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Pre-Implementation Evaluation of VR as a Mine Safety Training Tool

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ABSTRACT

High-fidelity, immersive training is known for its learning and logistical benefits. While other industries have used virtual reality (VR) for decades, the same uptake has not been seen in mining. NIOSH recently developed an adaptable, scalable VR training platform, VR Mine Rescue Training (VR-MRT), which has attracted significant industry interest. NIOSH is using VR-MRT to understand the barriers to adoption and implementation of VR. As a part of a larger effort to assess the effectiveness and implementation of VR-MRT, researchers have conducted pre-implementation interviews. In this paper, the authors use feedback from individuals at various implementation levels to assess the acceptability and appropriateness of VR-MRT and identify potential implementation barriers for VR more generally. Researchers also describe ongoing efforts to overcome these barriers as NIOSH works to position VR-MRT as a supplemental resource more generally for mine safety training.

Keywords: Virtual Reality, Training, Mine Rescue, Implementation Science

DISCLAIMER

The findings and conclusions in this paper are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention. Mention of any company name or product does not constitute endorsement by NIOSH, CDC.

BACKGROUND

Mine Rescue Training

Emergency preparedness is crucial in the mining industry, especially for underground mine rescue teams. These teams perform high-risk tasks in hazardous and rapidly changing environments, often requiring coordinated actions to be taken quickly and accurately. However, a recent survey found that more than 21%—more than one in every five—of mine rescue team members do not feel adequately prepared (i.e., 80% or more) to respond in the event of a mine emergency [1]. Furthermore, the mining industry has only minimally invested in new training content and delivery [2]. Moreover, many teams only receive minimal training—only 96 hours annually—in compliance with U.S. federal regulations (30 CFR 49.18). Unfortunately, this training often lacks realism. As a part of this required training, underground coal mine rescue teams must participate in at least two contests annually. These competitions have traditionally been in the form of low-fidelity competitive drills in above-ground facilities or open fields. The rules and scenarios used in these competitions also often incorporate unrealistic aspects (e.g., no gas leakage). While these features allow the competitions to be more accessible and cover more possible hazards, they lack the context and realism that has been shown to improve training [3]. Other traditional training methods, such as full-scale Mine Emergency Response Drills (MERDs) are more immersive, but are expensive and resource-intensive, limiting their frequency and accessibility. Virtual reality (VR) training may be a promising alternative.

VR as Effective Training

Previous research has shown that effective training is engaging, authentic, and understandable and includes opportunities to demonstrate, practice, debrief, and assess [4-6]. VR is a mechanism that supports all these characteristics.

Research has shown that immersive VR training helps increase engagement, performance, and retention [7, 8]. Research also has shown that immersion and the added realism of the VR increases saliency by eliciting more emotional responses from the participants [9]. Additionally, VR provides a safe means to simulate situations that would otherwise be too dangerous or expensive. Other strengths of VR are its ability to provide hands-on experience and objectively measure performance.

VR in the Mining Industry: Slow Adoption and Challenges

While VR has proven effective for training and assessment in various industries—such as the military [10]—its adoption within the mining industry has been slow. Research and development of VR applications for mining began about thirty years ago [11] with many specifically addressing mine safety training [12–14], but their scope and application was limited. Since then, new applications have been developed as summarized in a recent review and include incident reconstruction simulations, hazard awareness training, and equipment training [15]. These applications have ranged from non-immersive desktop programs [16, 17] to head mounted displays (HMDs) and treadmill setups [18], full-scale equipment simulators [19], and large theater implementations [20]. However, these applications still have limited content that may be less engaging and impactful once the trainees have already done it.

Beyond limited content, other barriers and challenges to the successful implementation of VR systems into mine safety training programs exist, including costs, portability, user acceptance, program integration, and limited industry collaboration [21–28]. While VR equipment costs have come down significantly in recent years, hardware costs can still be prohibitive. Furthermore, the development costs for the training content can outweigh the hardware investment [29]. This can be problematic because sustained learning and engagement relies on fresh content. Travel resources also play a role, especially for permanent installations [25]. The design of the system is another critical factor. User acceptance, based on system access, ease-of-use, comfort, and perceived benefit is crucial for successful implementation [30]. Lastly, previous research also suggests that dedicated staff with some specialized training may be required to set up, maintain, and operate these systems [31]. To prevent inefficiencies and failures, further research on VR implementation is essential.

Implementation Science

Implementation science (IS) is an expanding field that focuses on translating research findings into practical actions within community settings. IS research is defined as "the systematic investigation of the use of strategies to enhance adoption, integration, and sustainment of evidence-based health interventions in clinical and community settings to improve individual and population health" [32]. IS methodology asks researchers to consider how their findings could be used throughout the project cycle. The purpose of incorporating IS strategies into the development and dissemination of innovations is to clear and shorten the "pipeline" from research to practice. As summarized in Guerin et al., IS methods have been shown to be effective in hastening this translation in several disciplines, but critical gaps persist in the field of occupational safety and health (OSH) [32]. Furthermore, while IS frameworks have helped to facilitate and evaluate the translation of research into practice for several decades, such frameworks have been predominantly utilized for the post-hoc evaluation of implementation efforts [33]. Instead, Glasgow et al. advocate for the rapid and repeated use of IS strategies to inform iterative adjustments to the intervention and better facilitate the translation of research into practice [33]. This approach was successfully used in a rapid pre-implementation evaluation to identify key design factors and implementation strategies for a family engagement navigator program during COVID-19 [34]. Skivington et al. also highlight that engaging stakeholders and identifying uncertainties early can improve the feasibility and acceptability of an intervention [35]. They argue that early and continuous engagement enables iterative adaptations and refinements, ensuring the intervention better fits its intended context.

