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Competencies for the Competent Person: Defining Workplace Examiner Competencies from the Health and Safety Leader's Perspective

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Abstract
The ability to identify hazards during a workplace examination is a critical skill for mineworkers to have in order to maintain a safe workplace. While research suggests that being able to successfully recognize hazards requires a complex set of competencies, it is unclear which competencies are most critical to adequately perform a workplace examination. This paper presents a hazard recognition competencies framework as an explanation of the competencies that affect mineworker hazard recognition. To better understand how the industry is selecting and preparing workplace examiners, researchers from the National Institute for Occupational Safety and Health (NIOSH) interviewed nine health and safety (H&S) professionals at surface stone, sand, and gravel mine sites throughout the USA. A primary purpose of these interviews was to verify the competencies included in the hazard recognition competencies framework and to understand why these competencies are critical. Finally, the results of this study are presented within the context of current NIOSH research findings related to hazard recognition.

Keywords Workplace examiner · Hazard recognition · Competencies · Knowledge · Skills · Abilities

1 Introduction

In an industry that is often characterized by its dynamic and hazardous working conditions, workplace examinations are an essential practice that allow mine operators to find hazards and mitigate them before they cause injury or death. The Mine Safety and Health Administration (MSHA) has long held that the adoption of safe work practices, such as workplace examinations, provides mineworkers with protection from such hazards. For instance, in response to an increase in mineworker deaths from January 2010 through mid-December 2015, a time period in which 122 mineworkers lost their lives in the metal and nonmetal (M/NM) sector, MSHA issued a program policy letter emphasizing that "miners would benefit from rigorous workplace examinations conducted by experienced and trained examiners" [1]. Following these events, MSHA sought to improve the effectiveness of workplace examinations by proposing a new standard, first published in the Federal Register Volume 81, Issue 110, for the examination of working places in metal and nonmetal (M/NM) mines [2].

MSHA's current standards require a competent person, designated by the mine operator, carry out a workplace examination at least once each shift [3]. A competent person is defined as "a person having abilities and experience that fully qualify him to perform the duty to which he is assigned" [4]. Further guidance on this definition is given in the 2015 MSHA program policy letter stating that the competent person "should be able to recognize hazards and adverse conditions that are known by the operator to be present in a work area or that are predictable to someone familiar with the mining industry" [1]. Although this guidance gives mine operators expectations for what the competent person should be able to do, it does not offer additional detail on what qualifications and competencies are necessary to perform a successful workplace examination. For example, what specific knowledge, skills, and level of experience make a competent person good at workplace examinations? Or, what common practices are used by mine operators to prepare mineworkers to search for and find hazards?

For mineworkers to benefit from workplace examinations, it is important to identify what qualifies a worker to be the competent person and what practices can be used to best

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prepare them for this role. A first step in determining these qualifications is to identify the full scope of characteristics or competencies an individual must possess to be able to recognize and mitigate hazards. By gaining a better understanding of H&S professionals' practices surrounding workplace examiners, researchers can begin to identify how H&S professionals transfer knowledge to their workforce, maintain worker situational awareness, and prepare workers to recognize and respond to hazards in their work environment [5, 6]. In the current study, H&S professionals' perspectives and practices surrounding workplace examiners were analyzed within the context of a Hazard Recognition Competencies Theoretical Framework and current NIOSH research findings related to hazard recognition. The goal of this research is to utilize H&S professionals' expertise to help reveal the competencies and capabilities needed to successfully identify hazards during a workplace examination.

2 Hazard Recognition Competencies Theoretical Framework

In early 2016, NIOSH funded a contract with the Group for Organizational Effectiveness, Inc. (gOE) to provide a written summary report containing a review of current learning practices and any emerging trends in competency-based education and training for hazard recognition in high-risk occupations.[1] As part of this contract, an extensive literature review was conducted to identify the characteristics and competencies—or knowledge, skills, abilities, and other characteristics (KSAOs)—a mineworker should possess in order to recognize and mitigate hazards. These characteristics and KSAOs were then organized and categorized to create a theoretical framework (Fig. 1).

