bespoke facilities, which are available in some cases but still rare (e.g., Marks & Thomas, 2022).

Data collection involved participant observation and multimodal recording (Jorgensen, 2015), including transcribed audio of the entire session, photos of the room setup, in-headset and screen recordings from spatial.io (Figure 1).

Figure 1 about here

The platform (spatial.io) features full-body avatars, gesture controls (e.g., waving, clapping), teleportation, shared virtual object manipulation (e.g., sticky notes, images), and spatialised audio (Spatial, 2025). While facial expressions in spatial.io are not animated, postures can communicate engagement. Prior to the workshop, the researcher and RA familiarised themselves with the platform during a single session.

Participants spent ~ 45 minutes in spatial.io in an unstructured activity; no roles or tasks were assigned. They explored the space freely, with the researcher and RA providing setup support (e.g., logging in and adjusting headsets). They also entered the immersive environment as participant observers (Musante & DeWalt, 2010; Spradley, 1980). Their engagement in the sVR space was non-instructional, as they participated alongside others to preserve a peer-like social dynamic, allowing peer-to-peer scaffolding processes to unfold naturally.

Afterwards, we held an informal debrief to capture participants' reflections. These were not analysed separately but informed our contextual understanding, reinforcing the perceived significance of events (e.g., taking selfies, struggling to sit). Overall, this approach offered a nuanced micro-level view of how novices experienced the sVR (Echeverria et al., 2019; LeBaron et al., 2018).

3.2 Data analysis

We analysed the data using an integrated theoretical lens with social translucence theory and the ZPD as sensitising concepts (Blumer, 1954). We focused on how peer-to-peer scaffolding supported the realisation of affordances, specifically visibility, awareness, and accountability, in sVR.

Our analytic approach drew on multimodal analysis (Heath et al., 2010; Knoblauch et al., 2006; Mondada, 2019), attending to verbal and embodied avatar-mediated behaviours. While informed by ethnomethodological conversation analysis, we did not apply micro-sequential techniques. Instead, we identified interactionally rich episodes and constructed narrative accounts to examine how scaffolding unfolded in contextually meaningful ways, focusing on the intricacies (Fraser et al., 2000; Hindmarsh & Heath, 2000) and nuances of interaction (Goldman et al., 2014).

Analysis began with repeated viewing of 3D in-headset recordings, attending to both verbal exchanges and embodied interactions such as avatar movement, gesturing, and object manipulation (Emerson, 2007; Jordan & Henderson, 1995). We paid attention to sequences that involved adaptation, especially when participants supported one another. Episodes were then selected based on three criteria: a difficulty emerged, scaffolding was initiated, and the activity either stabilised or failed. In this way, episode selection followed a form of

theoretical sampling (Jewitt et al., 2016), privileging analytical richness over representativeness.

Our analysis thus focuses on episodes where peer-to-peer scaffolding was evident. We do not claim that peer scaffolding was consistent or universally effective. Participants also engaged in solo exploration (e.g., teleporting to explore the room's boundaries and importing virtual coffee cups to place on the meeting table). The episodes selected for analysis represent instances where peer-to-peer scaffolding emerged as a response to situational needs. These were neither constant nor uniform but contingent and interactionally significant, allowing us to explore social interaction in sVR, which is the focus of our study.

In this way, our aim is not to generalise or establish causality but to explore how peer-to-peer scaffolding may shape approachability. As such, the presented episodes serve as illustrative vignettes to ground conceptual insights (Heath & Hindmarsh, 2002; Stake, 1995).

4. Findings

Our episodes illustrate how participants sought to realise social translucence affordances, i.e., visibility, awareness, and accountability, in interaction with each other in sVR.

4.1 Episode 1: Scaffolding through progressive coordination

In this episode, approachability emerges through a three-step scaffold: gestures, verbal support and embodied relocation (teleporting). In this way, visibility, awareness, and accountability were realised (Tables 1, 2, 3).

Steps 1 and 2: Verbal and gestural scaffolds

Alex's avatar turned to the centre of the virtual boardroom, and he opened the interactive content menu. After briefly scrolling, he clicked to import a virtual selfie stick into the room. Just then, Riley's avatar enters the virtual room. Spotting a pop-up about who was already in

the room, she called out: 'Hey, Alex!' though her back was turned towards him. From behind, Alex waved and clapped his virtual hands: "I'm right here!" The sound and gesture helped guide her attention (Figure 2).