Consolidated Framework for Implementation Research

The Consolidated Framework for Implementation Research (CFIR) is a comprehensive IS framework designed to help identify factors that influence implementation success. CFIR was first introduced in 2009 [36] and has been used in a wide range of studies [37] and continues to be updated and used today [34, 38]. The CFIR 2.0 is made up of five domains—Innovation, Outer Setting, Inner Setting, Individuals, and Implementation Process—that each include a variety of constructs. Table 1 describes

Table 1. CFIR 2.0 Domainsa, Planning Questionsb, and Constructsa

Innovation	**Is this intervention superior to status quo?**
Constructs	Source, Evidence-Based, Relative Advantage, Adaptability, Trialability, Complexity, Design, Cost
Outer Setting	**Why is it important to implement this intervention now? Are there regulatory or environmental pressures?**
Constructs	Critical Incidents, Local Attitudes, Local Conditions, Partnerships & Connections, Policies & Laws, Financing, External Pressure
Inner Setting	**Will this intervention fit the system? Is it feasible?**
Constructs	Physical Infrastructure, IT Infrastructure, Work Infrastructure, Relational Connections, Communications, Culture, Tension for Change, Compatibility, Relative Priority, Incentive Systems, Mission Alignment, Resources, Access to Knowledge and Information
Individuals	**Does the staff have the skill and the will to deliver the intervention?**
Constructs	High-level Leaders, Mid-level Leaders, Opinion Leaders, Implementation Facilitators, Implementation Leads, Implementation Team Members, Other Implementation Support, Innovation Deliverers, Innovation Recipients
Imp. Process	**How is work affected by the intervention? What is needed to implement the intervention**
Constructs	Teaming, Assessing Needs, Assessing Context, Planning, Tailoring Strategies, Engaging, Doing, Reflecting & Evaluating

[a] As described in [40]; [b] Adapted from [39]

these domains through adapted planning questions [39] and lists the updated constructs [40]. The CFIR framework has been shown to be especially useful in identifying adoption and implementation barriers across each domain that can be directly mapped to implementation strategies [41]. Furthermore, Eaton et al. [38] suggested that an early structured pre-implementation evaluation can be beneficial in identifying actionable barriers and facilitators for future widespread adoption and implementation efforts. Some strategies identified from previous research include involving stakeholders at the outset, engaging subject matter experts to create meaningful content, piloting the intervention with subject matter experts, evaluating fidelity, usability, and acceptability with end users, and studying the effectiveness of the intervention. However, there are limited documented uses of IS frameworks in OSH. One of the few is Tinc et al.'s application of CFIR to identify barriers to and facilitators for the uptake of an evidence-based intervention in agriculture safety [42]. These researchers found that CFIR factors such as "access to knowledge and information," "leadership engagement" (Inner Setting), and "engaging" and "reflecting and evaluating" (Implementation Process) were significantly associated with positive intervention outcomes, suggesting the CFIR framework might be useful in other areas of occupational and public health.

VR Mine Rescue Training (VR-MRT)

Bringing together their expertise in mine rescue, training, and immersive development, NIOSH researchers have developed a VR training framework—VR Mine Rescue Training (VR-MRT). VR-MRT is a single or multiplayer VR application designed to supplement current mine rescue training. The platform focuses on scenario-based training with the goal of improving mine rescue team members' procedural, collaborative, and problem-solving skills with a focus on decision making. The trainees can visualize and interact with a mine environment using a VR headset (e.g., Meta Quest 2 and 3) and work through scenarios together with their teammates. As described in Bellanca et al. [1], VR-MRT consists of five modules: Scenario Editor, Simulation Module, Director Module, Spectator Module, and Debrief Module. The Scenario Editor allows trainers to create their own content through a drag-and-drop interface. Trainers can either use the built-in room-and-pillar style tile sets (i.e., coal, stone) that snap together or import their own geometry (e.g., LiDAR, photogrammetry). In the mine geometry, trainers can place both built-in and custom objects and hazards. They are also able to set up static ventilation zones as well as a dynamic ventilation node network that runs on NIOSH's MFIRE [43]. The Simulation Module allows one or more trainees to experience the scenarios. Trainees are either co-located or remote. They can freely walk around and interact with the environment using their tools (e.g., sound the roof) or collected objects (e.g., hang curtains). The Director Module is a desktop-based mode that allows trainers to facilitate training sessions. Trainers can select which scenarios to run, set up player configurations, monitor trainees' progress, and make changes and additions in real-time (e.g., add objects, change ventilation). Similarly, the Spectator Module is run on a desktop. The Spectator Module gives observers a birds-eye view of the simulation. This module is intended for mine rescue judging and other observers. Lastly, the Debrief Module enables playback of simulation sessions using the generated log file for an after-action review. The Debrief Module includes both a 2D and 3D view. The 2D view displays all the users' actions and movements, the map man's map, as well as the environmental conditions throughout the session (e.g., air flow, gas concentrations). The 3D perspective view depicts the trainee avatars, their motions, and their interactions to capture how and what they did. Both views can be played back continuously and scrubbed through. See Bellanca et al. for additional technical details [1].

NIOSH researchers are currently finalizing the development of VR-MRT through a multi-year evaluation effort using the RE-AIM evaluation framework [44]. The parent project of this study was conceptualized with the five dimensions—**R**each, **E**ffectiveness, **A**doption, **I**mplementation, **M**aintenance—to enhance the potential for successful translation of findings into a practical solution. In this case, researchers are using the VR-MRT platform to better understand barriers and challenges to VR training adoption and implementation in the mining industry, helping to facilitate the use of this program and inform the future design and implementation of other immersive applications for training. While RE-AIM can be useful during the implementation planning and execution stages, it emphasizes the evaluation of the overall impact and sustainability of the intervention. To better fit the current phase of the development and implementation process, researchers are utilizing a complimentary IS framework—the CFIR 2.0 [40]. Results of the first evaluation in this phase have captured the two antecedent assessments constructs "acceptability" and "appropriateness," as recommended by Proctor et al. [45, 46]. These constructs are defined as [47]:

- Acceptability: the extent to which an innovation is perceived as agreeable, palatable, or satisfactory.
- Appropriateness: the perceived fit, relevance, or compatibility of the innovation and/or the perceived fit of the innovation to address a problem or issue.

As described in Bellanca et al., surveyed mine rescue team members were overwhelmingly positive and found VR-MRT to be acceptable, usable, and immersive with limited concerns about simulator sickness [1].

OBJECTIVE

The objective of this study was to complete a pre-implementation evaluation using the CFIR 2.0 framework. First, researchers aim to assess the acceptability and appropriateness of VR-MRT for mine rescue training. Secondly, researchers aim to identify actionable barriers and facilitators to the adoption and implementation of VR safety training more generally. These results are intended to allow NIOSH researchers to preemptively eliminate or mitigate identified challenges prior to larger effectiveness and implementation evaluations efforts of VR-MRT. These results can also be used to inform stakeholders of potential strategies that they can adopt to improve implementation of any immersive trainings. This paper builds upon earlier pre-implementation efforts conducted by NIOSH to gather technical feedback from development partners such as the Mine Safety and Health Administration (MSHA), as well as end-user feedback evaluating VR-MRT's acceptability, feasibility, and usability [1].

