

**DFL**

Charting Out Safety Training Goals for Developing a Pedagogical Model for Immersive Virtual Reality Safety Training: A Qualitative Study

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ABSTRACT

The best instructional practices for immersive virtual reality (IVR) use in workplace learning contexts remain undefined after decades of research. Increasing the methodological range and rigor in the study of educational IVR have been proposed. To address these issues, we performed a qualitative study that contributed to the development of a pedagogical model for IVR safety training. The model is based on simulation training and draws on sociocultural and cognitivist perspectives on learning. Our research question was ‘What kind of training goals do the safety trainers perceive for their organizations, themselves, and the learners?’ Thematic interviews were performed on 18 safety trainers from two work organizations to gain insight into their professional perceptions. The interview data was subjected to deductive and inductive qualitative content analyses. Our findings revealed that the trainers consider upholding organizational safety culture and practices that ensure everyone’s safety the most important goal on all levels, despite understanding the role of external drivers for safety such as legislation and regulations. The findings contributed to the conceptualization of the pedagogical model for IVR safety training prior to the training interventions.

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INTRODUCTION

Novel technologies, especially when they appear suitable for widespread application in various commodifiable contexts, often become the subject of hype upon their introduction to consumers. Extended realities, such as augmented reality or virtual reality (VR), are no exception. The rapid technological development of commercial VR solutions resulted in their increased popularity in educational use in the 2010s, with researchers struggling to keep up with the pace (Checa & Bustillo, 2020; Martín-Gutiérrez et al., 2017). Commercial interest may have slightly declined since, but the appropriate educational and pedagogical uses for VR remain under debate. The lack of rigorous research on the best practices has caused some concern alongside the insufficient application of learning theory in the field (Çeken & Taşkın, 2022; Lawson & Martella, 2023; Radianti et al., 2020; Skulmowski, 2023). Methodological improvements such as the application of design-based research (DBR) and intervention studies and improved learning outcome measurements have been suggested (Checa & Bustillo, 2020; Luo et al., 2021; Radianti et al., 2020). Grounding empirical research more firmly in learning theories by, for instance, designing training interventions by using established taxonomies for learning objectives and outcomes has been recommended (Lawson & Martella, 2023).

Occupational safety training (OST) is an example of a training topic that appears to be well-suited for immersive virtual reality (IVR) education. IVR is commonly understood as an artificial, three-dimensional environment that is accessed by immersive technology such as a head-mounted display (HMD) and hand controllers (Cummings & Bailenson, 2016). The IVR learning experience deviates from a desktop computer or web browser-based VR due to its capability to evoke a sense of spatial presence in the artificial environment in the user (Lee, 2004). Thus, in IVR the learner may experience body ownership and embodiment: a sensory illusion of possessing and controlling a body that is spatially located in the virtual surroundings (Kilteni et al., 2012). These features enable the safety trainers and training designers to place the learners in convincing but computer-generated narratives and learning situations where they cannot be subjected to actual physical harm, even in environments or conditions that would be potentially hazardous in real life (Checa & Bustillo, 2020; Morelot et al., 2021).

IVR training scenarios may be used, for example, in learning emergency procedures for unexpected situations or safety incidents, or practicing standard safety procedures, checks, and observations that are essential to the trainee's work. It has been suggested that the emotionally engaging features of IVR learning

media may support the achievement of safety training objectives particularly well (Casey et al., 2021; Rey-Becerra et al., 2023). Active worker participation and action-focused reflection have been found to be focal features that improve OST efficiency (Burke, Holman, & Birdi, 2006). Adopting a simulation learning approach where experiential IVR practice is combined with reflective face-to-face instruction may increase learning achievement, especially for behavioral outcomes (Feng et al., 2021).

Occupational safety training does not occur in a vacuum but in the sociocultural context of the workplace. The workers' subjective norms and attitudes and the support and encouragement they receive from their peers and colleagues influence the possibility of training transfer to their work (Pham et al., 2023; Tynjälä, 2013). Simulations are an effective method for building and upholding a positive safety culture (Gaba, 2004), offering a good starting point for designing models for IVR-aided safety training. To advance pedagogically viable application of IVR in OST, we have engaged in developing a theoretically grounded pedagogical model for the benefit of safety training practitioners and training providers (Lehikko, Nykänen, & Ruokamo, 2025; Lehikko, Ruokamo, & Nykänen, 2022). This paper reports on a qualitative study that advanced the pedagogical model's development early in a DBR process, preceding the model's empirical testing in training interventions in two large Finnish work organizations operating in the energy and government sectors (e.g. Lehikko et al., 2024).

