Centers for Disease Control
National Institute for Occupational Safety and Health

Final Project Report
Enhanced Safety and Health Training for Western Mine Workers
September 1, 2017 to August 31, 2020
(Cooperative Agreement Number: U60OH010017-08 to 10)

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List of Terms and Abbreviations

CFR   Code of Federal Regulation

CIH   Certified Industrial Hygienist

CMSP   Certified Mine Safety Professional

CSM   Colorado School of Mines

CSP   Certified Safety Professional

CSU   Colorado State University

EMCIS   Energy, Mining, and Construction Industry Safety

ERC   Education and Research Center

IAC   Industry Advisory Council

NIOSH   National Institute of Occupational Safety and Health

MBA   Master of Business Administration

MS   Master of Science

MSHA   Mine Safety and Health Administration

PE   Professional Engineer

PhD   Doctor of Philosophy

R&D   Research and Development

r2p   Research to Practice

SA   Specific Aim

UA   University of Arizona

US   United States

WMTC   Western Mining Training Center

Title: Enhanced Safety and Health Training For Western Mine

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Abstract

The Western Mine Training Center at the Colorado School of Mines (CSM) is devoted to the development of effective training and education programs for workers engaged in mining operations throughout the Western United States. The cooperative agreement between CSM and the National Institute of Occupational Safety and Health began in September of 2010 and was renewed in 2014, 2017 and 2020. The overall objective of the cooperative agreement is to reduce the number of injuries and illnesses among workers in western mining operations. This is accomplished through a focused, relevant, and comprehensive training program that educates mine workers on how to identify and proactively protect themselves from risks and hazards in the mining environment. Over the course of the cooperative agreement, CSM has continued to improve and expand upon the initial training program by focusing extensively on Mine Safety and Health Administration (MSHA) required training (Specific Aim 1); being responsive to industry needs for professional and specialized training (Specific Aim 2); and creating meaningful educational experiences for university students, faculty and staff (Specific Aim 3).

Specific Aim 1

From September 1, 2017 to August 31, 2020, CSM conducted 79 courses designed to support MSHA training requirements as defined under 30 CFR Part 48 for New Miner, Annual Refresher, and MSHA Instructor training for workers at both surface and underground mines. This training was developed to meet the specific needs of underserved populations working on mine sites, including contractors, suppliers, consultants, equipment manufacturers, and researchers, as well as small mine operators.

Specific Aim 2

The successful development of a broad-based Professional Training Curriculum is a significant accomplishment that CSM is particularly proud of and serves as the foundation upon which the program will continue to build on in the future. During the most recent reporting period, CSM created five online

courses, delivered seven conference presentations for approximately 357 attendees at five different safety conferences, and conducted three webinars for 58 SME members.

Specific Aim 3

Providing educational experiences for university students helps facilitate an understanding of safety and establishes the foundation for life-long learning and a safety ethic that students can take with them into industry (Specific Aim 3). As such, during the project period, CSM taught three one-credit Mine Safety and Health courses (MNGN308) to 65 CSM students, led one tour of the US Silver Galena Mine for five CSM students, delivered 10 guest lectures to approximately 175 mining engineering students at seven universities.

CSM believes that the safety training provided to underserved populations has contributed to MSHA recording progressively fewer fatalities per year. It is also important to remember that the impact of training is often difficult to assess, and while the mine safety and health training provided may be directed towards mining workplace hazards, those individuals who are able to apply what they have learned to other aspects of their life will be proficient in identifying hazards and avoiding injuries. These individuals will also convey this knowledge to others creating a cumulative effect which is often overlooked but represents an important outcome of work-related safety and health training.