METHODOLOGY

Data Collection

As a part of a larger evaluation effort to better understand the barriers and challenges to implementing VR mine safety and health training, researchers conducted a mixed methods study including surveys with mine rescue teams and two rounds of pre-implementation, semi-structured interviews. The protocol was reviewed and approved by the Centers for Disease Control and Prevention (CDC) as exempt human subjects research* and reviewed for public burden and cleared by the Office of Management and Budget (OMB).

The surveys and first set of interviews were conducted with mine rescue team members and trainers respectively—would-be innovation recipients and deliverers—in August and September of 2022 following a technical demonstration of the VR-MRT platform. Part of this data set was previously published [1]. The second set of interviews was conducted across all levels of a large organization that was interested in adopting VR-MRT. These interviews were conducted in November 2022. Again, all participants

* See [45] C.F.R. Part 46.104.

participated in a demonstration of VR-MRT prior to the interview. Table 2 describes the breakdown of the interview participants' demographics including their experience in their current positions, if they have ever responded to a mine emergency, if they had experience with VR, and whether they identified as a decision maker within their organizations.

Surveys

Following the completion of the technical demonstration of VR-MRT, mine rescue team members completed a survey about their experience. The survey included the following multiple choice and open-ended questions about acceptability and implementation strategy:

- Did you enjoy participating in today's simulation and debrief exercise? (i.e., yes, no)
- Given the opportunity, would you be interested in participating in virtual mine rescue contests *in addition to* traveling to a physical location to participate? (i.e., yes, maybe, no) Why or why not?
- Given the opportunity, would you be interested in participating in virtual mine rescue contests *instead of* traveling to a physical location to participate? (i.e., yes, maybe, no) Why or why not?

The survey also included three yes or no questions about mine rescue experience and VR experience:

- Do you have any mine rescue experience in a real mine emergency underground and under apparatus?
- Have you ever responded to a real mine emergency as part of a mine rescue team, but your team did not go underground?
- Have you ever experienced VR using a head mounted display (HMD) before today?

Interviews

All interviews were conducted in person with a few follow-up phone calls due to scheduling conflicts. Prior to the start of the interview, all participants provided oral consent to participate in the research. Each interview was conducted individually. The interviews were conducted with one or two researchers where both researchers took notes. The interviews lasted between 20 and 60 minutes and contained questions to capture the participants' perspective about VR-MRT and its implementation. Example questions include:

- What, if any, value do you think VR simulations like VR-MRT bring to mine rescue training?
- What do you see as the biggest barriers to using training like VR-MRT?
- In your opinion, would your organization support the use of training like VR-MRT?
- In your opinion, does your organization have the resources to conduct training like VR-MRT?
- Do you have any suggestions to improve VR-MRT in terms of ease of adoption/use?

Data Analysis

Surveys

Quantitative analysis of the survey data was conducted using SPSS statistical software (version 26, IBM), where three main analyses were performed. First, a series of Chi-square tests of independence were performed to determine whether participants' responses (i.e., yes, maybe, no) to the implementation strategy (i.e., Instead of, In Addition to) varied as a function of their mine rescue experience or VR experience (i.e., yes, no). Participants were considered to have mine rescue experience if they answered "yes" to either of the mine rescue experience questions. Since no

Table 2. Participant Demographics and Experience

	Count (N)	Median Position Exp. (yrs.)	Mine Rescue Experience		VR Experience		Decision Maker	
			Yes	No	Yes	No	Yes	No
Mine Rescue Teams								
Recipients[†]	126	7.0	54.8%	45.2%	38.8%	61.1%	N/A	N/A
Deliverers	7	15.0	N/A	N/A	14%	86%	14%	86%
Organization								
Deliverers	4	8	N/A	N/A	0%	100%	50%	50%
Facilitators	3	11	N/A	N/A	0%	100%	67%	33%
Mid-Level Leaders	4	7	N/A	N/A	0%	100%	100%	0%
High-Level Leaders	2	2.75	N/A	N/A	0%	100%	100%	0%

N/A = not measured; † = survey participants significant relationship was found, these covariates were excluded from further analyses. Secondly, a Chi-square test of independence was performed to determine if the participants were generally interested in VR (i.e., yes, maybe, no). General VR interest was determined by the highest level of interest in VR from both implementation strategy questions. For example, if a participants responded "no" to "instead of," but "yes" to "in addition to" it would be a "yes" for general VR interest. Lastly, a marginal homogeneity test was used to assess whether participants preferred one implementation strategy over the other. This within-subjects comparison examined the change in responses from "instead of" to "in addition to." Missing data were excluded on a case-by-case basis (N = 107). Significance was set at $\alpha \leq 0.05$ for all tests. Because the qualitative survey responses were brief and sometimes incomplete, no formal analysis was conducted. Direct quotes are included as anecdotal support.

Interviews

Two researchers analyzed the interview notes from all 20 interviews using a combination of deductive and inductive strategies. For this study, researchers deductively applied the five domains and 45 constructs (Table 1) of the CFIR 2.0 framework [40] to the data. The researchers used the framework guidance from https://cfirguide.org [47] and the planning questions from a previous study [39] as a basis for the codebook. From there, the researchers used a constant comparison method [48] to identify "themes" made up of actionable barriers and facilitators for each construct. To do so, the two researchers first coded two of the interviews together—one mine rescue trainer and one organizational representative. The researchers then divided up the remaining interviews and coded them independently. The researchers met periodically while coding to refine the construct and theme definitions. One hundred percent agreement was achieved through discussion.

Other Pre-Implementation Activities

An important but sometimes overlooked aspect of IS is the criticality of ensuring that the innovation is well designed for implementation prior to deployment and dissemination at scale. In addition to the data collection described above, NIOSH has been engaging in additional antecedent assessment activities as defined in the CFIR 2.0 framework. These activities align with the constructs of acceptability and appropriateness proposed by Procter et al. [45, 46].

Since the project's inception, NIOSH researchers have relied on internal and external subject matter experts to conceptualize and guide the development of VR-MRT. Development began as a partnership with the Mine Safety and Health Administration (MSHA) in 2020, and the two organizations have maintained a cooperative relationship throughout the development process. Additionally, NIOSH has developed and sustained strong relationships with multiple state agencies, mine operators, universities, mine rescue teams, and myriad other stakeholders.