Within the theoretical framework, three types of characteristics (stable attributes, KSAOs, and temporary states) are hypothesized to influence an individual's ability and motivation to recognize hazards. This combination of ability and motivation should, in turn, impact an individual's hazard recognition proficiency [7].

A stable attribute is defined within the framework as a characteristic that tends to remain the same across situations and over time [8]. Stable attributes include characteristics such as intelligence [9], risk tolerance [10], and perceptivity/acuity [11]. The research literature suggests that stable attributes influence hazard recognition ability. As an example, risk tolerance, or an individual's general tendency to take risks, impacts the willingness to engage in unsafe behavior, which in turn can lead to an unnecessary exposure to workplace hazards [10]. There are likely individual differences in tendencies and preferences that impact ability and motivation to identify hazards. While stable attributes may influence hazard recognition, they are less malleable and less likely to change or improve with training [12] when compared with competencies or temporary states. Therefore, safety training aimed at enhancing hazard recognition ability may be more effective if it is designed to target competencies that are more malleable and likely to change with training.

There are several individual attributes identified within the framework that are classified as KSAOs including risk perception [10], general hazard recognition knowledge [13], hazard recognition skills [14], and situational awareness [15]. Under the framework, KSAOs are more malleable, relative to stable attributes, as they can be changed or improved through training [12]. As an example, Barrett and Kowalski [16] developed latent-image, 3-D slide simulation exercises to present participants with work-related training scenarios to improve hazard recognition ability. This study showed training with these materials significantly improved trainees' performance on an in-mine hazard recognition task.

Finally, within the hazard recognition competencies framework, temporary states are defined as short-term factors that can interfere with cognitive focus and, in turn, their ability to recognize hazards. Examples of temporary states include being distracted or lack of vigilance, being tired, or time pressure. One characteristic of temporary states is that individuals can experience them at any time during the day, which could negatively impact their ability to recognize hazards. Training could be designed to provide trainees with an awareness of such temporary states and provide guidance on how to overcome or prevent the negative impact of temporary states on hazard recognition.

There are several characteristics and competencies identified within the framework as being necessary for hazard recognition in high-risk occupations. The applicability of these characteristics to the mining industry has not been validated. To begin to validate these competencies, NIOSH researchers interviewed mine H&S professionals who are knowledgeable of the requirements and responsibilities of the competent person.

3 Methods

Qualitative research methods, including semi-structured interviews, were used to gain H&S professionals' perspectives on the scope of qualifications and competencies required for successful workplace examinations. Data collected from semi-structured interviews were analyzed to more clearly identify themes related to H&S professionals' practices surrounding workplace examinations. The data were then compared against the hazard recognition competencies framework and