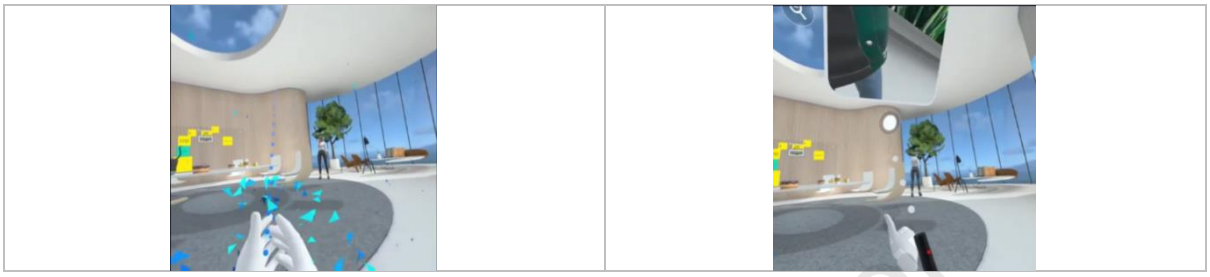

Figure 2: Alex's avatar's hands clapping and Riley's avatar waving

Riley turned toward his voice, spotted him, and waved: "Hi there!" Both laughed, acknowledging their co-presence.

Table 1 Realising visibility

Scaffold	Evidence	Affordance	Consequences for approachability
Gestural orientation	Alex waves and claps behind Riley	Visibility	Riley detects Alex's presence and confirms co-presence.

Still unsure, Riley asked, "Can you see me waving?" Alex waved back, confirming mutual visibility. Hoping to include her in the selfie, Alex asked her to move closer. But the real Riley was still adjusting her headset, delaying her response. He repeated, "I just want to take a selfie with you!" She giggled and attempted to move her avatar toward him.

Table 2 Realising awareness

Scaffold	Evidence	Affordance	Consequences for approachability
Verbal confirmation	'Can you see me waving?'; Alex waves back and confirms verbally	Awareness	Shared task goal articulated: take a selfie

Step 3: Embodied relocation

Positioning was tricky. Riley struggled to stay in frame, too close, too far. "Close, close, no, not there!" Alex told her but with little success.

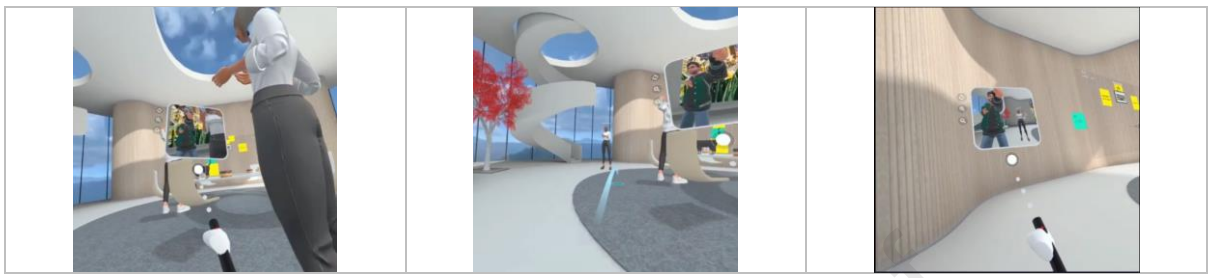

Figure 3: Riley struggles to navigate her avatar. Alex teleports closer, and both avatars finally appear in the frame.

Finally, he teleported beside her. Both avatars now in view, he hit the shutter: "Got it!" Riley, now more confident, exclaimed, "One more!"(Figure 3). Riley, now more confident, exclaimed, "One more!"

Table 3 Realising accountability

Scaffold	Evidence	Affordance	Consequences for approachability
Embodied relocation	Alex teleports to Riley	Accountability	Successful selfie, request for another

Alex tried again but fumbled with menus and interface clutter. "Just a sec," he muttered, adjusting the settings. After a few more clicks, he announced: "I think that worked." Riley turned her attention to the boardroom table, spotting another participant.

Implications for approachability

In this episode, peer-to-peer scaffolding supports the realisation of social translucence affordances, visibility, awareness, and accountability. Once consistent visual feedback is available (both avatars visible in the selfie frame), accountability can be fulfilled ("Got it!"). Riley's shift from hesitant newcomer to confidently requesting a second selfie signals a rise in felt approachability; she now engages with the space without fear of failure. No facilitator or technical intervention was needed; peer-to-peer scaffolding, in this instance, restored

interaction, suggesting that approachability can sometimes be socially produced when core technical features, such as avatar rendering, are reliable.

4.2 Episode 2: Emergent coordination through vicarious and collaborative action

In this episode, approachability emerges through vicarious trial and some role fluidity between helper and helped, leveraging and restoring visibility, awareness, and accountability throughout, despite repeated challenges (Tables 5, 6, 7).

Step 1: Vicarious trial

Alex's avatar stood near the boardroom table, uncertain of what to do. At the far end, he noticed Skyler placing sticky notes on the virtual whiteboard. He watched for a moment, then opened his content menu, selected a note, and scribbled "Hi" before quickly erasing it (Figure 4).