Specifically, researchers engaged in several pilot activities to understand the feasibility of long-term implementation including a VR mine rescue contest, a university implementation, and a general safety training. Researchers recently co-hosted a VR mine rescue competition with collaborators from the Pennsylvania Department of Environmental Protection. The contest involved six teams completing at least one 90-minute mine rescue problem in VR-MRT. This contest was held at NIOSH's Bruceton research facility and took place over a three-day period in September 2024. All teams were able to successfully complete the problem, and four of the six teams chose to extend their visit to complete a second 90-minute problem. NIOSH is also working with the West Virginia University Department of Mining Engineering to incorporate VR-MRT into their academic curriculum and outreach activities. University staff have helped improve the hardware specification, documentation, and software design through their testing and suggestions. The staff have even become proficient at running the system on their own. Lastly, researchers collaborated with an underground stone mine to develop and run a VR hazard identification training for use during the mine's "Stand-Down for Safety" day. The simulation demonstrated the utility of VR-MRT beyond mine rescue and the ability to provide site-specific training incorporating LiDAR scans of the mine.

RESULTS AND DISCUSSION

Antecedent Assessment: Acceptability, Appropriateness

By talking directly to the mine rescue team members—the innovation recipients—researchers were able to gain a better understanding of the acceptability and appropriateness of VR-MRT for mine rescue training. One hundred percent of the respondents indicated that they enjoyed the experience, suggesting that the demonstrated Simulation Module of VR-MRT was acceptable.

Results suggest that opinions about VR implementation strategy did not vary with mine rescue or VR experience. The Chi-square tests of independence revealed no significant association between participants' mine rescue experience and their responses to either of the implementation strategies (Addition to: $\chi^2(2) = 4.331$, $p = 0.115$; Instead of: $\chi^2(2) = 5.066$, $p = 0.079$). This was also true of participants' VR experience (Addition to: $\chi^2(2) = 2.751$, $p = 0.253$; Instead of: $\chi^2(2) = 0.977$, $p = 0.614$). Because of this result, the mine rescue and VR experience variables were not included in any further analysis.

Results also suggest that mine rescue team members are generally interested in VR. The Chi-square test of independence revealed that the responses were significantly different than chance ($\chi^2(2) = 97.133$, $p = <0.001$). As shown in Figure 1, most of the of participants reported that they were interested in VR (77%) compared to only 13% saying "maybe" and 9.7% saying "no." These strongly positive responses also support the idea that VR training for mine rescue is both acceptable and appropriate.

Digging deeper into preferences, the data suggests that mine rescue team member participants prefer to use VR in addition to traditional training. The marginal homogeneity test indicated a significant difference in individual participant's responses to each implementation strategy (MH = 6.00, $p < 0.0001$). As shown in Table 3, 39.2% of participants preferred implementing VR in addition to traditional training compared to implementing it instead of traditional training.

The positive quantitative data was supported by comments from the team members. For example, they stated that VR was quicker and more accessible because it did not require as much physical exertion and allowed participants to focus on their analytical skills. Many interviewees also stated that they really liked the idea that VR training could simulate dangerous situations while being "hazard free." Lastly, participants discussed how they liked that the "virtual rescue simulation provides actual experience." The respondents that were not interested in participating in a VR contest, especially instead of traditional training, cited concerns about how it would be implemented and how it might replace traditional contests. One team member said that "community is a huge part of mine rescue," presumably concerned about not getting to travel and meet up with other teams if they switched to VR contests. Others were concerned that VR did not incorporate "the physical challenge" of mine rescue.

Overall, the quantitative and qualitative data suggests that mine rescue team members were excited about and interested in the scenario-based training offered by VR-MRT. As a whole, they would prefer to see it as a supplement. Importantly, these findings also add to the very positive fidelity, usability, and acceptability previously reported [1]. They also suggest that the platform would fit well into existing curricula, and the mine rescue community accepts it.

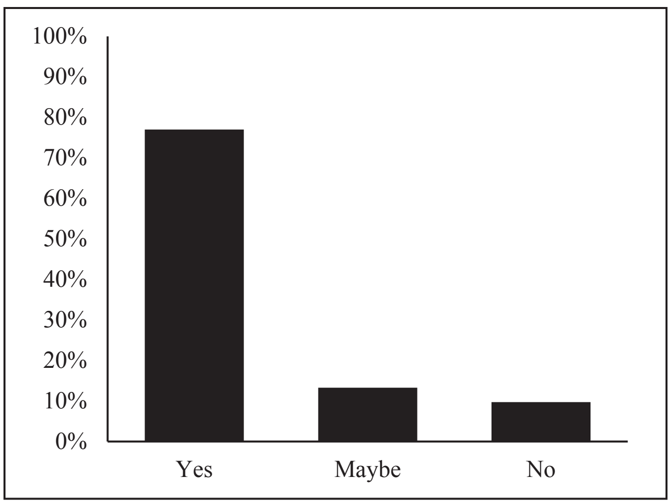

Figure 1. Graph depicting the percentage of mine rescue team member respondents that would be interested in VR

Table 3. Crosstab of Responses by Implementation Strategy

		In Addition to		
		No	**Maybe**	**Yes**
Instead of	No	9.3%	0%	30.8%
	Maybe	0.9%	12.1%	8.4%
	Yes	0	1.9%	36.4%

N = 107

Implementation Barriers and Facilitators

Diving deeper into stakeholders' perspectives, the semi-structured interviews helped researchers identify many of the barriers and facilitators of implementing VR training using the CFIR 2.0 Framework. Researchers found all five CFIR domains and 26 of the 45 constructs to be relevant, and the thematic coding resulted in 37 unique barriers/facilitators. The following sections describe the results by domain (See Table 1).

Innovation: Is this intervention superior to status quo?

Overall, there was excitement from the participants of all types (e.g., mine rescue, organizational) and levels (e.g., high-level leaders, mid-level leaders, deliverers, team members) about the Source, Relative Advantage, Trialability, and Adaptability of VR-MRT. Most of the feedback was positive in support of the innovation. However, participants also brought up barriers related to the Adaptability, Complexity, and Cost. Table 4 lists the identified constructs and themes from the data with paraphrased examples and actions that researchers have already taken or plan to take to support the facilitators and mitigate the barriers.

As evidenced by previous publications and recognized by the interview participants, a sense of trust and understanding that VR has the potential to improve mine safety and health training was apparent. Though opinions about NIOSH as the developer of VR-MRT were not explicitly solicited—the only direct statement recorded was "NIOSH is good"—some level of trust in NIOSH can be inferred by the willingness of the teams to participate in the demonstration and the overwhelmingly positive responses to the surveys and interviews. Furthermore, NIOSH has been working on immersive training for decades, creating products that offer both the realism and engagement levels that are critical to be effective [1, 13, 20, 23, 49, 26, 28]. However, one participant still did underscore the need to have effectiveness data specifically for this training. Researchers plan to address this through effectiveness and implementation studies that will demonstrate the potential impact of VR-MRT for mine rescue training as well as its general effectiveness.