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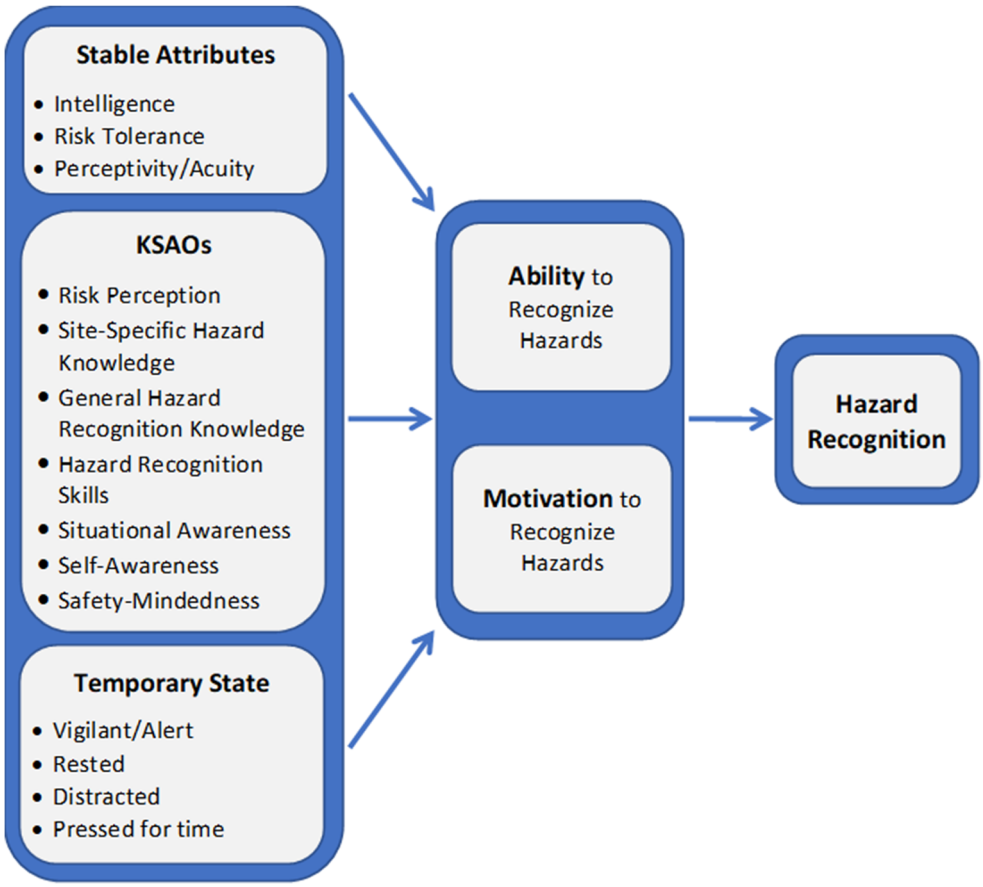

Fig. 1 Hazard recognition competencies theoretical framework [7]

current NIOSH research findings to reveal potential knowledge gaps and to identify potential courses of action for preparing mineworkers for the role of a competent person.

3.1 Recruitment of Participants

NIOSH researchers were interested in gaining the perspective of H&S professionals within the M/NM sector who had knowledge of MSHA regulations related to workplace examinations; therefore, a purposeful sampling strategy was used [17]. Researchers sought participation from individuals currently employed in a mining health and safety position at a mine site, contractor, government agency, or trade association. Mine health and safety professionals were first contacted by phone or e-mail and given a brief summary of the data collection process and an informed consent form approved by the NIOSH Institutional Review Board (IRB). If the contact agreed to participate, a 1-h time slot was scheduled for the interview to be conducted either over the phone or at an agreed-upon location.

3.2 Participant Sample

The study sample included nine H&S professionals (6 male and 3 female) from the surface stone, sand, and gravel sector. The participants' mining industry experience ranged from 4 to 45 years, with two participants reporting 5 years or less, two reporting 15 years, and five reporting more than 20 years of industry experience. Each participant was currently employed at a mine site, contractor, government agency, or trade association and held various health and safety leadership positions including Corporate Health and Safety Manager, Manager of Industrial Hygiene, Safety Director, Mine Safety and Health Representative, Director of Safety and Human Resources, Safety and Health Supervisor, Safety Supervisor, and Safety Manager. Participants were primarily employed at medium- to large-sized stone, sand, and gravel companies that had sufficient resources to have a dedicated safety professional at the mine site or the corporate level (overseeing multiple operations).

3.3 Interview Guide and Data Collection

NIOSH researchers developed a semi-structured interview guide to probe H&S professionals' perceptions and practices surrounding workplace examinations and the competent person. The interview began with several open-ended questions that were designed to establish rapport with participants, to elicit information about their histories within the mining industry and their roles and responsibilities in their current

positions. A second set of questions was designed to get participants thinking about workplace examinations and MSHA's proposed rule on workplace examinations (published in the June 8th, 2016 issue of the Federal Register) [2]. Questions pertaining to the competent person included language from the MSHA program policy letter (P15-V-01) [1] and the proposed rule on workplace examinations. In this section of the interview guide, H&S professionals were asked to provide their definition of the "competent person"; discuss the knowledge, skills, and abilities they think are critical for the competent person performing the workplace examination; and provide examples of how they evaluate workplace examinations at their sites.