Semi-structured thematic interviews were held with 18 trainers who deliver safety training and orientation in two work organizations. The trainers' perceptions of the safety training goals for the organizations, trainers, and learners will be examined and reported. In addition, the feasibility and suitability of the safety learning objectives for IVR training will be discussed (see Lawson & Martella, 2023). The interviews informed both pedagogical model and training intervention development. Understanding the trainers' views was necessary for safety training design and trainer collaboration in the empirical phase of the DBR (Billett, 2021). The findings illustrated the safety trainers' perceptions of the goals for safety training from the perspectives of different stakeholders in the workplace. This research aims to provide an example of a methodologically rigorous and theoretically grounded approach to pedagogical model development.

LITERATURE REVIEW

SOCIOCULTURAL AND COGNITIVIST VIEWS ON SIMULATIONS IN WORKPLACE LEARNING

The sociocultural learning perspective assumes that we are all situated and engulfed by the social and cultural

practices of the communities in our immediate social surroundings. Ontologically, the sociocultural view does not separate the act of knowing from the social and situational contexts where it unfolds. Artifacts of a physical or conceptual nature may carry cognitive and affective cultural content, extending our bodies and conceptual spaces and conveying meaning and information. Learning is mediated by the artifacts and tools we use. When learning at work, we participate in the social practices and interactions of the workplace; this activity also has a historical aspect (Billett, 2013; Säljö, 2004; Vygotsky, 1978). Learning is seen as a complex process that develops over time: building competence means gaining membership in the expert community. The results should be assessed by studying long-term systemic change (Sutherland, Lindström, & Lahn, 2009). This can be seen as problematic for the evaluation and development of occupational safety interventions where the learners' ability to transfer and integrate training contents into their daily work is focal (Pham et al., 2023; Tynjälä, 2013). Therefore, we advocate for considering alternative approaches to learning, such as the cognitive load theory, to complement the sociocultural view in IVR safety training development (see Billett, 1996; 2013).

From a non-contextual stance, cognitivist learning theories concentrate on the individual learners and their cognitive capacities and differences. The cognitive load theory (Sweller, 2020) proposes that the features of the learning event, instruction, and presentation of the learning content—such as the presence of external distractions that divert the learner's attention and their previous expertise on the topic—influence the learner's ability to process the presented learning content. Designing the learning event to minimize unnecessary strain on the learners' cognitive system while supporting their generative processing by, for example, providing opportunities for reflection is considered beneficial for achieving learning goals and enabling training transfer. Clearly defining the training goals and expected outcomes is considered essential for effective training design that also supports transfer to learners' work contexts, for instance, in simulation practice (Decker et al., 2013; Dieckmann, 2009; Kraiger, Ford, & Salas, 1993).

Simulations draw heavily on the sociocultural facets of learning, but they also incorporate other learning theories, such as cognitivist, behavioral and humanist approaches (Dieckmann & Ringstedt, 2013). The learners are set up for a learning experience that is artificial, designed, and possibly scripted to a degree beforehand but still authentic enough to provide them with an illusion of acting in realistic environments, incidents, and interactions, given that they exercise some suspension of disbelief (Dieckmann, Gaba, & Rall, 2007). Pre- and post-briefings envelope the experiential learning scenarios and form the sociocultural container that learners need

for understanding the learning context and appropriating the learning content in social interactions (Billett, 2013; Säljö, 2004; Wahl, 2020). However, briefings also provide necessary means for reducing the excess cognitive load inflicted on learners during the simulation (Dieckmann & Ringstedt, 2013). By introducing the relevant topics and concepts beforehand, giving clear outlines of the training session and practice scenario, and discussing the goals, trainers help learners to concentrate on the essentials during the actual simulation event and reduce cognitive noise. A similar framework can be applied in safety training settings where the practice scenario is performed in an IVR environment to support the social and contextual aspects of workplace learning.

The trainer may aim to establish and uphold an emotionally safe atmosphere for the session to support the learners in maintaining a positive attitude toward learning and to minimize any adverse effects from human or technical errors and failures during the training (Decker et al., 2013; Rudolph, Raemer, & Simon, 2014). The learners' previous experiences, attitudes, and beliefs can be discussed, and new concepts, artifacts, or interpretations of the existing knowledge can be introduced; ultimately, the learning experience can be reflected on, made sense of, and integrated into learners' personal histories and previous knowledge (Billett, 2013). During the facilitated briefings, learners may set their personal goals for the session and self-evaluate their performance afterward with the help of the trainers' constructive feedback (Decker et al., 2013; Dieckmann, 2009).