Figure 4 Alex scribbles 'Hi' on a sticky note, grabs a revised sticky note, and attempts to place it.

He tried again, this time writing: "Hello! When do we start?" and teleported closer to Skyler, mimicking her movements as he attempted to post the note. It floated away.

Table 4 Leveraging visibility

Scaffold	Evidence	Affordance	Consequences for approachability
Vicarious trial	Alex imitates Skyler's gesture; the note drifts	Visibility	Gesture observed, but replication fails

Step 2: Explicit help request

Unable to get the note to stick, Alex turned to Skyler: "How… uh… how do I get this to stick?" Holding out the note, he asked for help. "Perhaps I can do it for you," she offered, taking the note and attempting to place it on the wall (Figure 5).

Figure 5: Skyler works with sticky notes, loses track of one above her head, and repositions another.

Table 5 Leveraging awareness

Scaffold	Evidence	Affordance	Consequences for approachability
Explicit help request	Alex passes the note; Skyler accepts the role.	Awareness	A shared focus on task breakdown

Step 3: Role fluidity

Skyler struggled, too, losing grip of the note and scanning the space. "I don't know what I've done with your note," she laughed before spotting it floating overhead. "Ah, there it is." She retrieved it and finally placed it.

Table 6 Realising accountability

Scaffold	Evidence	Affordance	Consequences for approachability
Role fluidity	Skyler fails, then repairs	Accountability	Humour softens failure; persistence sustained

Step 4: Co-location and co-editing

Skyler read Alex's question and suggested: "Let's start with strengths and weaknesses of the VR tour." Alex agreed, and they began working side by side. Challenges persisted; for example, Skyler muttered, "I thought I was typing…" while Alex snapped, "Just stay there!" as he attempted to make another note stick. Yet both persisted, eventually placing notes on the wall. "Got it," Alex said. Skyler turned to check on the rest of the group.

Table 7 Realising social translucence

Scaffold	Evidence	Affordance	Consequences for approachability
Co-location and co-editing	Both edit notes side-by-side	Visibility, awareness, accountability	Smooth continuation without a facilitator

Implications for approachability

The interactions in this episode are indicative of how approachability during shared object work may be co-constructed through scaffolding that restores visibility, awareness, and accountability even when the technical affordances remain clumsy. During the interaction, Alex evolves from a passive observer to a confident 'co-author'. At the same time, Skyler briefly shifts from a demonstrator to a learner, managing to restore the activity when visibility breaks down (i.e., she loses sight of the note, but benevolent laughter sustains the social dynamics of the interaction). Despite multiple 'glitches', such as lost grip, drifting notes, and typing errors, neither participant withdraws from the interaction, indicating shared accountability. Their willingness to 'fail forward together' in continued experimentation may be seen as a marker of approachability as a developmental experience.

4.3 Episode 3: Limits of scaffolding in fragmented feedback loops

In this episode, approachability breaks down as participants fail to establish shared perceptual ground (Tables 8, 9, 10). Inconsistent avatar renderings and obstacles in view disrupt visibility, fragment shared awareness, and ultimately mean that accountability is not sustained, illustrating that peer-to-peer scaffolding also has its limits.

Step 1: Vicarious inquiry

Earlier in the session, Skyler had struggled to get her avatar to sit down at the table. A recent full-body avatar feature update to the spatial.io platform made avatar posture unpredictable when teleporting onto chairs. Suddenly, Skyler exclaimed: "Someone's actually managed to sit down!"

Riley replied, "Yes, it's me."

Curious, Alex asked, "How did you sit down?"

Riley shrugged: "I don't know, I just…"

Table 8 Leveraging visibility and awareness.

Scaffold	Evidence	Affordance	Consequences for approachability
Vicarious inquiry	Alex asks how Riley sat down	Awareness	Visibility intact; process unclear

Step 2: Self-test and feedback

Alex teleported to a chair. From his view, he couldn't tell if he was sitting. Riley, however, laughed: "You're standing on the chair… this is quite the chaotic meeting!" (Figure 6).

Figure 6: Alex teleports to the table, then onto the chair, glancing down to determine if he's seated or standing.

Table 9 Coping with loss of visibility and awareness

Scaffold	Evidence	Affordance	Consequences for approachability
Self-test and feedback	Riley's comment reveals posture discrepancy	Fragmented visibility	Conflicting perceptions; no shared awareness

Step 3: Perspective repair fails

Still unsure, Alex spun around: "Did I sit down?".

Figure 7 Ellis and Alex stand on chairs; Ellis leans forward to peek around the obstructing browser window.