Section 1

Significant or Key Findings

- Utilizing instructors with mining experience, who are technical experts in the topics they teach, provides credibility to the courses.
- Incorporating multiple instructors during training courses, either as team instructors or sequentially changing throughout the training, increased the attention span of trainees.
- Integrating personal safety and hazard recognition through stories provided real-life, relatable examples for trainees.
- Allowing opportunities for discussion with both instructors and trainees increased learning as trainees learn valuable insights through non-structured conversation with peers and instructors alike.
- Structuring training around active learning techniques, such as competitive games, interactive polling, small group exercises, hands on activities, and practical demonstrations, improved participation, knowledge retention, and learning.
- Re-imagining routine training systematically enhanced the quality of the training

Translation of Findings

The key findings of this research are useful to organizations that provide safety and health training and are interested in improving the quality and relevance of their training for employees/clients in dynamic operating environments. CSM follows the National Institute of Occupational Safety and Health's (NIOSH) Research to Practice (r2p) which is an approach that moves "research into practice in order to reduce and eliminate injuries, illness and fatalities" (National Institute for Occupatonal Safety and Health, 2018). The r2p approach includes six core elements: Partnerships, Intramural Science, Extramural Science, Technology Transfer, Communication and Evaluation (National Institute for Occupational Safety and Health, 2018). CSM focuses on three of the six core elements to disseminate research findings which are Partnerships, Communication, and Evaluation.

Partnerships

CSM has cultivated numerous partnerships with universities and colleges, professional associations, government, and labor unions to help promote the depth and breadth of research dissemination. The

key activities in support of this include providing training, participating on health and safety committees, serving as conference program chairs, advising on working groups, and collaborating with government and industry initiatives.

Communication

Communicating research findings is one of the most valuable ways to move research into practice as it provides a venue for dissemination, discussion, debate, questions, and answers. CSM communicates research findings through training courses (in-person, remote, and online), conference presentations, professional association presentations and webinars, and the submission of articles in trade publications and peer reviewed journals.

Evaluation

CSM believes that evaluating the success of our training is vital to understanding the impact and future outcomes for the mining industry and promoting continuous program improvement. As such, CSM utilizes Kirkpatrick's training evaluation model which has four levels (Kirkpatrick, 1994). CSM focuses on levels 1 (reaction) and 2 (learning) with attempts to gather level 3 (behavior) evaluation data. CSM uses an end of course evaluation to solicit feedback on instructor performance, training materials, pedagogy, and format (level 1). Additionally, pre and post tests are used to determine if learning took place (level 2). Finally, using a six-month follow-up survey for New Miners, attempts are made to gather level 3 (behavior) data.

Research Outcomes/Impact

"There were 24 mining fatalities in the U.S. in 2019, the U.S. Department of Labor's Mine Safety and Health Administration (MSHA) reports. This is the fewest annual fatalities ever recorded, and only the fifth year in MSHA's 43-year history that mining fatalities were below 30" (Mine Safety and Health Administration, 2020). While difficult to quantify, it seems logical to conclude that the utilization of more effective safety training is at least partially responsible for this decline in workplace fatalities. CSM is driven by the belief that training matters and that an effective safety training program can enhance the overall culture and efficiency of an operation. Although it is difficult to identify a direct correlation between the quality of regulatory training and worker behavior, it is critically important to adhere to the prescriptive requirements of Part 48 training and to provide current, relevant safety training topics to maximize the likelihood of safe worker behavior while continuing to improve the safety performance of mines across all sectors of the industry.

Section 2

Background

The United States (US) mining industry includes approximately 536,000 direct jobs and 1,000,000 indirect jobs (National Mining Association, 2019). Comprehensive data from 2015 reveal that mining exists "in all 50 states, Puerto Rico, and the Virgin Islands" with 29% of employees identifying as stone and sand and gravel operators, 19% as coal operators, 19% as metal and nonmetal operators, and 32% as contractors (Centers for Disease Control and Prevention, 2015). These descriptive and demographic statistics are useful in highlighting the demand for delivering regulatory and other health and safety related training.