IMMERSIVE VIRTUAL REALITY'S STRENGTHS AND WEAKNESSES AS LEARNING MEDIA

Sutherland, Lindström, and Lahn (2009) have suggested that affordances—the opportunities for action that may or may not be perceived and acted upon by the perceiver (Gibson, 2014)—are primarily associated with the physical tools and artifacts. Nevertheless, an immersive and embodied virtual training environment that is accessed by the appropriate technological equipment could be considered to possess both physical and conceptual dimensions and, therefore, have affordances of its own. The learner does not perceive the virtual environment directly; their visual perceptions are mediated by the technology that is used to create the illusion. Due to technological limitations such as a narrower field of vision, the learner may have to move and look around considerably more actively to perceive the available affordances (Bhargava et al., 2020; Gibson, 2014). Visual cues called signifiers can be used to help learners identify the available actions (Norman, 2013) (Figure 1).

Currently, there are several alternative ways to create artificial environments for a training scenario: for instance, game engines and 3D design applications,



Figure 1 A screenshot of an IVR training scenario on X-ray baggage inspection. An X-ray machine stands in a room, and a cabin bag sits on the floor next to the machine's conveyor belt. A red pointer connects the bag to a blue shape that indicates the placement of the user's right-hand controller. Floating text on the bag says 'Place on the belt' to inform the user of the action that will follow from clicking on it—picture courtesy of Finnish Institute of Occupational Health.

360-degree photography, scanning, or a combination of these (Nebel et al., 2020). Depending on how the IVR environment has been created, it may have different affordances for the learner and a varied range of choices available for the instructional designer. For example, a 3D-programmed environment may afford walking around and freely accessing the virtual training area from all angles. In contrast, an environment built using 360-degree photography may only allow the learner to switch between specific predetermined locations, i.e., to 'teleport' into certain spots in the virtual space while staying physically in the same location in the real world. As illustrated by Figure 1, the IVR environment that was used in our training interventions was 3D-programmed. The training scenarios were presented to individual learners from a first-person perspective. The scenarios included familiar objects and sceneries such as machinery and workspaces from the learners' everyday work environment, and the safety-related interactions and events associated with these. During the scenario, learners were able to walk over the virtual and physical training area within pre-determined four by four -meter boundaries.

Congruence between the virtually presented and the learner's actual physical sensory data influences their sense of embodiment (Pritchard et al., 2016), but no conclusive evidence is presently available on the significance of embodiment for learning gains across different learning objectives. Emphasis on photorealism at the expense of instructional considerations may cause an overload on the learners' cognitive system, reducing the educational value of the experience (Mayer, 2024; Sweller, 2020). Training transfer is considered to be largely dependent on the various aspects related to the validity and fidelity of the IVR experience, such as psychological, physical, or affective fidelity (Harris et al., 2020).

The influence of technical and social fidelity of the learning experience on learning outcomes has been previously debated in the field of simulator education. The lack of realism in the simulators has been associated with unintended, possibly harmful learning outcomes and negative skill transfer. Some authors, however, have pointed out that the dissimilarities between real-life and simulator practice may also provide instructional opportunities, especially for learners with prior experience in the task (Dieckmann, Gaba, & Rall, 2007; Sellberg,

Nordenström, & Säljö, 2024; Wahl, 2020). Similarly, the visual and haptic, i.e., touch-based, features of the technology used to access the IVR environment should be considered in relation to the relevant learning objectives and expected learning outcomes in the training design.

Cognitive learning outcomes correspond to declarative and procedural learning objectives, such as learning new concepts or principles and applying them in problem-solving (Anderson & Krathwohl, 2001). Attitudinal learning objectives, such as improved self-efficacy, motivation, or aptitude for teamwork, are connected to affective outcomes that depend on the acceptance and internalization of values (Krathwohl, Bloom, & Masia, 1973). The affective and cognitive goals are often intertwined. For instance, Wahl (2020) proposed that the goals of acquiring technical knowledge and enculturation within the community of practice overlap in technology-mediated maritime safety simulations. Psychomotor learning objectives may include detailed hand-eye coordination; however, some procedural learning is also linked to the skill-based outcomes, such as when one learns to operate a type of machinery (Kraiger, Ford, & Salas, 1993).

