2.4.2. Effectiveness of Training

2.4.2. Effectiveness of Training

In this section we looked at the effectiveness of training. The question guiding our scoping review was: What are the best practices in education and training in order to improve safety engagement of employees in the mining industry?

Method

A scoping search of the literature was undertaken using the following words:

1. Miners (miners or mining or "resource extraction" or industry) and

2. Best practice in education ("best practice in education" or "teaching practices" or "teaching guidelines" or "teaching strategies" or teaching or "practice guidelines" or teach* or educat* or training) and

3. Safety engagement ("risk taking behavior/behaviour" or "safety behavior/behaviour" or safety or "high risk behavior/behaviour" or "safety engagement" or "safety rule violation" or "accident proneness" or "risk perception" or "perception of safety" or "safety devices" or "workplace safety" or "work safety" or "risk tolerance" or "safety culture" or "industrial accidents" or "occupational safety" or "occupational health").

Search Strategy. The databases searched are listed in the results. From this search, we selected articles based on the inclusion/exclusion criteria. The inclusion and exclusion criteria were kept broad in that we did not specify the types of research methods to be included or excluded in order to capture as many research articles on the topic as possible. In our search, we collected articles that were pertinent in this topic area. The broad inclusion and exclusion criteria allowed us to explore the literature in this area more completely.

Table 1. Best Practices in Education Inclusion/Exclusion Criteria for Article Selection

Inclusion Criteria	Exclusion Criteria
• Articles with key terms in the title or abstract	• Editorials
• Peer reviewed	• Commentaries
• Within 5 years	• Book reviews
• English language articles	• Simulated or game-based project descriptions
• Best practices in safety training	

Screening Strategy. The articles were checked for inclusion by two team members. The inclusion process was iterative in that the included/excluded articles were reviewed again for inclusion as the themes were developing. The team had final approval of the included articles. Those not applicable to the scoping review were excluded.

Results

A brief summary of each article including its location, population studied, main issue addressed, comparison group, and primary outcomes is provided in Appendix G. Table 2 is an overview of the scope of the review and articles identified.

Table 2. Best Practices in Education Databases and Articles Selected

Databases selected	Articles selected for further review	Articles selected for inclusion
Scopus	25	42
Academic Search Complete	4	
Nursing and Allied Health		
CINAHL	16	
CBCA Complete (Business and Education)	2	
PsycInfo	12	
Engineering Village	20	
Embase	11	
Web of Science	38	
ABI/Inform Complete	9	
Medline	33	
Google Scholar	228	
ERIC	126	

Description of Included Articles. Table 3 provides an overview of the types of publications, country of publication, and populations studied.

Table 3. Best Practices in Education: Population, Country of Research, and Type of Study

Type of Study	Country of Research	Population
Quantitative studies • Five cross-sectional surveys • Two pretest-posttest intervention studies • One meta-analysis • One longitudinal study • One controlled intervention study • One systematic review Qualitative studies • Four mixed methods • Two qualitative interviews • 2 qualitative case studies • One grounded theory study • One ethnographic study Other • 10 program evaluations • Two program descriptions • One literature review • Seven articles	North America (25) Europe (7) Asia (6) Australia and New Zealand (2) Middle East (1)	Construction (15) Mining (6) Manufacturing (5) Agriculture (2) Education (2) Chemical (2) Oil and gas (2) Other (8)

Description of Identified Factors. In order to make it easier to describe the results of the scoping review, the articles were divided into six conceptual categories: principles of adult learning, lack of safety training, initiatives to engage workers, benefits of safety training, improvements in training, and program examples.

Principles of adult learning. Three articles discussed the importance of using principles of adult learning when designing a safety training program. Kaskutas et al. (2010) developed a falls prevention program for apprentice carpenters. They targeted new apprentices prior to workplace exposure, and used adult learning principles to emphasize hands-on experiences. They developed a fabricated area for

apprentices to practice fall protection behaviors in a realistic setting. Kaskutas et al. (2010) suggested integration of a needs assessment prior to developing training is invaluable and results in positive responses to training. Mayer et al. (2012) developed and evaluated a safety program for beryllium-using industries. They found a sustained improvement in workplace safety practices, and work practices that had changed as a result of the training. Mayer et al. stated adults are motivated to learn when they can immediately apply what they have learned and when they expect it to enhance their job performance. In an exploratory study of construction safety training, Wilkins (2011) found participants were dissatisfied with the training and the training lacked adult learning principles. He suggested training programs based on adult learning theories would more likely promote employees' safety retention.