In the Eastern US, the MSHA Training Academy plays a critical role in providing training opportunities to a wide range of professionals in the mining industry. The location of the Academy (Beckley, West Virginia), however, presents certain logistical challenges for individuals working at western mines, resulting in the under-utilization of this training resource by this industry group. Unfortunately, no comparable training facility currently exists in the western states which raises concerns over the quality and availability of training opportunities for safety professionals and instructors at western mining operations and the impact this may have on training at individual mines. Despite the absence of a western version of the Academy, it is possible to meet some of the critical training needs for the western mining industry and its workers through short courses and training activities conducted at western universities, such as CSM.

The Western Mine Training Center (WMTC) is located within the Energy, Mining, and Construction Industry Safety (EMCIS) program at CSM and is devoted to the development of effective training and education programs for workers engaged in mining operations throughout the Western United States. The cooperative agreement between CSM and NIOSH began in September of 2010 and was renewed in 2014, 2017 and 2020. The overall objective of the cooperative agreement is to reduce the total number of injuries and illnesses among workers in western mining operations. This is accomplished through a focused, relevant, and comprehensive training program that educates mine workers on how to identify and proactively protect themselves from risks and hazards in the mining environment. Over the course of the cooperative agreement, CSM has continued to improve and expand upon the initial training program by focusing extensively on Mine Safety and Health Administration (MSHA) required training; being responsive to industry needs for professional and specialized training; and creating educational

experiences for university students, faculty and staff. The key focus of this training program is to meet the needs of underserved groups such as suppliers, contractors, consultants, equipment manufacturers, and small mine operators.

Trainees

Given the scope of the cooperative agreement, most of the mine workers participating in CSM training reside and work in Colorado and surrounding western states.   Furthermore, CSM also hosts trainees who live in other states or countries, but who work in the Western United States. Additionally, most of the mine workers who attend courses offered by CSM are contractors and consultants working on short-term projects at mine sites and have no internal training programs that could provide MSHA required training. These companies rely on contract trainers, like CSM, for required mine safety and health training, as well as professional development courses.

Staff

Over the course of the cooperative agreement, the CSM staff consisted of one academic faculty member, five research faculty members, two graduate students (from CSM and Colorado State University (CSU)), and two CSM undergraduate students. Among the listed staff is the 2019 addition of a research faculty member focused on evaluation and research. The professional staff has over 190 years of professional experience in mining, health and safety, training, and leadership. In addition, all professional staff members have graduate level degrees (i.e. PhD, MS, and MBA), four staff members have professional certifications (i.e. PE, CMSP, CIH, and CSP), and five staff members are MSHA approved instructors.

Industry Advisory Council and Industry Needs Assessment

The experience and education of the professional staff demonstrates a level of expertise in the subject matter. However, to remain current and relevant, CSM meets with an Industry Advisory Council (IAC) and conducts industry needs assessments on a periodic basis. These activities ensure that the training provided is responsive to the current trends in the mining industry, as well as addresses any specific training needs. The IAC is comprised of the following types of volunteer members connected to the mining industry:

- Producers & Operators
- Suppliers
- Contractors
- Attorneys

- Research Institutes & Academics
- Construction Companies
- Fire Departments
- Service Providers

The most recent IAC meeting occurred on January 16, 2018 at CSM with the following goals:

- Review and revise as necessary the strategic plan for future program growth
- Identify training needs, including types of training and topics for training.

The companies represented include:

- Freeport McMoRan
- Southwest Energy
- Mountain and Plains ERC
- Westmoreland Coal Company
- Martin Marietta
- Husch Blackwell
- AMS
- Newmont

- Rocky Mountain
- Whiting Petro
- Atkinson
- Kiewit
- GMS Mine Repair
- Seattle Fire
- Hecla Mining

The next IAC meeting was tentatively scheduled for 2020. Unfortunately, due to the coronavirus pandemic, the 2020 IAC meeting has not been able to be scheduled but remains a high priority.

An industry needs assessment was conducted in 2017, and again in 2020. These needs assessments provided valuable information used to improve and expand the existing training. A concise summary of the different methods used to solicit feedback from distinct focus groups can be found below. Complete reports can be found in Appendix A and B.