Ellis, also on a chair, tried to help, but a virtual browser window blocked her view. She leaned forward to look around it, but by the time she saw clearly, Alex had stepped off the chair. Skyler, rejoining via screencast, saw Alex standing and added: "Not in my view, you're not." (Figure 7).

Table 10 Attempting to leverage shared accountability

Scaffold	Evidence	Affordance	Consequences for approachability
Perspective repair attempted	Multiple views offer no agreement; No shared reference point	Limited visibility, awareness and accountability	Confusion deepens; activity abandoned

Implications for approachability

This episode illustrates that peer-to-peer scaffolding alone is not sufficient; it also relies on basic technical affordances, such as consistent visual feedback for all users. Here, orientation cues fail; participants perceive different avatar postures, while verbal checks generate contradiction rather than clarity. Alex's decision to "move on" suggests that the scaffolding has failed to restore shared awareness or sustain accountability.

Yet, even in the breakdown, scaffolding helps participants identify affordance limits, giving them a shared understanding of each other's behaviour, e.g., standing on stairs, where systems are imperfect, and feedback is fragmented.

4.4 Cross-episode analysis

Across our episodes, approachability is shaped by participants' ability to scaffold one another in realising the affordances of social translucence. This process typically begins with orientation cues, gestures, gaze, or spatial audio, followed by explicit metatalk (e.g., 'Can you see…?', 'How do I…?'). When one mode, e.g. verbal instructions, seemed insufficient or unavailable, participants escalated to embodied strategies, such as teleporting or repositioning objects. Moreover, social dynamics, such as humour, helped sustain engagement

, which was in marked contrast to Episode 3, where feedback is delayed or ambiguous (Table 11).

Table 11 Finding synthesis

Episode	Technology feedback	Peer-to-peer scaffolding	Immediate outcome	What we can infer	Net effect
1. Scaffolding through progressive coordination	Gestures and voice are rendered consistently	Adaptive: gesture & talk, then teleport	Shared selfie succeeds	Reliable system feedback enables scaffolding to build incrementally	Approachability improves through confident co-action
2. Repairing brittleness through role fluidity	Object manipulation occasionally fails	Reciprocal: role fluidity, humour	Note wall co-edited	Engagement is sustained through flexible roles and humour	Approachability is maintained via adaptive collaboration
3. Limits of scaffolding in fragmented feedback loops	Ambiguous system feedback on posture	Repeated failed efforts: queries, workarounds	Task abandoned	Visibility breakdown prevents effective scaffolding	Approachability collapses when perception is unresolvable

Across episodes, peer-to-peer scaffolding acts as a contingent accelerator of approachability, helping novices persist with error-prone interactions when the system offers at least minimal stability. However, as Episode 3 suggests, peer-to-peer scaffolding is insufficient when technical designs do not provide the conditions for social translucence to be fully realised.

Taken together, our findings support the view that approachability is a situated, emergent phenomenon co-produced through the interplay of social interaction and system responsiveness. It unfolds developmentally, shaped by how effectively participants can realise the layered affordances of visibility, awareness, and accountability in practice.

5. Discussion

In this study, we examined how approachability in sVR can be understood through a social-interactionist perspective. While our episodes cannot fully explain how approachability emerges in all cases, our findings draw attention to the role of avatar-mediated peer-to-peer scaffolding in early sVR interaction and, in this way, challenge prior conceptualisations of approachability that have focused either on human-technology interaction or interpersonal dyads alone.

Specifically, our episodes foreground how participants in sVR engaged in peer-to-peer scaffolding to jointly manage coordination challenges through mutual orientation, adjustments and a shared willingness to experiment and "fail forward" together. This suggests that, in some cases, at least, managing uncertainty and partial understanding may be possible by remaining responsive to one another in early sVR interactions.

5.1 Exploring approachability in sVR

Our episodes show that approachability is contingent, not simply a product of designed-in affordances. Participants struggled with partially realised social translucence, obstructed views, ambiguous spatial positioning, and incomplete feedback, highlighting the supportive role of peer-to-peer scaffolding. These examples underscore that affordance realisation is conditional, emerging through developmental, co-constructed interaction.

Our findings suggest that affordances are actively realised through scaffolding, revealing a reciprocal relationship between technological design and social interaction. Approachability, then, appears to us as a developmental experience arising from efforts to make actions perceptible and support one another while engaging in meaningful activities through the situated realisation of technological affordances for social translucence. Peer-to-peer scaffolding, as seen in our episodes, may contribute to accomplishing that at times.

Accordingly, our conceptual model (Figure 8) provides a heuristic for considering this interplay. We do not present it as definitive but as a starting point for exploring how scaffolding shapes novice experiences of sVR, an under-theorised but important dynamic.