Considering the possibly engaging and embodied features of the IVR experience, it appears to be better suited for teaching procedural rather than declarative training content. Nevertheless, Gao, Gonzalez and Yiu et al.'s (2019) systematic review of computer-aided health and safety training in the construction industry found evidence of VR's effectiveness for safety knowledge acquisition. A simulation learning approach where IVR is applied as the experiential training component has been proposed to support knowledge acquisition and behavioral outcomes based on empirical results (Feng et al., 2021). Previous empirical studies indicate that IVR may be a suitable training media for self-efficacy and motivation-related learning objectives in various learning contexts (Makransky, Borre-Gude, & Mayer, 2019; Makransky & Lilleholt, 2018; Meyer, Omdahl, & Makransky, 2019; Stenberdt & Makransky, 2023). Safety-related self-efficacy improvement is a typical safety training objective, as it is considered to enhance training transfer to work (Burke, Holman, & Birdi, 2006). Previous studies from IVR use in occupational safety training suggest that it supports both cognitive and affective learning gains (e.g., Rey-Becerra et al., 2023); however, supporting the learners' agency and involvement through the instructional and interaction design of the IVR scenario may be particularly important for self-efficacy related objectives (Bandura, 1997; Lehikko et al., 2024).

RESEARCH QUESTION

To successfully design IVR safety training based on simulation learning principles, it is vital to understand the

sociocultural setting for the training at the organizational and team levels and to apply this knowledge in the design process (Billett, 2013; Tynjälä, 2013). Identifying the goals and expectations for the safety training and assessing the viability of the safety learning objectives in relation to the affordances of the IVR training media provides a solid foundation for training design. Studying the safety trainers' perceptions of the various goals and expectations involved deepened our understanding of the sociocultural context for the safety training interventions in the target organizations. The examination of the safety learning objectives highlighted the limitations of the IVR learning environment that was used in the training interventions. The study's research question was, 'What kind of training goals do the trainers perceive for their organizations, themselves, and the learners?'

MATERIALS AND METHODS

Situational and contextual considerations are essential for the constructive research paradigm, associated with social constructive and sociocultural approaches to learning (Creswell, 2009). The present study was performed in the beginning of a DBR to improve the contextual validity, and to advance the conceptual development of the pedagogical model used in the interventions. The DBR method comprises cyclical phases of proposing a design, repeated testing and reflection on the results, leading to redesign and, eventually, a new testing cycle (Amiel & Reeves, 2008). As a method, DBR demands flexibility from all the parties involved (Moore et al., 2023); however, it also enables researchers to lift the weight of conducting rigorous research off the practitioners (Amiel & Reeves, 2008). In workplace learning research, it may be necessary to carefully select the research activities that demand intense involvement from personnel in the collaborating organizations to minimize the impact on their daily operations. We sought to improve our understanding of the context through the practitioners' lens by performing trainer interviews in the first stage of DBR (e.g. van der Wal et al., 2021), which allowed us to engage a larger number of the safety training professionals than would have been possible in workshops. The study provided us with insight on the training context, and helped us to prepare for the training interventions in the empirical phase.

Thematic interviews are often performed to elicit views or opinions directly from the participants in a coordinated exchange. The interviews can take place during a teleconference or a telephone call; unlike some other qualitative methods of data collection, they do not require the researchers' presence on-site. The interview recordings can then be organized, transcribed, and subjected to data analysis. The theoretical approach and the research question direct the selection of the analysis

methods (Creswell, 2009). In this study, thematic interviews were selected as a data collection method to gain an in-depth understanding of the trainers' current beliefs and perspectives on the safety training goals within the sociocultural contexts of their work, i.e., the organizational safety culture and training situations. The interview script was designed to prompt the trainers to discuss their perceptions of the organizational goals, their own goals, and the learners' goals on the basis of their own experiences as expert practitioners (e.g. Tynjälä, 2013; van der Wal et al., 2021).