Seven interviews took place over the telephone, one took place at the NIOSH Pittsburgh Research Facility, and one interview took place at a surface limestone mine. All nine interviews were conducted one-on-one during each participant's regularly scheduled workday and lasted approximately 1 h. There were two NIOSH researchers present during all interviews, one serving as the interview lead and the other acting as note taker. Eight of the interviews were audio recorded, while one interview was recorded by handwritten notes. All audio recordings were transcribed for data analysis.

The interview guide contained additional questions about the working place, training related to workplace examinations, and imminent danger. The authors of this paper have previously reported on analyses of the data related to imminent danger [18].

3.4 Data Analysis

Interview data was analyzed using a directed content analysis approach. The goal of this approach is to validate or extend conceptually a theoretical framework or theory [19]. Content analysis using a directed approach is guided by a more structured approach [20] through the identification of key concepts and variables as initial coding categories [21]. Following this approach, NIOSH researchers used the competencies identified within the Hazard Recognition Competencies Theoretical Framework to guide analysis of the interview data.

To analyze the data, two researchers first read through the interview transcriptions to identify examples of KSAOs and other characteristics (i.e., stable attributes, temporary states) found within the Hazard Recognition Competencies Theoretical Framework. The researchers then independently coded all nine interviews using a process of initial and focused coding [22]. The first phase of coding allowed for as many themes as possible or necessary to be identified [23]. Following this initial review, a codebook was created based on emerging themes and patterns found within the framework [24]. The codebook was then utilized in the second phase of coding, focused coding, to apply preestablished codes while allowing for recording of any additional themes. Following this, a process of combining or separating categories was then used to ensure that each category was distinct, and final resulting themes and subthemes were given labels. To ensure that the data interpretation was consistent between researchers, ad hoc meetings were held to review codes and discuss agreements and rectify any disagreements. Trustworthiness [25] of the analysis and categorization of the data was established by providing thick, rich descriptions, including participants' actual words so that readers could verify the researchers' interpretation of the data.

4 Results

Health and safety professionals described competencies and work-site practices that supported the KSAOs and other characteristics identified within the Hazard Recognition Competencies Theoretical Framework, including general hazard knowledge, site-specific hazard knowledge, and situational awareness. Additionally, H&S professionals identified characteristics, such as experience and motivation, as key factors for successful workplace examinations. The following sections discuss the primary themes in the data along with examples H&S professionals gave for competencies within the framework.

4.1 General Hazard Knowledge

Within the Hazard Recognition Competencies Framework, general hazard knowledge is defined as knowledge of basic hazards found at most mine sites, regardless of commodity [26]. When reviewing the interview transcripts, researchers identified examples of general hazard knowledge throughout. H&S professionals identified examples of types of general hazards that mineworkers are exposed to in the mining environment (e.g., lock out/tag out, slip/trip/fall, housekeeping, electrical, PPE, and handrails). This type of knowledge was identified as critical for the workplace examination process. One H&S professional stressed that mineworkers should focus on finding general hazards in their workplaces: "Start off with just tripping hazards. That their laydown areas are neat. Sometimes you don't have a lot of room but normally on new construction we have room. Just to check all the equipment. Look at their harnesses. Look at the footing for the aerial lifts." Another safety H&S professional described general hazard knowledge when talking about how to prepare mineworkers for workplace examinations: "…we recommended to all our plants to do hazard identification task training to work in with their workplace inspections. So they go through what are the most common types of electrical hazards, what housekeeping infraction might look like, what the difference between an unsafe access versus a safe access."