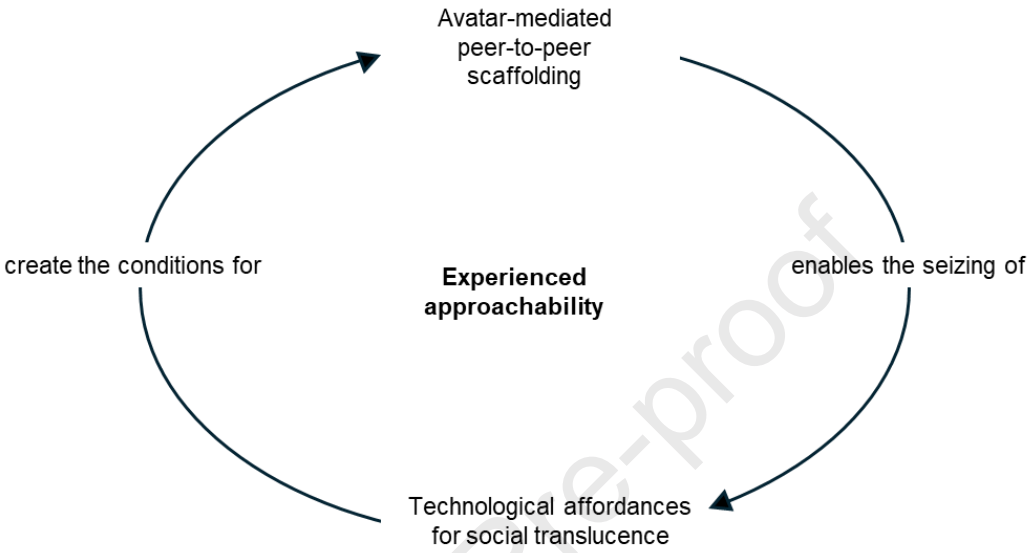

Figure 8: A proposed conceptual model of emerging approachability

The conceptual model proposes that technological affordances create the conditions (Scarantino, 2003) for peer-to-peer scaffolding to be leveraged in their realisation (Gordon & Theiner, 2015; Novick et al., 2009). Scaffolding, when used in collaboration to pursue a shared activity, may contribute to the experience of approachability, aligning with the ZPD (Roth & Radford, 2010). Approachability, in this sense, is not a static feature of sVR but an emergent developmental experience.

These dynamics are illustrated in the episodes. First, basic sVR features, e.g., rendered gestures, spatial audio, and manipulable objects, set the stage (Episode 1: gestures + selfie stick; Episode 2: sticky-note tools). When those features are at least partly reliable, participants can engage in peer-to-peer scaffolding, such as waving, teleporting, joking, or swapping roles, to capitalise on the affordances and advance the activity. That successful back-and-forth may be experienced as approachability in the moment. In turn, feeling that the

space is workable may encourage further peer-to-peer scaffolding (e.g., Riley asking for a second selfie, Alex co-editing sticky notes), completing the loop. Episode 3, however, illustrates the flip side: when the underlying affordances are insufficient for shared visibility and awareness, the loop stalls.

Thus, we frame approachability as a situated, dynamic process shaped by the interplay of design and interaction in lived sVR experiences. Our heuristic model, grounded in social translucence and the ZPD, encourages deeper inquiry into how novices engage in meaningful activity in sVR (Van Der Stuyf, 2002).

5.2 Implications for practice: Failing forward together?

Our findings suggest that avatar-mediated peer-to-peer scaffolding may, in some cases, support approachability by helping novices make themselves and others visible, build mutual awareness, and co-construct shared meaning (Kwon et al., 2014). By foregrounding how social translucence affordances are realised through peer-to-peer scaffolding, we shift attention from technological design implications toward considering social interaction in situ (Jonassen & Rohrer-Murphy, 1999; Norman, 1988).

Rather than assuming frictionless sVR use, our study foregrounds how social strategies can bridge gaps in early interaction. While prior research has examined collaboration (Freeman et al., 2022), embodiment (Maloney & Freeman, 2020), and social presence (McVeigh-Schultz et al., 2019), many studies assume a baseline level of user proficiency and focus on enhancing user experience through system design. Recent work, however, highlights persistent onboarding challenges among novices, including confusion with gestures (Khurana et al., 2024), mismatched interface expectations (Goncharov et al., 2023), and difficulties navigating social norms (Sykownik et al., 2023).

Building on this, we call for analytical attention to how novices adapt together in real-time. Our episodes illustrate how avatar-mediated scaffolding may help realise social translucence even amid breakdowns, positioning approachability as a co-constructed, developmental process, especially in open-ended sVR contexts with limited or ineffective onboarding.

Although our analysis is limited in scope, it reveals that peer-to-peer scaffolding can sometimes enable the emergence of visibility, awareness, and accountability. This invites a practical question: how can we support novices in being helpful to one another, even when none are yet fully competent?