DATA COLLECTION AND ANALYSIS

The study was reviewed and approved by the Finnish Institute of Occupational Health's Ethical Committee. The review covered essential aspects of the study such as the interview script and the data handling and privacy procedures. Eighteen safety trainers were interviewed: Eleven trainers from a government services organization and seven trainers from an energy sector company. They were recruited by contact persons within the work organizations on the basis of informed consent. These individuals were approached for their practical experience in safety promotion and first-hand knowledge of the factors that contribute to successful safety training. The sample also involved both contact persons, as they fulfilled these preconditions and were considered key actors in the safety training development. The contact persons informed other potential interviewees of the study and asked if they were interested in participating. They had permission to participate in the interviews during their working hours. If the trainer agreed, their email address was then passed on to the first author, who contacted them with further information and documentation, such as the data privacy statement, and arranged the interview. The interview script was sent to the participants in advance. The interviewees were told they could cancel their participation in the research at any stage. Their consent was confirmed again verbally at the start of the interview.

Semi-structured thematic interviews were performed in December 2021 and January 2022 (see Appendix A for the interview script). There were two main themes in the interview that the safety trainers were asked to discuss: The goals for safety training — the object of the current study — and the trainers' pedagogical practices (see Lehikko, Nykänen, & Ruokamo, 2025). The warm-up questions concerned the interviewees' responsibilities and involvement in safety training in their workplace. The interviews took between 25 and 40 minutes, averaging 34 minutes and totaling 10 h 9 mins. They were performed online using the Microsoft Teams video conference tool and recorded on two external audio recording devices. Cameras were kept on or off according to the interviewee's preference; no video was recorded.

A service provider transcribed the audio recordings. The transcribed material totaled 55,920 words and 143 pages (size A4, with interviewer and interviewee lines single-spaced). Before being subjected to content analysis in NVivo software, the transcripts were checked against the audio recordings for accuracy and were corrected as necessary (see Hsieh & Shannon, 2005).

The content analysis of the interview data to address the research question was both theory- and content-driven (cf. Bengtsson, 2016). One or more sentences expressing a coherent thought or idea represented one unit of analysis. In the process, the interviews were read several times while an initial round of codes was created. The safety training goals, as understood by the trainers, were coded into thematic groups according to the interview script, forming a theory-driven layer in the analysis: organizational goals, trainers' own goals, and the learners' goals. Categories were then identified within the groups by coding and categorizing the recurring themes in the interviews using an inductive approach. For example, when discussing their own goals, Trainer #6 mentioned that safety training is performed according to the instructions received from the administration; this was coded into the 'applying organizational safety guidelines' category that appeared in ten interviews. In order to ensure conceptual clarity, the codes and categories were checked several times during the process and edited, occasionally renamed, combined, and regrouped as the analysis progressed. Coding was initially performed by the first author, and coding consistency was confirmed by another member of the research team (see Creswell, 2009). The findings were quantified and reported as frequencies (f) to illustrate which themes and categories dominated the interview data (e.g. Bengtsson, 2016).

FINDINGS

In the following, the findings will be presented by theme and category. The coding frequencies are reported in Table 1.

ORGANIZATIONAL GOALS

The goals reflected the trainers' perceptions of the organizational motivations and objectives for the safety training. Seventeen trainers brought up goals pertinent to ***maintaining the organization's safety culture***, including occupational safety-related practices and tactics and the values underlying them.

'We cover [safety topics] in the training, but we also observe it when implementing the training. So, there are like two angles, in my opinion.'
[Trainer #4]

THEME	CATEGORY	n	f
Organizational goals	Maintain organizational safety culture	17	27
	Comply with external regulations	7	10
	Minimize cost of safety incidents	2	4
Trainers' goals	Maintain safe work practices	17	41
	Apply organizational safety guidelines	10	10
	Deliver high-quality training	8	19
Learners' goals	Learn to work safely	17	41
	Motivation to learn	14	28
	Comply with external pressure to participate in training	6	6
	Modify attitudes and safety behavior	3	5

Table 1 Findings on the trainers' perceptions of the training goals arranged by theme and category.

Note. n = number of trainer interviews with coded units; f = number of coded units in category.

'So, the idea is that everyone who works at the plant would understand and internalize our safety goals and requirements and understand that they have been created for [the employees'] safety and not to disadvantage or burden them.' [Trainer #11]

Seven trainers discussed the need to **comply with external regulations**, such as those issued by the government and those concerning certain tasks or work roles.

'... the starting points are the requirements of the authorities, and the goals set by the authorities ...' [Trainer #12]

'We have the radiation module ... [that is required] to work safely at the surveillance zone ... and [the training] must be repeated every three years.' [Trainer #14]

Only two trainers brought up issues related to **minimizing the costs related to safety incidents**.