Lack of safety training. Five articles discussed the lack to safety training. Three articles discussed the risks of poor safety training. In a cross-sectional survey of injured workers; Ada, Sever, and Aksay (2013) found a lack of workplace or vocational safety training put workers at more risk for injury. They also found a high prevalence of accidents in more experienced workers, and they attributed it to a lack of ongoing safety training and noncompliance with workplace standards. In a grounded theory study with residential contractors, Hung et al. (2013) identified the following themes: barriers to safety training, problems with formal safety training programs, important areas for fall prevention programs, recommendations for training, training delivery means, and design features of training materials. They found a need for informal jobsite safety training to complement formal training. They also found instructors were not always considered knowledgeable, and safety training taught in class was not always practiced on site. Kaskutas et al. (2013) reported school-based training was not reinforced at the workplace and often was incongruent with workplace practices. They called for interventions at multiple levels to increase safety compliance and decrease falls from height.

One article discussed the difficulty transferring safety training to the workplace. Kraus, Casey, and Chen (2014) reported problems with transfer of workplace safety training, and they found training not used increases with time with high rates of training failure at the end of one year. They suggested involving leadership before, during, and after training; provide coaches or mentors; incorporate safety training into meetings and performance evaluations, and provide mentoring and coaching. Nyateka, Dainty, Gibb, and Bust (2012) examined interventions for younger workers. They stated traditional training fails to consider the social context of learning, and younger workers need active learning through interactive activities. One article addressed the limitations of training in small organizations. Holte and Kiestveit (2012) identified differences between training in large and small organizations. They found larger companies have more management implementing training and more formal routines for training young workers.

Initiatives to engage workers. Eleven articles discussed how to better engage workers in safety. They recommended more engaging safety training, using threat to improve training, empowerment, and perceived management commitment as factors in safety engagement of workers. Six articles discussed training methods to engage workers. Burke et al. (2011) found highly engaging safety training methods were more effective than less engaging methods in improving safety performance for high hazard conditions. They reported no increase in safety performance under low hazard conditions. Williams

(2011) discussed employee engagement in safety through involvement in safety education projects, peer feedback, and positive reinforcement for safe behaviors. He stated behavior-based safety education improves employee safety engagement. Kaskutas, Dale, Lipscomb, and Evanoff (2013) designed a safety training program to meet the needs of both foremen and crew members. They suggested learner-centered and contextually-relevant training can increase use of fall protection, improve safety behaviors, and enhance safety communication.

Anger, Patterson, Fuchs, Will, and Rohlman (2009) tested vineyard workers before and after a computer-based safety training course, and they found a significant improvement post training. When tested five months later, Anger et al. found a decrease in overall scores but somewhat higher than pretest. In a systematic review of the literature on whether safety training is beneficial to workers, Robson et al. (2012) found evidence to support effectiveness of training on workers' safety behaviors but not enough on effectiveness on health. The authors suggest even low-engagement methods of teaching may impact safety behavior. Cullen (2011) stated culture is linked to the development of safety training. The author emphasized experienced workers do not want traditional training performed by outsiders, but site specific safety training.

Two articles discussed the use of threat to engage workers in safety. Burke et al. (2011) found the dread factor may illicit an affective reaction which increases motivation. They found when the dread factor is high, engagement in the training is higher. Westerman, Margolis, and Kowalski-Trakofler (2011) stated the principles of innoculation theory can be used for emergency safety training especially for underground coal mines, emergency response groups, high-risk industries, firefighters, police, and other first responders. The authors stated innoculation theory uses threat and refutational preemption as a basis for developing mentor/learner learning relationships.

One article discussed employee empowerment. Leiter, Zanaletti, and Argentero (2009) examined the relationship between injury risk and perceptions of safety engagement. They found a negative relationship between evaluations of safety training and perceptions of risk exposure; and they emphasized the importance of training interventions that increase adoption of safety procedures. They stated workers who receive adequate training feel empowered to address hazards encountered. Leiter et al. also stated an organizations commitment to safety training affects safety culture and employees' perceptions of workplace risk. One article discussed the effect different trainers have on safety engagement. Laberge, MacEachen, and Calvet (2014) found experienced workers generally taught one way of doing things but apprentices require different techniques adapted to them and the task. The authors suggested including several experienced informal trainers exposed the apprentice to a variety of teaching content and strategies they could rely on. One article discussed the importance of perceived management commitment. Huang et al. (2012) explored employee perceptions of safety training and management commitment to safety in the restaurant industry. They found employees' perceptions of management's commitment to safety and safety training predicted future injury rates. They reported if employees perceive management as having a high commitment to safety they will perceive the safety training as good.