First, designers might draw on research into help-giving and help-seeking (Grodal et al., 2015; Kiani et al., 2020) to scaffold exploratory interaction. Second, prior work suggests that normalising failure as part of getting to grips with sVR, i.e., what we call 'failing forward together', may be a worthwhile consideration when planning early sVR engagement (Poretski & Tang, 2022; Smith & Henriksen, 2016). Designing for productive failure (Kapur, 2024) may also involve paying closer attention to communicative dynamics in avatar-mediated interactions (Hide et al., 2025; Smith & Neff, 2018), including, for instance, humour (Burger et al., 2018; Zhou & Lee, 2025). In this way, our findings encourage the exploration of how social interaction dynamics can facilitate approachability in sVR environments.

5.3 Theoretical contributions

While we do not offer a comprehensive theory of approachability in sVR, our study suggests that peer-to-peer scaffolding sometimes supports novices in navigating affordance-related challenges in sVR. In doing so, it encourages attention to more than technical fixes or expert-led onboarding, pointing instead to the value of situated, collaborative effort, where users support one another in real-time to make sVR feel approachable while acknowledging that other factors also contribute. Our analysis contributes to theory in three key ways:

First, regarding the micro-level applicability of social translucence theory, we demonstrate that the core properties of social translucence, i.e., visibility, awareness, and accountability, are not inherently effective but are enacted through situated, embodied cues, such as waves, object hand-offs, and teleportation (Erickson & Kellogg, 2000). Affordances in sVR must be actively realised, not assumed, highlighting the need to study translucence at the micro-interactional level.

Second, regarding peer-to-peer scaffolding as a means to realise affordances, drawing on the ZPD, we see such scaffolding as a social process that may help activate latent affordances when the system provides enough coherence to support this. Actions such as spatial orientation, calling out via spatial audio, or guiding others through gestures reveal how users collaboratively leverage affordances for approachability. Yet, despite the increased use of VR, it has been suggested that many tools lack a solid grounding in pedagogical theory, and studies assessing their impact remain rare (Lu et al., 2024). From our research, we can suggest that the ZPD may offer a useful complementary lens for understanding how approachability unfolds as a co-constructed learning experience in sVR.

Third, by considering approachability as a socially situated accomplishment, we suggest nuancing prior work which frames approachability as either a personality trait (Denzine & Pulos, 2000) or a user interface feature (Desurvire & Wiberg, 2015). We would suggest viewing it as a shared, emergent accomplishment, which may, in some instances, be aided by peer-to-peer scaffolding. This invites a theoretical shift toward studying how social interaction dynamics and technological affordances intersect in real-time, especially in non-scripted, novice-led sVR contexts.

Finally, we consider some limitations of our analysis.

5.4 Limitations

As an exploratory, theory-building study based on three detailed episodes, our work offers depth rather than breadth. While this focus enables close interaction analysis, it limits the generalizability of the findings. Findings may differ across sVR platforms, participants, and use cases. Platforms vary in built-in affordances (Liu & Steed, 2021), and interface design can shape interaction possibilities (Wells & Houben, 2020). Our data, drawn from a small group of university student novices in a single exploratory workshop, do not reflect the diversity of real-world users or platforms (Cummings & Shore Ingber, 2024). Specifically, participants were all university students, further limiting the representativeness of the findings, given that constant exposure to new activities and challenging tasks is part of their everyday lives.

The study also draws from a single session with a fixed group size. Group composition and size can significantly shape avatar-mediated behaviour (Wang et al., 2024), which we did not systematically vary. Our theoretical sampling focused on interactionally rich episodes of scaffolding and affordance realisation, thus privileging participants who initiated and sustained shared activity. This means our analysis did not aim to capture participation across the full group.

While we focused on moments where peer-to-peer scaffolding occurred, we did not systematically compare sessions with varying levels of scaffolding, nor did we analyse sequences where it was absent. Unlike studies that systematically examine how participants manage emerging difficulties (e.g. Seuren et al., 2021; Zahn et al., 2010), our analysis was exploratory. As we did not systematically track learning outcomes (Zahn et al., 2010) or offer fine-grained repair analyses (Seuren et al., 2021), future work could extend this by studying episodes of failed coordination or breakdown to provide greater insight into patterns across contexts.

Additionally, although participants occasionally assumed informal roles, such as initiator or helper, we did not analyse group role dynamics in depth (cf. Dowell et al., 2018). Similarly, while in-person verbal reflections informed our interpretations, they were not systematically analysed.