Participants were also predominately positive about the Relative Advantage of VR-MRT. Participants describe the benefits in terms of logistics, cost savings, content, realism, safety, appeal, and the ability to assess trainees. Many of the participants talked about how VR training is more efficient, allowing them to complete more repetitions and the possibility to do other training in the time saved. When compared to the field-based scenarios, there is minimal set-up time between problems; VR-MRT allows trainers to load a new scenario in seconds as opposed to the 30+ minutes it would take to reset a field. They also noted that the breadth and depth of the content could cover "one million things," making it better than the fixed content of videos or presentations typically used during new miner or annual refresher training (30 C.F.R. Part 48/46). Almost all the participants also mentioned the realism of VR-MRT as a major benefit. One person specifically mentioned that VR is better because it "allows trainees to see actions make a difference." Several other participants also mentioned that the ability to "experience" things that would be dangerous to do or see in real life is important. This not only reduces risk to trainees, but also increases the amount of practice they receive with dangerous tasks, which the literature has shown improves both learning and retention [50]. Another point that participants brought up was the appeal of VR as a medium that is good for a new generation of students that would rather be physically doing something as opposed to sitting in a classroom. NIOSH researchers are acting upon this sentiment in their university implementation pilot, where VR-MRT is being used in both classroom and outreach events. Lastly, participants acknowledged the advantage of being able to objectively assess trainees. Again, this is well documented in the literature as a critical component to effective training [51]. NIOSH researchers plan to further integrate assessment in VR-MRT through the automatic mine rescue scoring as the development is finalized.

Participants balanced their positive feedback to VR-MRT with a discussion of the implementation challenges as barriers to adoption. Participants discussed concerns around VR-MRT as a replacement for current training in that 1) remote contests would reduce team networking and team camaraderie and that 2) VR-MRT lacked certain physical aspects such as being able to wear a breathing apparatus. Researchers plan to address these concerns in a few different ways. First, VR-MRT is intended to be a supplemental training that focuses on decision making. It is not intended to replace hands-on or in-person training. Additionally, the intended deployment mechanism for VR-MRT is for the team to be collocated (i.e., in the same physical space) and remote practice is intended as a backup, which incidentally, was mentioned as an important facilitator for adoption. Furthermore, the researchers would like to see VR-MRT added as an additional event at mine rescue competitions. This would still allow teams to get together and interact while still capturing the realism and experience of VR. Lastly, researchers have also spoken to breathing apparatus manufacturers about the potential to make a half mask that would fit below the HMD. If completed, this would allow apparatus training during VR-MRT training.

The complexity of the innovation was identified as a potential adoption barrier for VR-MRT. Participants spoke about resistance to technology, concerns about execution and maintenance, and the difficulties of generating new content.

Resistance to change and difficulties in execution were discussed by all types and levels of participants. As excerpted in Table 4, the concerns focused on not wanting to use the technology, the technology being too difficult, and the intervention being too time consuming as well as concerns over the lack of support needed to implement and maintain its use. Resistance to technology occurs for many of the same reasons as resistance to organizational change in general: fear of loss, lack of trust, low tolerance for change, and differing perceptions [52]. However, these may differ across individuals as well as organizations. Techniques for reducing resistance to change vary widely and should be considered based on the type and source of resistance. These techniques include both positive and negative reinforcement like education and communication, participation, facilitation and support, negotiation, manipulation and co-optation, and coercion [53]. Education, communication, and participation may be particularly helpful in the case of VR-MRT. As seen in the usability data, users with VR experience felt that they would need significantly less support and prerequisites to use the system [1], suggesting that exposure and training could address some of the barriers.

Familiarity and support are also some of the reasons that the development team has chosen to use commercially available hardware. In the second quarter of 2024, Meta had 74% of the global immersive hardware market share [54], greatly increasing the likelihood that potential trainees and trainers have had exposure to the hardware. The large user base also provides a large support community which can be helpful in addressing maintenance and support concerns. Lastly, using commercial hardware has the greatest likelihood of reducing the overall system cost as opposed to a specialized system that is only used in a small market. Regardless of the change management strategies employed, effective planning and a realistic, achievable timeline is critical to successful implementation of an innovation [52].

To address the barrier of content creation, NIOSH researchers continue to make software improvements. Specifically, researchers have added a new Scenario Editor module. This functionality will allow users to create new scenarios quickly and easily with a drag-and-drop interface. Additionally, researchers have added the ability to add custom environments and objects. This greatly expands the range of training scenarios that VR-MRT can cover. Lastly, researchers are working to include other commodity-specific items (e.g., underground metal mining, surface). The Scenario Editor module has been piloted with great success, where university staff have been able to make their own content for classroom activities.

Outer Setting: Why now?

As shown in Table 5, interview participants discussed all the Outer Setting constructs except for External Pressure. They identified relevant points that can be both facilitators and barriers to the implementation of VR-MRT.

Related to the Policies and Laws construct, interviewees focused on compliance. They suggested that VR-MRT could be adapted to include general mine safety and health content for both new miner and annual refresher trainings required by law (30 C.F.R. Part 48/46). Many also expressed interest in incorporating a virtual mine rescue contest option to satisfy the 30 C.F.R. Part 49 contest requirement. This aligns with the 36% of mine rescue team members that also said they would be interested in using VR-MRT instead of traditional mine rescue training (Figure 1). Since these interviews, NIOSH has successfully hosted a VR mine rescue contest, fully incorporating all the features needed to create and score scenario-based problems. At this event, the possibility of VR-MRT serving as a substitute for at least one traditional contest was raised by the participating teams, citing added benefits and greater applicability. As a first step towards adoption, NIOSH plans to work with mine rescue contest hosts to incorporate VR-MRT as an additional competitive event. Researchers are also exploring the development of automatic, objective scoring for mine rescue problems. Both could enhance the likelihood that VR-MRT contests can be seen as a suitable, and in some ways, preferable alternative to traditional mine rescue contests.

NIOSH researchers have strong industry and academic partnerships and connections as exemplified by the pre-implementation efforts described above. However, interview participants discussed the need for more formal relationships and access to the technology. One participant talked about not knowing who to call or how to get the help they need to implement VR-MRT. NIOSH plans to combat this barrier by helping to establish and maintain VR working groups and connecting stakeholders.