Benefits of safety training. Eight articles were related to the benefits of safety training. Four

articles found safety training was beneficial to the organization. In a mixed methods study, Bahn and Barrat-Pugh (2013) found construction induction training was valued by managers in the construction industry. They found the training was beneficial to the businesses and reduced employee work-related injury. The participants suggested a more robust and regulated training was still needed to further reduce work-related injuries. Liu, Fu, and Pei (2014) explained safety management is needed to be able to rely on safe work environments, therefore, if the training is strengthened the workforce is safer. The authors stated that using extra training taught by management will decrease the number of incidents and unsafe conditions. The monthly safety checks measured a monthly safety score and checklist, which was used to identify problems (Liu et al., 2014). Nguyen and Khai (2014) evaluated participatory action training for improving safety at work. They found improved production as well as improved overall health costs. They stated this program allows management and employees to work together and share knowledge for better safety outcomes. Taylor (2015) evaluated the importance of a 10-hour Occupational Safety course and if it improves safety training. The results did not present enough evidence to conclude if it does improve fatality rates and non- fatality rates and overall safety. Taylor recommended further analysis.

Four articles found safety training was beneficial to the employees. In a cross-sectional survey of workers in three companies in Italy, Cavazza and Serpe (2010) reported employees who attended a safety training course were less likely to violate safety norms especially if the safety training program was liked. They also found younger workers were more likely to be unsafe so more complex, persuasive techniques integrated into safety training are needed. Cavazza and Serpe suggested training programs should not target a particular worker but involve the whole work group to bring in the team context and create a safety climate. Margolis, Westerman, and Kowalski-Trakofler (2011) reviewed a training program to train miners how to cope and deal with emergency situations in a refuge chamber. This included psychological and physical effects of being in a refuge chamber. Although there were high awareness scores in training, it is still probable to panic during an emergency. The training helped miners cope mentally with being inside a chamber. Mischo, Brune, Weyer, and Henderson (2014) described a mine rescue and emergency training program in an engineering training program that included a scenario which takes place at an actual mine site. They also have mine rescue specialists from the mining industry come in to help at student practice and to teach specifics of mine rescue. They stated these training programs improved student skills and allowed for professional networking through working as a team in an underground mine rescue. Mahan, Morawetz, Ruttenberg, and Workman (2013), reviewed a 10-hour General Training course that was started by occupational health and safety members of the International Chemical Workers Union Council to help improve health and safety of plant workers after creating a new job leadership role. In this case study, management and labor collaborated to train all employees resulting in an educated workforce that could problem solve and improve safety and health in the workplace.

Improvements in training. Eight articles were identified which related to improvements in safety training. Two articles described the factors required in safety education. Kim, Kim, and Kim (2011) identified an optimal set of safety education factors (age, position, trade, number of years of work, past experience with accidents, and personality) and linked them with education type (periodic, occasional, and special), form (on-the-job, off-the-job, and apprentice education), contents (knowledge, technology,

and attitude), method (lecture, discussion, audiovisual, case study, role play, experience, and e-learning), and evaluation (survey, examination, test, interview, and observation). The authors suggested individual factors should be taken into account when developing safety education, and different types, forms, contents, methods, and evaluation should be used for different factors. Lukic, Littlejohn, and Margaryan (2012) proposed a framework for understanding effective learning from safety incidents. They identified five factors important in learning from incidents: participants of learning, type of incidents, learning process, type of knowledge, and learning context. The authors stated employees should have more involvement in educational strategies, systemic issues, and organizational routines. In a controlled-intervention trial,

Six articles discussed where improvements are needed to safety training. Haas, Hoebbel, and Rost (2014) reported that communication and collaboration, leadership development, and responsibility and accountability are areas where improvement is needed in training. They stated training should be developed for all levels to improve safety: individual, interpersonal, organizational, and community and using ecological methods can improve health and safety behaviors for workers. In a cross-sectional survey of construction firms, Hare and Cameron (2011) found increased durations of safety training was associated with lower accident rates and better safety performance.   Ji (2014) stated safety training in coal mining should be systematic and an integral part of daily life and work. The author called for dedicated personnel for safety education and a commitment from management to improving safety consciousness and field practice, adapting to current safety practices, improving administrative approaches, and including proper evaluation of safety practices.

Bahn and Barratt-Pugh (2012) stated a majority of the literature is about safety culture and climate, and there is little on training effectiveness in the construction industry. The authors pointed out that safety culture and training are closely linked and, without enough safety training, there is increased work related injury, which is why Australia and the US has made safety training mandatory. The intent "… is to ensure that all construction workers have a minimum training in general site safety, including all working heights, working in confined spaces, general lifting and working with hazardous materials before they work on any construction site" (p.338). In an ethnographic study with trades apprentices and experienced workers, Stuart (2014) described the importance of additional training and lifelong learning for the students learning with heavy machinery (industry machinery). In this study, the students were given additional training and allowed to reflect on their own experiences to promote safety.   Stuart also stated that to fully promote better safety, there needs to be more evidence of training even though the safety training provided does enhance the students understanding of the culture of safety. In a case study of nine participants; Hsieh, Tsai, Chen, and Chang (2009) identified the safety training needs of an organization at both the organizational and individual level. They found hazard recognition, evaluation, and control were the main training needs; and these served as guidelines for developing the program.