Another possible critique is that peer-to-peer scaffolding among novices resembles trial-and-error more than structured support, i.e. that it is simply a 'muddling-through' or a 'sink-or-swim' strategy (Hadley et al., 2023). In this view, the real issue lies in inadequate interface design or a lack of structured onboarding. Structuredtured tasks or prompts may be necessary for peers to scaffold each other effectively, especially in more complex activities. Research indicates that structured pre-training can enhance task success in immersive VR (Meyer et al., 2019), and tutorials can help identify latent interface issues (Doroudian, 2023; Paulsen et al., 2024). Technical limitations, restricted social cues, or varying social presence can also limit the efficacy of scaffolding (Oh et al., 2018; Rojas-Sánchez et al., 2022).

Furthermore, struggles with orientation or self-presentation may even make peer support harder (Freeman & Maloney, 2021; Maloney et al., 2021). Thus, scaffolding should not be viewed as uniformly helpful but rather as an interactional process that can both aid and complicate progress. Moreover, scaffolding is not unidirectional. If it becomes overly compensatory, it may obscure flawed affordance design or limit equitable participation (Pea, 2004).

At the same time, dominant assumptions in instructional technology posit that variables can be fully controlled through design (Belland & Drake, 2013; Grodal et al., 2015; Kiani et al., 2020). Yet, in sVR, avatar-mediated interaction often exceeds design constraints (Turner, 2005). Scaffolding effectiveness hinges not just on correctness but on how support is experienced and negotiated (Pea, 2004). In our study, peer efforts were not always successful;

however, they fostered mutual orientation, persistence, and shared exploration, which are key aspects of developmental interaction. Moreover, research shows that peer-to-peer scaffolding is often a preferred real-world strategy for novice software users (Kiani et al., 2020).

This suggests the possibility of moving beyond control-oriented designs to a richer understanding of instructional strategies (Tusher et al., 2024), grounded in mediated social interactions (Carroll & Rosson, 1987; Kiani et al., 2020).

In sum, this study explores how peer-to-peer scaffolding can support leveraging affordances for approachability in sVR. It highlights moments where support fostered continuity. Yet, our analysis is based on a small number of illustrative episodes and does not claim that scaffolding is universally necessary or sufficient for approachability. Rather, we offer one possible way through which participants collaboratively realise affordances.

To further develop and refine these ideas, several directions for future research can be suggested.

5.5 Research agenda

As a first area for further research, comparative studies across different sVR platforms could seek to clarify how platform-specific affordances create differing conditions for visibility, awareness, and accountability, i.e., the foundations of social translucence, and how these, in turn, may influence peer-to-peer scaffolding and approachability.

Second, while our study focused on observable in situ interactions, future work could examine the emic perspectives of how participants experience scaffolding. Different scaffolding modes, such as verbal, gestural, and spatial, may contribute differently to engagement, confidence, or task success (Pea, 2004), and alternative methods, like think-aloud protocols, may provide more insight into their experiences. Similarly, our emphasis on

social translucence affordances is only one possible angle; theories of motivation and self-efficacy (Ryan & Deci, 2017) may reveal further dimensions influencing approachability.

Third, future research could investigate the comparison and potential complementarity of peer-to-peer scaffolded exploration with structured onboarding approaches. While prior studies have shown that pre-training improves outcomes in immersive VR (Meyer et al., 2019), the comparison and potential interaction with spontaneous scaffolding in open-ended contexts remain unclear. Experimental or mixed-methods studies could potentially be used to assess their relative effectiveness across different user types and tasks with different levels of complexity.

Fourth, future research should pay greater attention to group composition, size, and emergent roles in sVR interaction. Prior research has already established that group dynamics influence nonverbal behaviour and social strategies (Wang et al., 2024). As such, possible asymmetries, such as those between ‘dominant helpers’ and more passive participants, may affect both the success of peer-to-peer scaffolding and how affordances are realised. Studies that aim to systematically analyse these role dynamics could potentially advance our understanding of approachability.

Relatedly, more advanced methods, such as those involving gaze tracking, spatial movement analysis, or AI-based pattern recognition (Andrist et al., 2018; Ouyang et al., 2023; Wells & Houben, 2020), may reveal thus far underappreciated interaction patterns, thereby extending prior research methods.

Fifth, future research might give greater attention to sociocultural norms. Our Episode 3, for example, illustrates how ingrained expectations, such as avatars sitting at the start of a meeting, shape how affordances are interpreted. Riley's remark about the "chaotic meeting"

reflects the disruption of a cultural norm (Mansfield et al., 2018) and illustrates that affordance realisation is not neutral but culturally situated (Ramstead et al., 2016). Similarly, contextual elements, such as the use of selfie sticks (Karwowski & Brzeski, 2017; Saltz, 2014), further illustrate this. Therefore, cross-cultural research could unpack how norms around space, formality, or timing influence perceptions of approachability.