2017 Industry Needs Assessment	2020 Industry Needs Assessment

- Method
  - Direct phone calls
- Contact Information
  - MSHA databases
  - Society for Mining, Metallurgy and Exploration
  - Colorado Mining Association
  - Commercially purchased list
- Focus
  - Safety Directors/Managers
  - Safety Training Directors/Managers

- Method
  - Electronic survey
  - Chance to win $50 gift card
- Contact Information
  - Linked-In
  - Facebook
  - WMTC Training Database
  - Society for Mining, Metallurgy and Exploration
- Focus
  - Industry professionals

Collaboration

In January 2020, the current U60 grantees (CSM and University of Arizona (UA)) met with NIOSH representatives to provide an update on goals and objectives of the cooperative agreement. During and following this meeting, the opportunity to collaborate with both NIOSH and UA was realized.

NIOSH: CSM and NIOSH are currently in the process of formalizing a data analysis and evaluation collaboration on a research project within NIOSH called EXAMiner. The intended outcome of this collaboration is a report that can be submitted for peer review. A secondary goal is the identification of lessons learned during the design and implementation of the EXAMiner software evaluation. Background on the EXAMiner is as follows:

> *For several years, NIOSH has conducted research aimed at increasing understanding of knowledge, skills, and abilities (KSAs) related to mine worker hazard recognition. In an effort to put research findings into practice, NIOSH developed the EXAMiner hazard recognition training software. This software has been made available to the mining community. Recently, NIOSH has worked with stakeholders to implement the EXAMiner software at their sites. The purpose of this implementation was to conduct an evaluation study to determine whether the EXAMiner software is effective at improving mine worker hazard recognition performance. For this*

evaluation study, NIOSH researchers worked with three mining companies to incorporate the software into existing training programs and then assessed ease of use, evidence and impact of learning with mine management, safety professionals and trainers, and mine workers. NIOSH has completed this data collection effort and is now preparing to analyze and disseminate this data to the mining and research communities.

University of Arizona: The UA has created several training activities and games that are specifically applicable to MSHA Part 48 training. While UA currently enlists other training entities to pilot their products and provide feedback, both CSM and UA agreed that it would be beneficial for both universities to have CSM pilot UA products during Part 48 training and provide feedback to UA. While several products were discussed, a card game developed by UA, titled, *A Very Good Day,* will be the first product CSM will pilot. The goal is to provide an opportunity to enhance the game and possibly expand on the methodology to be more specific to various mining sectors. CSM was scheduled to pilot the game in March 2020 and provide feedback to UA. However, this activity was postponed until September 10, 2020 due to work-at-home orders pertaining to the current pandemic. The report was sent to UA in October 2020 and can be found in Appendix C.

Service

The Specific Aims of the cooperative agreement support the objective of reducing the incidence of injuries and fatalities in western mining operations through systematic efforts. However, CSM is driven by the belief that to strengthen the health and safety message in the mining community, one must also be involved in acts of service. Therefore, CSM staff go beyond the Specific Aims and engage in service activities that help advance the health and safety knowledge of those miners in leadership and health and safety positions as well as those who educate the mining workforce. The service activities CSM staff participated in include the following:

- Society for Mining, Metallurgy and Exploration
    - Certified Mine Safety Professional
    - Health and Safety Division
    - THRIVE Conference
    - Board of Directors
- National Occupational Research Agenda
    - NORA Mining Sector Committee Members

- o   NORA Mining Sector Working Groups I and II
- National Institute for Occupational Safety and Health
    - o   EXAMiner
    - o   Mountain and Plains Advisory Council and Lectures
    - o   Safety and Health Research Advisory Committee Workshops
- Colorado Mining Association
    - o   Health and Safety Committee
- American Exploration & Mining Association
    - o   Health and Safety Committee
- Colorado State University, Industrial Hygiene Program
    - o   Industry Advisory Committee
- Conference Program Chairs