As an additional component to general hazard knowledge, H&S professionals identified knowledge of MSHA regulatory standards. According to H&S professionals, this type of knowledge encompasses the Code of Federal Regulations (Title 30 CFR) and what constitutes a citable hazard or an MSHA violation. For example, one H&S professional explained what is expected of a workplace examiner within the context of industry regulations: "They have to understand what constitutes a hazard, what constitutes a violation. Have to understand—be trained on—what the expectation is for those things that are maybe not black and white."

4.2 Site-Specific Hazard Knowledge

Site-specific hazard knowledge is knowledge of hazards that are unique or specific to a mine site [26]. H&S professionals talked about knowledge of site-specific hazards as mineworkers understanding the mine's specific policies, procedures, and expectations. One H&S professional indicated that it is important that mine examiners receive training on mine-specific policies: "Housekeeping is a great example. So, you know they have to be trained on what is expected." H&S professional responses related to site-specific knowledge also captured the need for an understanding of the uniqueness of each mine site's geology, which is important because "every mine is different when it comes to the geology." One H&S professional recommends that mine examiners "have to get out there and walk on top of that highwall or at least drive slowly in daylight and look for cracks."

H&S professionals also talked about the need for specialized knowledge and persons with the right knowledge of hazards in a given area. As an example, one H&S professional recalled an incident where there was a structural failure and collapse of a bin that resulted in a fatality: "How many people realize that you're not going to take a grade 3 or grade 5 bolt and expect it to hold a 100-ton bin over time? There's special bolts that go in those things." This participant indicated that the examiner would need specialized knowledge of structural components to have identified this hazard.

4.3 Situational Awareness

Situational awareness is defined as the ability to identify, process, and comprehend the critical elements of information about what is happening to oneself in the environment [15]. The interview data reveal that H&S professionals believe that mine examiners should be able to assess a situation and then be able to anticipate or predict what could happen next. An H&S professional gave an example of this skill when describing the practice of inspecting the highwall for unsafe conditions: "If someone actually got up there and looked, well you can see that crack is filling up with water and a week later it falls off… you'd have to identify it and then do something about it or minimize it. And that may be to drill in behind it so it falls in the pit and maybe barricade the area off down below until they can get it shot off." In this case, the H&S professional identified that the mine examiner must be able to identify, process, and comprehend what is going on around them. Similarly, another H&S professional described a situation that would require the ability to predict and anticipate changes in the future: "When dirt, moisture goes into that L-cover left off that conduit. It's going to sink down to where the bend is and it's going to rest in that bend... eventually if that cover is left off long enough. There's going to be enough stuff in there to where it grinds on that sheathing on that conductor. And you're going to have an electrical short."

Another H&S professional described a situation that would require the ability to associate hazards with specific situations: "You can build a fine road, proper grades, good crowns, proper berms, but you're going by a 40 to 100–200 foot highwall. Can you evaluate that highwall properly? If you don't see something big in the road, okay. You think that area is okay. But did you know... at this time a year we got freezing and thawing conditions, you have a tremendous amount of rock movement because of that." In this case, the mine examiner must associate changing weather leading to the hazard of rock movement due to freezing and thawing conditions.

One of the H&S professionals indicated that some situational awareness comes with experience (i.e., less experienced examiners are unable to make these associations/predictions because they have never been a part of the situation) when describing the characteristics of a good workplace examiner: "someone who has not only had the training but also shows through knowledge and experience, you know, a great understanding of what's going on. He's not just a person that sat through an hour-long class, he's someone who's been in the field with more experience who can anticipate hazards as they come up and get the importance of fixing them."