Finally, while we have focused on foundational affordances through the lens of social translucence, not all scholars agree that face-to-face communication is the best baseline for sVR (Erickson & Kellogg, 2000). Alternative perspectives may be needed to explore more complex affordances (McVeigh-Schultz & Isbister, 2021), particularly through diverse methods and contexts (Makransky & Petersen, 2023; Maloney & Freeman, 2020; Paulsen et al., 2024).

6. Conclusion

This study offers an exploration of how avatar-mediated peer-to-peer scaffolding may help realise affordances for approachability in sVR. Rather than viewing approachability solely as a function of system design or user disposition, our findings reveal some of its interactional facets. Specifically, we illustrate participants' shared efforts to realise social translucence affordances, i.e., visibility, awareness, and accountability, as they are enacted in real-time through peer-to-peer scaffolding.

By foregrounding the lived dynamics of peer-to-peer scaffolding, we expand the conceptual toolkit for understanding novices' early experiences in sVR. Our findings highlight how participants use gestures, repositioning, talk, and humour to proceed despite incomplete or ambiguous feedback and maintain engagement. This illustrates a socially grounded pathway through which approachability may emerge, especially when formal onboarding or expert guidance is absent.

At the same time, this study has limitations. We do not propose a general theory of approachability, nor can we assess the relative value of scaffolding compared to interface improvements, structured onboarding, or individual learning strategies. Based on a single session with a small group of novices on a single platform, our findings are not generalisable, and we cannot measure long-term outcomes or isolate the effectiveness of specific scaffolding practices. As such, the conceptual model we offer is heuristic rather than definitive.

Still, these limitations do not diminish the contribution of our qualitative, exploratory study. We suggest a useful reorientation: from assuming approachability stems from seamless design to recognising it as a situated, collaborative effort, a process shaped by interactional adaptation and peer responsiveness. In this light, approachability may arise not from avoiding failure but from failing forward together.

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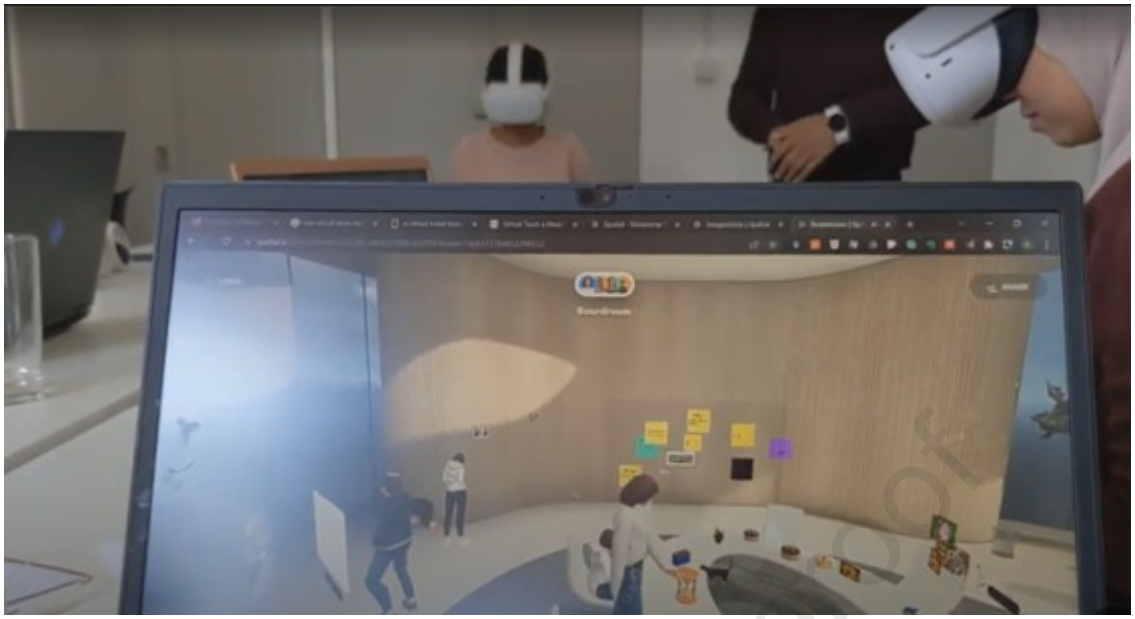

Highlights

- Explores how peer-to-peer scaffolding may shape early experiences in social VR (sVR)
- Considers how novices realise visibility, awareness, and accountability in practice
- Analyses situated episodes of avatar-mediated peer-to-peer scaffolding in sVR
- Proposes a heuristic to explore approachability as a developmental experience

Declaration of interests

☐ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☒ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Katharina Burger reports financial support was provided by Bristol Digital Futures Institute (BDFI) at the University of Bristol, UK. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.