'... the aim is to have staff on sick leave less often and to keep the equipment in good condition ...' [Trainer #9]

'... Safety incidents should be minimized, not to have situations that cause sick leave, and also that the work environment would be safe for everyone.' [Trainer #7]

Overall, the external drivers for safety training were recognized by the trainers but discussed less extensively compared to the goals related to the organizational safety improvement tactics. Trainers in both organizations exhibited awareness of their employer's stance on safety issues and the regulations that guide and influence their

work. However, they emphasized the importance of the goals related to upholding the safe work practices and attitudes that promote the safety of the work community. This finding echoes Wahl's (2020) notion of the overlapping objectives for knowledge acquisition and enculturation.

TRAINERS' GOALS

The most frequently mentioned subcategory of the trainers' goals—brought up in 17 interviews—concerned **training and maintaining safe work practices**. In addition to discussing the safe performance of specific tasks or procedures, safety-related values and attitudes were indicated in contexts such as general safety awareness and a responsibility for everyone's safety, including not just themselves or their immediate colleagues but the general public encountered during work tasks.

'For example, when the driver must exit the vehicle [during an inspection]—how to ensure their safety.' [Trainer #1]

'Work is often carried out outdoors, in the courtyard; you need to mind the traffic, so you don't get run over and ensure that you are carrying the right kind of equipment and all that.' [Trainer #8]

Ten interviewees specifically mentioned **applying the organizational safety guidelines** as a basis for their training implementations.

'We will see to it that all staff is trained as the administration has instructed us.' [Trainer #6]

'I will try to get the [learners] to understand and internalize the instructions and guidelines and to observe all hazards particular to [the task].' [Trainer #18]

Eight trainers mentioned goals that were related to **delivering high-quality training**.

‘... the aim is for the training to be as effective as possible, for people to recognize its purpose and, ultimately, to understand—to go through it and internalize what was sought with it.’ [Trainer #12]

‘So that it would be a pedagogically sound training.’ [Trainer #14]

The trainers’ goals for safety training reflected their ability to apply their pedagogical and contextual expertise in both training design and delivery. Foremost, the trainers appeared to recognize their role in guiding learners in adopting safe working practices and attitudes. When discussing this theme, one interviewed trainer stated that they want to act as a model or an example to the group of learners in the teaching situations. From the sociocultural standpoint, the trainers apply their professional capabilities and skills to guide learners to become knowledgeable participants in safe working practices (Billett, 2013). The trainers are pedagogical experts whose involvement and activity are essential when designing and performing safety training interventions.

LEARNERS’ GOALS

When asked about the learners’ safety training goals, some interviewees expressed doubt about being able to speak on the learners’ behalf. However, all were able to name some such goals. Fourteen trainers mentioned **getting to know the operating environment, typical hazards, and safety instructions**; this was the most frequently mentioned learner goal.

‘[Students] really want to know what the dangers are, what kind of situations can arise.’ [Trainer #1]

Eight trainers identified goals related to the **drive to learn and develop in safety-related matters**.

‘Clearly, they have goals and quite a good motivation for [learning about] these topics, so that you can perform your work safely, and consider [the safety of] the rest of the work community as well, and the work environment.’ [Trainer #4]

Six interviewees mentioned learner goals related to **external pressure for participating in safety training**, such as having to pass the training to be able to work at the site or in a specific role.

‘For some, training is just something you’ve got to do ... the training has to be attended in order to be able to perform the tasks here.’ [Trainer #11]

Three trainers discussed goals related to the learners’ ability to **reflect on and modify their attitudes and behavior** to improve the safety of their work practices.

‘They should understand how to perform their job as safely as possible ... So that they would rather ask [for advice] if they are uncertain, instead of just going ahead. Because sometimes one can be more keen than skillful ... They should understand the importance of restraint in their work.’ [Trainer #16]

Interestingly, the trainers discussed the learners’ goals from two distinct angles: goals pertinent to learners’ motivations to attend safety training and those related to expected learning outcomes. They displayed an understanding of the learners’ varying motivations—some may have a genuine interest in learning more about safety topics. In contrast, others may attend the training only to fulfill the external demands and expectations of the job (Ryan & Deci, 2000). The interviewees were able to make these observations based on their experience and professional expertise; previous research has established that the learners’ initial motivation and interest in the training subject influences the learning outcomes (e.g., Tynjälä, 2013). The trainers identified learning to perform the work tasks and procedures safely as the most crucial goal for the learners.