Specific Aims

The cooperative agreement included the following specific aims:

Specific Aim 1

The implementation of a safety and health training program intended to satisfy MSHA requirements as specified under 30 CFR Part 48 for New Miner and Annual Refresher training in both surface and underground operations, MSHA trainer certification, and general mining related first aid training. The main focus of this training program is intended to meet the needs of underserved groups such as suppliers, contractors, consultants, equipment manufacturers, and small mine operators. This aim is designed to supplement and enhance current training activities sponsored through the Colorado MSHA State Grants program. Below is the proposed annual course offering. The number of courses conducted for each type of training is determined by demand.

- MSHA Part 48 New Miner Courses (Surface and Underground) – 4 times/year (quarterly)
- MSHA Part 48 Annual Refresher Courses (Classroom and Remote Format) – 12 times/year
- MSHA Part 48 Instructor Course – 1 time/year
- First Aid Training – Demand dependent

The effectiveness of the Part 48 training will be evaluated by requiring each trainee to complete a pre/post examination and a course evaluation form. As part of the program's effort towards continuous

improvement, the results of the pre/post-test and the responses on the evaluation forms will be analyzed and reviewed to determine what improvements are needed prior to the next course. CSM will also continue to determine if students applied what they learned during the New Miner courses after they have returned to work and are performing job tasks. Within six months after completion of the course, contact will be made with the participants via email requesting information about how they applied what they learned to their job.

Specific Aim 2

The development of a broad-based Professional Training Curriculum that seeks to augment and improve the technical abilities, working knowledge, and effectiveness of safety and health professionals/trainers in their capacity to train workers at their individual operations, and to assist their mines with the implementation of their safety and health management systems. The following training activities will be considered annually:

- Offering presentations/workshops at the Annual Mine Safety and Health Conference.
- Developing online content for Part 48 Train-the-Trainer courses.
- Initiating webinar series that focus on current safety and health topics of interest.
- Offering safety and health training courses for improving the effectiveness of safety and health programs and/or safety management systems.

Specific Aim 3

The development and implementation of an innovative and interactive safety and health educational experience for university students, faculty and staff that utilizes effective pedagogies to ensure proficiency within mining engineering, economic geology, geological engineering, and the extractive industries. The program will target those universities in the Western United States that, given the financial limitations of the academic departments, have insufficient faculty and staff to teach safety courses. This project aim will be facilitated through two program components including:

- Conduct safety and health courses for Mining Engineering, Geology and related extractive industry undergraduate and graduate students, staff and faculty at CSM.
- Develop/conduct/offer safety and health short courses and educational experiences for undergraduate and graduate students, faculty and staff at Western United States universities.

Methodology

CSM focuses its efforts on MSHA required training (Specific Aim 1); being responsive to industry needs for professional and specialized training (Specific Aim 2); and creating educational experiences for university students, faculty and staff (Specific Aim 3). CSM believes that creating impactful, effective training will empower trainees to take what they have learned back to mine sites and their homes. This purpose and action driven learning will result in reduced injuries and illnesses in the mining industry.

The foundation of CSM's systematic instructional design methodology is built upon proven industry processes and standards as found in Branch's Analysis, Design, Development, Implementation, and Evaluation (ADDIE) Model (Branch, 2009); Merrill's First Principles of Instruction (Merrill, 2002), and Kirkpatrick's Four Levels of Training Evaluation (Kirkpatrick, 1994). CSM employs the ADDIE instructional design process to provide an organized approach to develop, deliver, and evaluate training while incorporating Merrill's principles of instruction and Kirkpatrick's four levels of training evaluation into the ADDIE framework.