Speaking about the Local Conditions construct, participants also identified barriers related to politics as well as software and hardware availability and accessibility. Politics often play a large role in federal programs and initiatives because priorities can change as administrations change. Several interviewees mentioned that the changing of political priorities could affect uptake either positively or negatively. Interviewees also talked about barriers such as the technology's accessibility for all mineworkers (e.g., literacy, physical limitations) and the overall availability of the platform. Researchers are working to address these concerns through the development of training scenes that could be included with the software. Researchers are also reviewing the software to ensure it follows good design practices such as making the interactions simple (e.g., only two buttons), consistent (e.g., green for "grab") and clear (e.g., visual and audio confirmation for all actions). As for availability, following the evaluation effort, NIOSH plans to make VR-MRT freely available on their website. Ultimately, the goal is for stakeholders to be able to incorporate VR-MRT into their own training curriculum.

Finally, participants discussed how Critical Incidents like the COVID-19 pandemic served as both a facilitator and barrier to implementation efforts. Participants discussed how the pandemic made remote options for training more salient and acceptable, but they also noted the two-year delay in the demonstration of VR-MRT at the International Mine Rescue Contest. Since this data was collected in 2022 COVID-19 was still top of mind, but future serious external events could similarly impact the mining community's ability and resources to train. Therefore, it is critical that the community take advantage of the current technological boom. The commercial investment in the hardware and software for immersive training as a result of the COVID-19 pandemic has made this technology more ubiquitous and accessible than ever. To prepare for future critical incidents, mining companies may consider adopting a holistic VR training strategy that is expandable and adaptable to meet emergent training needs rather than commissioning trainings one at a time. As described in the background, one-off trainings are typically limited in content and may use incompatible hardware and software, resulting in an inefficient use of the already scarce training resources. The developers of VR-MRT also tried to address this concern. The flexibility of VR-MRT described in the innovation section makes it well suited to address far more than mine rescue, and using VR-MRT for multiple training applications give it a higher potential return on investment.

Inner Setting: Will this intervention fit the system?

Given this pre-implementation interview study was not site-specific, it is not surprising that responses to questions related to the Inner Setting varied widely among respondents (Table 6). Individual mine rescue trainers were more likely to point to lack of Resources such as equipment and funding as barriers to adoption, while the organization participants reported that access to Resources was of less concern. As discussed previously, NIOSH chose to design the system with low-cost commercially available hardware to reduce the costs, and the VR-MRT software will be free when released.

During the interviews, participants from the organization focused on issues of prioritization and action. They emphasized deficiencies in the Work Infrastructure (e.g., lack of dedicated personnel, procurement red tape), IT Infrastructure (e.g., lack of expertise, IT procurement red tape), Physical Infrastructure (e.g., space, set-up configuration), Communications (e.g., lack of transparency), and Relative Priority (e.g., time to take actions). As one participant put it, leaders talked a lot, but "you have to walk the walk." While VR training was very attractive to this organization, the employees felt there was no clear path forward. They lacked clarity about the next steps largely because the organization was not set up to easily support a technology-heavy innovation, and for them organizational change is difficult (e.g., hiring, reallocation of space, purchasing). Researchers plan to study the implementation process further at various sites to better understand if this is a challenge across the industry. One possible solution to these barriers is following an implementation model such as proposed by Endsley [55]. Using this model, an organization would intentionally step through the implementation process in a logical and open way, where feedback is continually sought and integrated in the change management process. Another possible solution would be to identify and empower an organizational change champion—"a person at any level of the organization who is skilled at initiating, facilitating, and implementing change" [56].

Common across all participants were concerns about having Access to Knowledge and Information. This pertains to a stated need for support from NIOSH throughout the implementation process, specifically system-user guidance and train-the-trainer as well as establishing lines of communication for support. As a part of NIOSH's future implementation research, researchers plan to take an active role in the planning and execution of implementation strategies at individual sites willing to adopt the platform. As a part of the study, researchers will offer ongoing support while evaluating the process from pre-implementation through maintenance. These initial implementation efforts will further inform future efforts and the development of supporting documentation and software updates until NIOSH support becomes less critical to successful implementation. As VR-MRT becomes more widely available, it is possible that NIOSH or other entities could offer training sessions in central locations such as a mine rescue contest. Another possibility is that a group(s) implements the platform in existing regional training facilities open to all teams enabling resources and expertise to be widely shared.

Individuals: Do they have the will and the skill to deliver?

If individuals will not or cannot implement an intervention, the design, pressures, and fit are irrelevant—and it will fail. Despite some concerns related to lack of IT personnel earlier, most participants focused on a lack of will to implement VR-MRT as can be seen in Table 7. Concerns related to Individual Buy-In spanned across all organizational levels including High-Level Leaders, Mid-Level Leaders, Implementation Leads, Innovation Deliverers, Implementation Team Members, and Innovation Recipients. Individual mine rescue team trainers only identified High-Level Leaders' (i.e., Corporate) support as an issue. Organizational participants were far more mixed in their responses. In general, there was an impression that High- and Mid-Level Leaders were bought-in to VR training, but only about 50% of the Deliverers were bought-in. There were also concerns that the Recipients would be hesitant to try it.

Despite the organizational leadership strongly expressing support for the adoption and implementation of VR-MRT, there was some concern about what could be described as Lack of Action. In addition to organizational inertia, many of these concerns were attributed to competing priorities, long-term commitment, high expectations, and a lack of understanding of what it would take for successful adoption and implementation of VR-MRT (i.e., leadership was "out of touch with reality").

Considering this organizational inertia and lack of a common vision and shared expectations, many interviewees expressed the need for a champion(s) of the effort. However, none of the organizational interviewees felt they could fill this role. They all suggested other individuals. As discussed by Warrick [56], a change champion needs to have specific skills to be successful. When looking to implement VR-MRT in the future, organizations may consider identifying and training individual(s) to fill this role. It may also be possible for NIOSH to include some of this training in their future implementation research.

Related to Individual Buy-In, many participants also talked about Technology Aversion with both the Deliverers and Recipients. As discussed with respect to the Complexity of the Innovation, resistance to technology and change in general is a common issue. In this case, participants felt that the Deliverers and Recipients could be swayed with time and exposure, like how they eventually accepted other IT innovations (e.g., computer-based tools for mapping).

Lastly, the organizational participants discussed the need to Build the Implementation Team. They underscored the need to find the right people, align their roles, and give them time to develop working relationships to be successful.

Implementation Process: What is needed to implement?