Program examples. Eight articles discussed specific programs implemented to improve safety engagement. Four articles described programs for migrant workers. McCauley et al. (2013) looked at the differences between training videos in Spanish and a peer-promoted training in pesticide exposure. They found both groups showed significant improvement in pesticide knowledge post-testing with the promoter

group scoring higher, and the peer-promoter group retained more learning over time. In a mixed methods study comparing Hispanic and non-Hispanic construction workers, Kane (2010) found a significant difference in locus of control and decision-making: Hispanic workers had a higher internal locus of control; and non-Hispanic workers exhibited higher information-seeking behavior. Kane suggested programs should be designed so workers will choose to adopt new technologies; and new programs should be flexible enough to engage workers of different ethnic backgrounds.

In an article describing a multimedia approach to raising health and safety awareness; Loney, Cooling, and Aw (2012) stated education of migrant workers is important and safety education should be provided in a manner congruent with the workers' educational background and in their language. They suggested ethnicity and diversity needs to be considered as well as involving front-line workers when developing educational programs to promote ownership of and engagement in safety. Prochnow (2012) examined a non-traditional safety program which targeted Spanish-speaking construction workers. The training used participatory methods and focused on group learning as well as developing workers' leadership skills. Prochnow found the training had a positive impact on the workers' knowledge, and the trainees were highly satisfied with the training.

Four articles looked at alternate safety training methods. Hermann, Ibarra, and Hopkins (2010) examined the effects of a safety program combining behavioral-based safety with traditional safety methods. They found substantial improvements in outcomes with this program as compared to a traditional safety program. The program included ongoing safety talks, posters, and audits and more. Fullen (2010) developed and tested an online training program aimed at teaching construction workers about falls safety. He found the Internet allowed for broad use of the training materials by this hard to reach population.

Li, Lu, Chan, and Skitmore (2015) evaluated the Proactive Construction Management System (PCMS) for training construction workers through data visualization to be both productive and safe. They found the system allowed for faster tracking of equipment, proactive warning signals, real-time accident reporting, equipment maintenance information, and comparison tool for different sites. They also identified the following limitations to the PCMS training: many unsafe conditions cannot be identified, workers do not like to be tracked, difficulty with signal due to structures at site, and limited degree of realism. Vasconcelos, Silva, Pinto, and Duarte (2011) evaluated implementation of the Matriosca Model in a chemical industrial company. The authors described this model as involving workers in changing their working conditions and transformation through training. They found it improved communication between workers and management that allowed a better understanding and transformational learning within the workplace.

Discussion

In a scoping review of the literature on best practices in education, 42 articles were selected linking education and training to safety engagement. The analysis identified six concepts: principles of adult learning, lack of safety training, initiatives to engage workers, benefits of safety training, improvements in training, and program examples. The literature identified the importance of using principles of adult learning when developing training programs. Included in these principles are the

importance of reflection and lifelong learning.

There was a lack of training identified in the literature. Smaller companies have more difficulty developing adequate safety training programs. Overall, more emphasis should be placed on ongoing training; informal training from mentors and coaches; interactive strategies for engaging workers; persuasive technologies and online learning; and more robust, regulated training. To improve training there needs to be improved communication and collaboration between managers and employees with employee involvement in development of the training programs. The responsibility and accountability for safety behaviors should be well established and written into job descriptions.

Safety training is beneficial to both organizations and employees. Organizations have reduced injuries and improved production. Safety training contributes to the overall safety climate of the organization. Employees benefit by gaining enhanced coping skills and safety skills as well as developing professional networks. By linking safety training with individual factors, both the employee and the organization may benefit.

Gaps in the Literature. There were a number of articles related to safety engagement and best practices in education. More information specific to principles of adult learning and safety engagement may help with development of safety training programs. There is support for the benefits of safety training and for the lack of safety training.

Recommendations. The following recommendations for industry came out of the scoping review:

- Safety training should be based on theoretical concepts such as principles of adult learning.
- Safety training has to be ongoing, and include both employees and management in its development. There should be both a formal and informal training program.
- Establishment of mentorship or coaching relationships will improve safety engagement.
- Use of interactive technologies should be increased such as persuasive technologies, online technologies, simulated scenarios, and other behavior-based methods.

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