4.4 Experience

While experience is not specifically identified as a competency within the Hazard Recognition Competency Theoretical Framework, it emerged as a reoccurring theme within the interview data. H&S professionals indicated that the number of years of work experience makes workers more qualified and better able to identify hazards when performing the workplace examination: "…from my point of view at that site, it took about a year to finally get all the different tricks and trades done to finally learn exactly how you should operate that system. But even then there [were] was new things that would pop up and surprise you on how the operation performed. So I would say at least a year." Another described experience as a characteristic that makes the mine examiner better able to identify hazards for specific work locations and processes: "a brand new guy who is new to not only the area

but also probably the operation who doesn't know the process well enough to say if step A doesn't occur then this will result in consequence A and so on and so forth. So I think there is a degree of experience and familiarity with the process that makes them the most competent."

4.5 Safety Motivation

Within the Hazard Recognition Competencies Theoretical Framework, the definition for motivation aligns with Neal and Griffin's [27] safety motivation, which reflects "an individual's willingness to exert effort to enact safety behaviors and the valence associated with those behaviors." Within the interview data, H&S professionals indicated that workers should have the "right" motivation towards safety. One H&S professional talked about this attribute in terms of displaying a sense of caring and willingness to put forth the effort: "Caring... it does come down to individuals and how they look at safety and the attitude they have towards it." Relatedly, another H&S professional described the competent person as someone "who's more concerned about his or her fellow workers."

Another H&S professional described safety motivation in terms of effort and willingness to take the proper amount of time to complete an inspection: "Someone who will be quote unquote mature enough to say okay this could be a problem; I'm going to do something about it right now… Someone who isn't just going to blow by and say I'm going to keep that in mind, I'm going to stop and act on it." In this case, the H&S professional is describing an individual who is both invested in their work and wanting to take the time to follow the correct procedure.

Safety motivation was also described in terms of willingness to stop work and not work in unsafe conditions, even under the pressure of production: "So you might have a guy that's getting into work and he might be a little tired from the night before whatever he was doing and he'll do a paper pencil report, which we don't appreciate, or he might not do it at all because he wants to get right into production."

5 Discussion

To ensure health and safety, mineworkers must be able to recognize hazards in their work environment. The purpose of this research paper was twofold: first is to present a theoretical framework, the Hazard Recognition Competencies Theoretical Framework, to demonstrate competencies that potentially influence hazard recognition ability, and second is to verify the competencies critical to hazard recognition through interviews with H&S professionals from the mining industry. Data analyses reveal agreement between H&S professionals' perceptions of competencies and capabilities needed to successfully identify hazards during workplace examinations and those included within the Hazard Recognition Competencies Framework. Specifically, H&S professionals identified three competencies (general hazard knowledge, site-specific hazard knowledge, and situational awareness) found within the hazard recognition theoretical framework as critical competencies for the competent person. Additionally, H&S professionals described experience and motivation as key factors for successful workplace examinations. The following sections provide a summary and explanation of what we heard health and H&S professionals say about hazard recognition competencies, what we did not hear, and a research-based discussion of the work NIOSH has recently completed to address hazard recognition competencies.

5.1 What We Heard from H&S Professionals About Hazard Recognition Competencies

5.1.1 General Hazard Knowledge

The results indicate that H&S professionals identify a variety of competencies as critical for the mineworker. However, general knowledge of hazards was paramount within the conversations. One H&S professional talked about general hazard knowledge in terms of preparing mineworkers for the role of the competent person, indicating that general hazard knowledge is likely seen as the first step towards orienting mineworkers to potential hazards in the field. Another H&S professional talked about general hazard knowledge in terms of MSHA regulations, indicating that the mineworker should have a baseline knowledge of hazards as outlined within the Code of Federal Regulations. Indeed, research has shown that general knowledge of hazards allows workers to be better prepared to identify hazards in the field when they are present [13, 28]. To help build general hazard knowledge, mine operators may consider using training interventions aimed at developing a knowledge base of hazards, especially for mineworkers who may be new to industry.