Although the Implementation Process domain is more applicable to site-specific implementation efforts, it contains many of the same strategies required for the appropriate design, development, and evaluation of the innovation. Constructs such as Teaming, Planning, Tailoring, Engaging, Reflecting and Evaluating, and Adapting all strongly align with strategies that have been employed by NIOSH during the conceptualization and development of VR-MRT. These same strategies will also be applied throughout the future evaluation research to not only enhance the chances of success, but to define and measure implementation progress. One general suggestion that emerged from the responses of several interviewees across roles was the belief that for something like VR-MRT to be widely adopted and implemented, its deployment should be gradual and incremental. It was suggested that this approach could help to alleviate several of the barriers that were identified across interviewees, including Technology Aversion and Individual Buy-In as well as concerns around Resources and Personnel. This concept is captured under the Doing construct.

LIMITATIONS

While this research provides an important step in the implementation evaluation of the VR-MRT platform, the results should be considered along with the limitations of the study. First, the surveys and interviews were conducted with a relatively small sample size and may not reflect the opinions of the entire mining industry. Similarly, the sample was one of convenience and self-selected which might have caused the perceived barriers of a less motivated group to go undetected. Furthermore, this analysis was conceptualized exclusively across the CFIR 2.0 domains, which may have precluded the emergence of themes that exist outside the framework. However, the goal of this pre-implementation study was to identify potential facilitators and barriers early in the process to better prepare researchers and stakeholders for future widespread implementation efforts where these limitations will be addressed. Lastly, though the barriers and facilitators are intended to be general to VR mine safety training, the lack of exposure to other VR applications may bias the results towards VR-MRT specifically. Further study may be needed to support the generalization.

CONCLUSION

As the mining industry continues to evolve, it is critical to maintain and enhance emergency preparedness efforts, particularly in the realm of mine rescue training. VR training offers a promising avenue to supplement traditional training, making it more realistic, accessible, and effective. To better understand the challenges and barriers to implementing VR training, NIOSH researchers developed the VR Mine Rescue Training platform (VR-MRT). As a part of the pre-implementation phase of the innovation's evaluation, researchers talked to individuals at various implementation levels to assess the acceptability and appropriateness of VR-MRT and to identify actionable barriers and facilitators to the implementation of VR mine safety training in general. Researchers employed an inductive and deductive strategy based on the IS framework, CFIR 2.0. This framework helped to make potential solutions more obvious by grouping the concerns in the domain where they were most applicable.

Overall, the results suggest that VR-MRT is acceptable and appropriate for use in mine rescue training. Mine rescue team members expressed a strong interest in using the scenario-based training offered by VR-MRT in addition to their current training. Similarly, trainers and organizational employees recognized the relative advantage, trialability, and adaptability of the platform.

However, participants also identified barriers to successful implementation of VR mine safety training more generally. Industry level potential barriers (i.e., Outer Domain) included uncertainty whether and how VR training can be used for compliance, the need for industry partnerships and support, and a need for additional funding. On the organizational level potential barriers related to work structures, specifically IT support, prioritization of VR training over other initiatives, and ensuring personnel with the right training were available. Lastly, on the individual level, potential barriers were alignment of expectations, individual buy-in, resistance to technology, and a lack of action. These barriers reaffirmed the need for systematic change management strategies. More generally, the results underscore the need for additional implementation research to confirm the effectiveness and develop the support materials necessary to empower organizations to implement VR training.

At the conclusion of this effort, NIOSH plans to package the VR-MRT platform for public release. The successful implementation of VR-MRT could not only improve mine rescue training but also set a precedent for the broader adoption of VR to create dynamic, immersive, and engaging training across a wide range of mine safety and health topics.

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Table 4. Innovation domain constructs, themes, and supporting evidence

Construct		Theme	Feedback	NIOSH Actions
Source		Trustworthiness	NIOSH is good.	History of effective training [20, 49]
Evidence-Base		Domain Effectiveness	Need to show value.	Planned future effectiveness research
Relative Advantage	Facilitator	Logistics	Can increase training repetitions. Offers options, flexibility to train remotely (e.g., COVID, other hazards). Could save time and we could do other things.	Planned future implementation research
	Facilitator	Cost	Long term cost-savings.	Commercial hardware
	Facilitator	Content	There are 1 million uses for new people (e.g., basic mining principles). Allows mine-specific training.	Including content from all commodities
	Facilitator	Safety	Can do [things] that would otherwise be dangerous, enhances training.	Planned accident recreations
	Facilitator	Appeal	Good for a new generation of students. VR means less classroom time.	Pilot university implementation (e.g., student outreach)
	Facilitator	Realism	VR allows trainees to see actions makes a difference.	
	Facilitator	Assessment	VR-MRT would be good for assessment (i.e., automatic scoring).	Planned adding automatic mine rescue scoring
	Barrier	Physical Training	Team is not under apparatus.	Potential to adapt rebreather to fit with HMD
	Barrier	Face to Face Interactions	Missing team unity, interaction, and camaraderie when not together. MERDs better for BO to CC for training communication.	Planned future implementation research
	Barrier	Equipment Availability	Class size might be an issue.	Planned future implementation research
	Barrier	Simulator Sickness	Sim sickness might be a concern (e.g., thought I would get motion sick, but didn't).	Modality proven [1]
Adaptability	Facilitator/Barrier	Content	Good for simulated inspections and different mining methods (e.g., longwall). VR-MRT can create site-specific training (e.g., custom assets, environments). Would want long (e.g., fatigue, stress) and short scenarios (e.g., small segments). VR is limited with what you can program; every operation is different.	Added ability import custom content Including content from all commodities Including surface content Developed Scenario Editor
	Facilitator/Barrier	Delivery Mechanism	Different modalities (e.g., desktop, cast to screen rather than HMD). Different set-up spaces (e.g., size, conditions). Add multiple entry searches (i.e., 2 × 2 exploration).	Updated Spectator Module Developed Scenario Editor

(continues)

Table 4. Innovation domain constructs, themes, and supporting evidence (continued)