Analysis

The trainees that attend CSM courses are mine workers, underserved groups, health and safety professionals, and students, faculty and staff in the extractive industries. Due to the diverse nature of trainees, CSM must remain aware of current trends and best practices in the mining industry to provide relevant training that meets the needs of the varying demographics. CSM utilizes the following resources to determine applicable training topics:

- Industry Needs Assessments
- Industry Advisory Council
- MSHA Initiatives
- Professional & Trade Organization Data

- NIOSH Research
- NORA Mining Sector R&D Goals
- Trainee Feedback

Example topics used in training during the cooperative agreement include MSHA initiatives, such as Powered Haulage, Rules to Live By, and Fire Suppression, as well as topics like Shift Work Survival Strategies, Correlation of Sleep and Safety, Training Multiple Generations, and Leadership.

CSM uses the enhanced training content by incorporating it into the various courses that are offered. The prescriptive training requirements found in 30 CFR Part 48 for MSHA New Miner, Annual Refresher, and Train the Trainer courses dictate the baseline for what CSM develops. However, CSM uses pertinent,

contemporary health and safety topics to build on and strengthen the required MSHA topics. CSM also uses these topics to create professional development training in the form of conference presentations, online training modules and webinars, and university educational experiences.

Design and Develop

The five Merrill (2002) principles have been effectively used to assess the dynamics of an environment where learning is promoted: (a) when learners are engaged in solving real-world problems, (b) when existing knowledge is activated as a foundation for new knowledge, (c) when new knowledge is demonstrated to the learner, (d) when new knowledge is applied by the learner, and (e) when new knowledge is integrated into the learner's world. These principles are incorporated into the design and development of CSM's training.

Due to the repetitive nature of the required training provided by CSM, it is necessary to provide fresh and updated material each year. Therefore, CSM operates under a continuous improvement model where each training activity is designed/re-designed, developed, and/or updated based on the following schedule:

Type of Training	Designed/Re-Designed	Developed	Updated
New Miner	Every 3 years	Every 3 years	Annually
Annual Refresher	Annually	Annually	Annually
MSHA Instructor	As needed	As needed	Annually
Professional Development	Annually	Annually	As needed
Educational Experiences	Upon request	Upon request	Annually

In addition to Merrill's (2002) five principles, CSM uses best industry practices, qualified training professionals, interactive content, adult learning techniques, and auditory, visual, and kinesthetic methods to design and develop engaging training. This type of training increases participation and enhances learning by using teams or groups, encouraging collaboration, and requiring the trainees to recall training and experiences. Therefore, when designing or re-designing training, CSM staff determines which techniques provide the most impact for the subject matter. Examples of interactive training content and the desired learning outcome used during this cooperative agreement can be found below.

Interactive Training Content	Learning Outcome
Revisits	Recall and explain training
Games	Review training
Fatalgram Teach-backs	Analyze/determine cause/prevention
Group Exercises	Apply knowledge
Communication Exercises	Listen and clarify instructions
Hazard Cards	Recognize and rank hazards
NIOSH Challenge	Hazard recognition
Harry's Hard Choices	Consequence thinking

The 2020 COVID-19 pandemic provided many challenges to CSM, especially related to the delivery of training courses. The pandemic brought industry and CSM constraints such as remote work, travel restrictions, and shutdowns. Additionally, CSM had to consider the MSHA requirements to be able to physically see the trainees, verify participation for the entire course, and have instructors available to answer questions during training. CSM addressed these challenges head-on using the proven methods of course design embedded in our instructional design methodology. After the CSM shutdown on March 13, 2020, CSM staff successfully re-designed Annual Refresher for remote delivery via Zoom while being cognizant of the MSHA requirements. Keeping true to our belief that training should be impactful and effective, CSM incorporated several tools into the training which resulted in the desired result – engaging training. Examples can be found below.

Training Tool	Training Result
Audience Response System	Enabled competitive games
Breakout Rooms	Allowed for small group discussion
Polling	Provided real-time feedback
Asking Questions	Required the student to pay attention

 July 27, 2020 was the first day CSM successfully offered limited (10 trainee max) in-person training again with strict COVID-19 preparation protocols and training day requirements. While limited in-person training is still being offered, CSM understands that not everyone can or is willing to attend. Therefore, CSM plans to continue to offer remote and limited in-person training for the foreseeable future.