5.1.2 Site-Specific Hazard Knowledge

In addition to general knowledge of hazards in the work environment, H&S professionals identified that a mineworker may require specialized knowledge of the work area that he or she is examining. This is likely due to the variety of working areas typically found at a mine site, including pit areas, roadways, processing plants, and maintenance shops. For example, when examining the plant area, a mineworker may need the specific knowledge of structural components to identify the potential for failures. Furthermore, a mineworker in the pit area needs to be knowledgeable of ground conditions that can lead to highwall failures or rockslides. H&S professionals indicated that assigning the person with the right

knowledge of a specific area may help them recognize hazards or potentially hazardous conditions. Mine operators may consider developing skills and specialized knowledge through training and interaction among those who have specialized knowledge in different areas and by encouraging mineworkers to discuss both typical and atypical hazards found at their work location(s).

5.1.3 Situational Awareness

H&S professionals also discussed situations that require a mineworker to have situational awareness. In these situations, the mineworker must be able to identify, process, and comprehend what is going on around them. In other words, it can be thought of as "what is going on around you" [15]. H&S professionals likely identified this skill as critical due to the dynamic nature of the mining environment [29]. Because of the constant change in environment and the variety of tasks being performed, mineworkers must continuously assess their workplace for risks and make decisions about how to manage those risks. Certain situations are likely to be considered higher priority or to have a significantly greater consequence to the mineworker than other risks [30]. Maintaining situational awareness could help mine examiners identify hazards that may be low risk in the near term but may lead to high-risk situations in the future. Formalizing risk management practices has been suggested to help improve mineworkers' situational awareness of hazards [31].

5.1.4 Experience

Within the discussions, H&S professionals emphasized that mineworkers should have experience working within the mine environment. One possible explanation for H&S professionals' emphasis on experience is that MSHA defines a competent person as "a person having abilities and experience that fully qualify him to perform the duty to which he is assigned" (30 CFR 56/57.2) [3]. From a legal perspective, H&S professionals may be more likely to select someone with a certain amount of documented experience for the role of the competent person to meet the requirement of experience in this definition.

Experience may also be viewed as important to H&S professionals because it plays a role in how mineworkers gain general and site-specific knowledge over time. For example, one H&S professional said, "it took about a year to finally get all the different tricks and trades done to finally learn exactly how you should operate that system," indicating that hazard knowledge may be gained through familiarity with a specific task or area. Recent research has shown that safety professionals were able to identify significantly more hazards in a simulated workplace examination task than inexperienced student volunteers [32].

5.1.5 Motivation

Finally, H&S professionals talked about the importance of motivation towards safety. Motivation is likely a combination of an individual's stable attributes (e.g., personality, history, risk aversion, personal values) and factors specific to their situation and work environment (e.g., immediacy, need, incentive) [7]. To illustrate this point, one H&S professional described motivation in terms of someone "who's more concerned about his or her fellow workers," indicating that the mineworker should have personal values that are in line with maintaining a safe workplace, while another H&S professional described motivation in terms of "someone who isn't just going to blow by and say I'm going to keep that in mind, I'm going to stop and act on it," indicating that the mineworker should have a sense of immediacy or an incentive to maintain a safe workplace.

5.2 What We Did Not Hear from H&S Professionals About Hazard Recognition Competencies

Several of the competencies identified in the Hazard Recognition Competencies Theoretical Framework were not discussed by H&S professionals. These competencies include risk perception and tolerance and hazard recognition skill. Additionally, H&S professionals did not talk about temporary states, such as being tired or distracted. One potential explanation for this is the limited amount of time researchers had to interact with H&S professionals. For example, diving deeper into topics such as experience may have led to discussions on risk perception. Experience has been shown to affect how mineworkers perceive risk associated with a hazard. For example, Perlman et al. [33] observed differences in the level of risk that was assessed for construction hazards with the more experienced groups of workers, including superintendents and safety directors, assessing risk levels higher than more inexperienced student volunteers. Being able to understand the risk associated with hazards is critical to safety as inaccurate risk perception can lead workers to ignore or misinterpret cues that signal a hazardous event or activity [10].