DISCUSSION

We sought to understand how the safety trainers perceived the goals and expectations for safety training from the perspectives of all the involved parties, and to identify relevant learning objectives for safety training. Most interviewed trainers mentioned organizational goals that were pertinent to maintaining positive safety cultures in their workplaces; cultivating safe working practices, values, and attitudes dominated their responses when asked about their own goals as trainers (Billett, 2013; Tynjälä, 2013). A vision of safety as a collective responsibility in the workplace permeated the operations and tasks described by the trainers: Everyone should learn to keep both themselves and their colleagues out of harm’s way. This idea was crystallized by one trainer who emphasized that in safety training, the safety theme does not only concern the training topic—the training situation must also be safe for learners. As researchers, this was a key message for us. Upholding the learners’ emotional and physical safety was important both in the design of the pedagogical model and the training interventions.

Overall, the trainers appeared to recognize their pedagogical role and responsibility in preparing the learning content to be understood and learned as easily as possible and strived to guide the learners towards the correct and safe work practices in the training situations (Billett, 2013; Casey et al., 2021; Vygotsky, 1978). The trainers appeared to consider the knowledge of safe working procedures and safety instructions and the ability to perform the work tasks safely in the work environments as the most essential goals for safety training from the individual learners' point of view; these were brought up in 14 interviews. Based on the discussion of attitudinal learning objectives in the trainer interviews, we conclude that providing the appropriate sociocultural context for the individual training scenarios is an essential aspect of IVR safety training design. Furthermore, the pedagogical approaches for addressing issues related to learner motivation and attitudes should be studied in more detail in the next stages of the DBR.

The benefits and limitations of the IVR as a learning media must be communicated clearly when designing training scenarios or interventions with the practitioners (see Lawson & Martella, 2023). Embedding the IVR learning scenarios in a simulation training framework by adding facilitated pre- and post-briefings to the training session may help learners to reflect on and interpret scenario events and support both learning achievement and the transfer of training to their daily work. Our qualitative findings informed the development of the pedagogical model that was applied in the IVR safety training interventions (Figure 2).

In the model, a safety training event is presented linearly in four phases: Introduction, IVR briefing, IVR scenario and debriefing. Icons are used to indicate the instructional arrangement between the human trainers and the scripted IVR tutorials and scenarios.

They also illustrate the alternation between the small group setting in the introduction and debriefing phases, and the individual IVR experience that takes place in between. Cognitive and affective factors should be considered throughout the training design, not just in IVR development but by facilitative actions to reduce the trainees' cognitive load and uphold an emotionally safe learning atmosphere (e.g. Eppich & Cheng, 2015; Rudolph, Raemer, & Simon, 2014). To support the safety trainers in this regard, simple discussion scripts that included themes and questions for the training group were prepared in collaboration with the trainers to help them facilitate the introduction and debriefing phases (see Lehikko, Nykänen, & Ruokamo, 2023).

The affordances of the virtual learning environment and the IVR technology should also be observed in the training design (Norman, 2013). As the technological limitations dictated in our study context, psychomotor training goals were excluded from the model and the training interventions. However, the learning objectives must be firmly grounded on the organizational goals and aligned with the safety culture and safety-related practices of the workplace to enable training transfer and both cognitive and affective learning outcomes. Therefore, the safety trainers and subject matter experts from other operative roles must be closely involved in scripting the IVR training scenarios. Engaging all relevant organizational stakeholders is essential in the design and implementation of IVR safety training.

LIMITATIONS AND FUTURE CONSIDERATIONS

The collaboration between researchers and practitioners is a key DBR feature (Moore et al., 2023). This qualitative study was carried out at the beginning of the DBR process to support the conceptual development of a pedagogical model and to indirectly engage the expertise of eighteen trainers working in the collaborator organizations.