Trialability				Pilot safety training Pilot university implementation
Complexity	Barrier	Technology Aversion	Resistance to the technology. Too much time to train the trainers and the trainees. Need contractor for tech modifications and maintenance. Needs to just work (e.g., there were technical issues with the calibration).	University collaboration (i.e., less tech resistance) Commercial hardware
	Barrier	Scenario Creation	Need Unity training for building scenarios. Concerns about development time and getting content.	Developed Scenario Editor Incorporated easy file sharing
	Barrier	Execution	Too much training time. Setup is a challenge, too much time. Would need tech support.	Planned future implementation research
Cost		Cost	Cost of equipment is general concern.	Commercial hardware
Design	Barriers	Additional Interactions	Add additional task training (e.g., W65 rebreathers, rock dusting, first aid). Add more instruments (e.g., anemometer, thermal imaging cameras).	Added smoke tube Added patient interaction (e.g., donning rebreather)
	Barriers	Additional Features	Add fire suppression on UG equipment and components. Add smoke (e.g., idea of taking light off and could see better in smoke too).	
	Barriers	Fidelity	4D interactions (e.g., heat, wind, weight of equipment).	
	Barriers	Additional Instructions	Need better teleport instructions to avoid disorientation.	Planned future implementation research

Table 5. Outer setting domain constructs, themes, and supporting evidence

Construct	Theme	Feedback	NIOSH Actions
Policy & Laws	Compliance	VR-MRT could be used to teach required training (e.g., 30 CFR parts 48, 46, & 49). MSHA might not accept VR training for contest compliance (e.g., we're stuck with physical contests). There is legislation in Queensland, Australia that requires this.	Working with MSHA for approval Conducted VR Mine Rescue Contest
Partnerships & Connections	Community	Need for relationships and access to the technology. Need to be able to call people and build relationships necessary to use VR.	Establishing VR working groups Building relationships with VR users
Local Conditions	Politics	Political appointees and other politics dictate federal support.	Conducted VR Mine Rescue Contest Planned adding automatic mine rescue scoring
	Accessibility	Aging workforce, those with literacy or other challenges might resist or be unable to use VR-MRT.	Planned VR-MRT design review prior to release
	Availability	Haven't used VR yet because it is new and not yet available (e.g., nothing like that in Africa).	Planned VR-MRT public release
Critical Incidents	Serious Event	COVID delayed VR development in Australia. COVID and other serious events can make remote training a necessity (e.g., it's a different world today).	Planned future implementation research
Financing	Funding	Might be good avenue for states' grants. Some governments (e.g., New South Wales, Queensland) provide funding for mines rescue training.	Encourage stakeholders to apply for grants Planned future implementation research

Table 6. Inner setting domain constructs, themes, and supporting evidence

Construct	Theme	Feedback	NIOSH Actions
Resources	Funding	Believes company has the resources. Funding could be a problem for some companies.	Commercial hardware
	Equipment Availability	Have funding, but VR technology is not available. Lack of resources to acquire equipment to do this type of training.	Commercial hardware Planned VR-MRT public release
Work Infrastructure	Personnel	Lack personnel in general. (e.g., short-staffed, as it is. I don't see how we can do all of this). Need a bigger team of personnel with dedicated time. A lot of turnover and attrition.	Planned future implementation research
	Bureaucracy	Procurement is difficult (i.e., it's hard to get things). Major alterations to training curriculum require different levels of approval (could be 3 months to a year).	Planned future implementation research
IT Infrastructure	Personnel	Need dedicated IT support for network and troubleshooting. Organization wants in-house expertise, but VR talent is hard to find in this location.	Planned VR-MRT design review prior to release Planned future implementation research
	Bureaucracy	Purchase of software requires approval from IT department.	Planned future implementation research
Physical Infrastructure	Logistics	A lot to figure out (e.g., rooms, scheduling). Tradeoff between available space and proximity to training facilities.	Planned future implementation research
Communications	Transparency	Organization is siloed – no communication across levels and roles. Lack of transparency from high-level leaders (e.g., say what you mean, mean what you say). Biggest barrier is taking and accepting feedback.	Planned future implementation research
Relative Priority	Lack of Action	Interest in VR training is there, need to act. Organization wants to be leader in technology, but VR is not prioritized over other initiatives.	Planned future implementation research
	Resource Allocation	Concerns about trainer training time (e.g., trainers need time to practice with system). Need time to train the team on the tech before the actual training (i.e., lose a day of work). Hiring can be dependent upon administration priorities.	Planned future implementation research
Knowledge & Information	POC	Need to know who to contact from NIOSH and how	
	Train the Trainer	We would need training on the system and technology. We're good in tech but need hands-on training. (e.g., better training on how to wear headset).	Planned future implementation research Documentation with VR-MRT public release

POC: Point of contact

Table 7. Individuals domain constructs, themes, and supporting evidence

Construct	Themes	Feedback
High-level Leaders	Individual Buy-In	High-level leaders support it (e.g., they've all seen it and are on board). Not much corporate support (e.g., this is the biggest barrier).*
	Expectations	High-level leaders need to check their expectations (e.g., Need to have vision and mutual understanding). It's overwhelming for everyone that they are trying to do everything at once.
	Lack of Action	The organization has been talking about it for a while, but there's always been something [else]. Need a high-level champion to get money and people to make it happen. Maintenance will be a problem; management will drop the ball.
Mid-level Leaders	Individual Buy-In	Mid-level leaders say they bought in, but they don't support it.
	Lack of Action	Maintenance (i.e., upkeep) could just disappear without support from mid-level leaders.
Implementation Leads	Champion	Many interviewees suggested that other individuals (i.e., not themselves) at other levels need to be champions. Individual team trainers will champion the effort but are concerned about corporate push-back/trade-offs.*
Innovation Deliverers	Individual Buy-In	Mixed support (e.g., it's a great tool for mine rescue and mining, in general, but we have other things to do). Need to convince the trainers of VR-MRT's usefulness (e.g., maybe 50% of our instructors are into it). It's important to keep the trainers involved in implementation and seek recommendations from them. Already low morale and burnout; trainers will resist unless there is some reward. Pressure comes from outside, not from instructors (i.e., no self-motivation).
	Technology Aversion	Resistance to the technology (e.g., trainers want to be technology hands-off, fear of breaking the technology). Resistance to change. (e.g., concerns about being replaced by technology). There is/was resistance to other VR trainings. Many, but not all, eventually bought in.
Implementation Team Members	Individual Buy-In	Need key people to be bought-in across the board. The team needs to be enthusiastic about the product and process. Everyone is overwhelmed, and they need an incentive to adopt.
	Building the Team	Need to get the right people involved and have an understanding of it. Need to shift roles and responsibilities across the organization. Need development group (e.g., needs to be a team effort, need time for group relationship building).
Innovation Recipients	Individual Buy-In	Trainees aren't going to do it unless there is a reward.
	Technology Aversion	Need time to get accustomed to technology (e.g., it's different). Trainees might accept it (e.g., they resisted Visio, but liked it when they saw it).

* Mine Rescue trainer comment