Another potential reason H&S professionals did not talk about some competencies within the framework and temporary states is the approach typically taken to perform a workplace examination—by using checklists. Mine operators often use a checklist approach for workplace examinations and preoperational inspections for equipment to focus the worker on hazards specifically called out in Title 30 Part 56 of the Code of Federal Regulations [34]. These checklists are intended to help mineworkers meet compliance expectations and often direct workers to look for routine hazards (e.g., buildup of material on catwalks, loose rollers on a conveyor belt), to inspect specific locations (e.g., stockpiles, roadways), and to check for required personal protective equipment. Workplace

examination checklists oftentimes do not include a risk assessment component. Therefore, mineworkers who are assigned to use checklists may not be expected to consider the risk associated with potential hazards. Research shows that the use of checklists is beneficial in standardized situations, when time is not critical, when the series of tasks or items is too long to commit to memory, and when the environment is conducive to carrying the list [35]. However, evidence also suggests that the use of checklists can cause inattentional blindness to salient objects or events [36]. In other words, directing workers to use a checklist as a guide may focus their attention to items on the checklist to such an extent that they are no longer perceptive to hazards or risks not included on the checklist.

5.3 Recent NIOSH Research on Hazard Recognition

As the metal/nonmetal mining sector continues to seek novel ways to prepare mineworkers for the role of the competent person, NIOSH has focused laboratory-based research efforts on identifying factors that affect hazard recognition performance [32, 37]. In a recent laboratory-based research study, NIOSH investigated the impact of worker experience on hazard recognition. In the study, experienced and inexperienced mineworkers, along with H&S professionals and mining engineering student volunteers, participated in a hazard search task. While researchers hypothesized that participants with more experience (experienced mineworkers and H&S professionals) would accurately identify a greater number of hazards than participants with less experience (less experienced mineworkers and students), only H&S professionals identified significantly more hazards than the students. In addition, and importantly, the participating mine safety and health professionals were only able to accurately identify 61% of the hazards. This indicates that there is room for improvement in hazard recognition ability across all levels of experience. NIOSH researchers took the lessons learned from this study and created a software intervention called EXAMiner that targets specific hazard recognition competencies for improvement [26].

The EXAMiner software is designed to address four specific hazard recognition competencies from the Hazard Recognition Competencies Theoretical Framework: general hazard recognition knowledge, site-specific hazard recognition knowledge, visual search, and pattern recognition; the latter two competencies are encompassed within hazard recognition skills. These competencies were targeted because they are necessary for all mineworkers, and they aligned with software design specifications in that they could be easily visualized within the software. EXAMiner is a software tool that gives mineworkers the opportunity to check their hazard recognition skills through practice searching panoramic images for general and site-specific hazards. To reinforce knowledge of hazards, EXAMiner provides mineworkers with information about their hazard recognition performance as well as hazard descriptions and relevant references to the Code of Federal Regulations (CFR Part 46.5 and 46.8 of Title 30 Mineral Resources). To further reinforce general and site-specific hazards, EXAMiner gives H&S professionals the opportunity to create custom panoramic images that represent workplaces where their mineworkers work and focus on hazards critical to their workforce.

6 Conclusion

The purpose of this research paper was twofold: first is to present the Hazard Recognition Competencies Theoretical Framework as a means to demonstrate competencies that potentially influence hazard recognition ability and second is to verify critical competencies through interviews with H&S professionals from the mining industry. Identification of critical hazard recognition competencies is an important first step for developing interventions and strategies to improve hazard recognition and workplace examination abilities in the mining workforce. The findings of this analysis may be informative for future studies or interventions aimed at preparing mineworkers for the role of the competent person. The EXAMiner software is one example of an intervention developed from research findings. However, EXAMiner was designed to target a specific subset of competencies. There are several other competencies (e.g., situational awareness) that should be studied with mineworkers so that researchers can take an evidence-based approach to develop additional interventions and strategies to further improve hazard recognition and workplace examination abilities.

Compliance with ethical standards

Conflict of Interest The authors declare that they have no conflict of interest.

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.

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