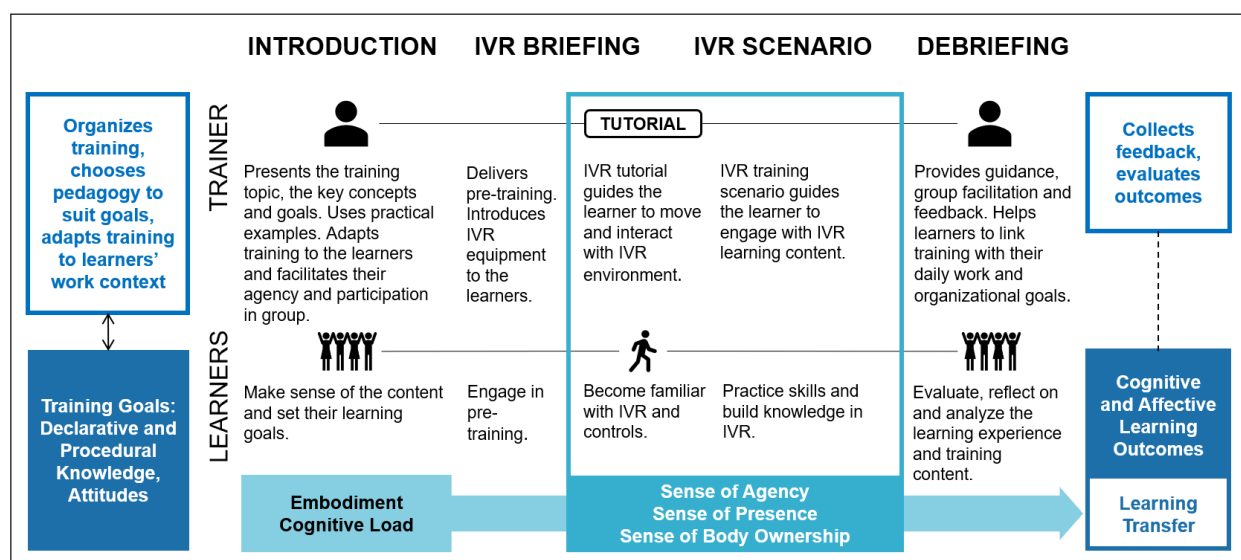


Figure 2 The pedagogical model for IVR safety training (Lehikko, Nykänen, & Ruokamo, 2025).

Only five training experts were appointed by the organizations to be directly involved for the duration of the interventions. Four of them were also interviewed for this study, two of whom acted as the contact persons for their organization. The interviewer had met these two persons previously in an online meeting, unlike the other participants. However, the interviews were performed according to the same protocol. The informants were selected on the basis of their expertise for this study. It is possible that inexperienced trainers would have discussed the training goals from a different perspective, or seen their professional roles as instructors in a different light.

Only three interviewees explicitly mentioned attitudinal and behavioral learning objectives when asked to discuss the learners' goals for safety training. The interconnectedness of the learning objectives (Anderson & Krathwohl, 2001; Krathwohl, Bloom, & Masia, 1973) was possibly taken for granted by many and thus not communicated separately when the theme was discussed. In hindsight, it may have been informative for the researchers to study sample training plans or programs to be able to interpret better and contextualize the explicated learning objectives. In qualitative content analysis, there is always the possibility of researcher bias; the data should be interrogated in depth to avoid superficial interpretations (Twining et al., 2017). Only one researcher conducted the initial analyses for this study, and coding consistency was later confirmed by another researcher. Collaboration between several researchers throughout the analysis process would have been preferred (Creswell, 2009).

A manuscript draft containing the findings presented in this study was sent to the contact persons in the participating organizations for feedback and approval. The contact persons did not request any alterations. In the subsequent DBR stages and the following iterations in the model development, the practitioners' direct involvement in the research should be given priority, and feedback should be sought more actively. For example, workshops could be arranged to subject the study findings to examination and discussion by the practitioners (e.g. van der Wal et al., 2021). Given that the psychomotor learning objectives were not included in the developed model for the training intervention, exploring alternative IVR technologies that enable the training for these learning objectives is recommended in future research.

CONCLUSION

We sought to understand the trainers' perceptions of the safety training goals by discussing the goals

from three angles—organizational, their own, and the learners'—in semi-structured thematic interviews. Based on our findings, many trainers share the view of safety as a collective responsibility that demands everyone's involvement. Our findings supported both the conceptual development of the pedagogical model for IVR safety training and the preparation and planning for the training interventions within a DBR design. This study presents an example of a research-based, pragmatic, and contextually sensitive approach towards the application of IVR in a workplace learning context.

DATA ACCESSIBILITY STATEMENT

The research data is not publicly available due to the data privacy agreement.

ADDITIONAL FILE

The additional file for this article can be found as follows:

- **APPENDIX A.** Interview Script. DOI: <https://doi.org/10.16993/dfl.237.s1>

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COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

First Author performed the literature review, data collection, formal analysis, project administration, and drafting of the manuscript. Both Authors participated in funding acquisition, research design, methodology, and revising and editing of the manuscript. Second Author also supervised the research.

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