Implement

After training has been designed/re-designed and developed, CSM delivers the course content to trainees as described in the Specific Aims. Upon successful implementation, CSM publishes interactive training content on the CSM EMCIS website (https://emcis.mines.edu/templates/ and https://emcis.mines.edu/training/other-courses/). During the cooperative agreement, CSM has made available recorded presentations on *Sleep: The Most Important Component of Safe Behavior* and *Stress, Fatigue, and Your Brain*; train the trainer modules on *MSHA 101*, *Job Hazard Analysis*, *Materials Handling*, and *Safety Management Systems;* as well as interactive games such as *Mineopoly*, *You Blew Up Our Haul Truck, Jenga, and 4 in the Hole*.

Evaluation

The Kirkpatrick (1994) model was used to assess the effectiveness of CSM's training. Training sessions were evaluated for adherence to course objectives, effectiveness of instruction, conduciveness of the training environment, value of course content, and applicability of training to daily work activities. Trainee feedback was used to improve and refine the course content and delivery. Additionally, comments and recommendations regarding the training or the training topic was solicited from trainees and broadly from industry stakeholders through biennial training needs assessments. CSM applied three of Kirkpatrick's four-level evaluation model (see below).

Level	Evaluation Type (what is measured)	Evaluation Description and Characteristics	Examples of Evaluation Tools and Methods
1	Reaction & Satisfaction	Reaction evaluation is how the learners felt about the training; it is a form of customer satisfaction.	Feedback forms, verbal forms, verbal reaction, post-training surveys, or questionnaires.
2	Knowledge Retention	Evaluations efforts seek to identify whether learning has taken place as a result of training.	Pre- and post-tests conducted for New Miner trainings delivered.
3	Application & Implementation	Application evaluation refers to examining trainees' use of knowledge gained through training.	Follow-up surveys administered 6-months post New Miner training sessions.

Training was evaluated in terms of instructor effectiveness, quality of the content and instruction, and student learning and performance, among other criteria of effectiveness. Evaluation efforts were both formative (trainee's progress as demonstrated by pre- and post-tests for new miner sessions,

attendance, and instructor's reflection of effectiveness) and summative (trainees' evaluation of course, and instructor's observations and analysis of quality of student learning). Overall and specific findings for evaluation methods are detailed in the Results and Discussion section below.

Course Evaluation Form (Level 1) – At the end of each training session, trainees were asked to complete a course evaluation form. This evaluation solicited ratings on the course quality utilizing a variety of descriptive factors, including, but not limited to: content, pace, and quality of instruction; use of visual aids and course materials; and opportunities for discussion and engagement with the instructors and other participants. Evaluations were consolidated for each course and reviewed by CSM staff and instructors shortly after the completion of the training as a means of continuous improvement which could include revisions in materials, training content and teaching methodology. For example, based on evaluation feedback, more "gamification" and interactive activities have been included in our Annual Refresher course. The new course design has received favorable reviews from trainees and has incorporated adult learning principles and Part 48 training requirements resulting in a better product. A copy of the evaluation can be found in Appendix D.

Pre- and Post-Test for New Miners (Level 2) – The effectiveness of the Part 48 New Miner training was evaluated by requiring each trainee to complete a pre- and post-test to measure the level of knowledge gained during the New Miner course under a variety of teaching methods. The test questions were developed according to MSHA regulations and the CSM MSHA Training Plan curriculum. Upon completion of the New Miner course, the results of the pre- and post-test were analyzed and compared. Historically, CSM has seen an improvement of 20 percentage points from the pre- to the post-test with trainees scoring in the 60% range on the pre-test and greater than 80% on the post-test. The findings are used to determine the effectiveness of the training and provide opportunities for training improvements. For instance, if trainees consistently miss a question or if collectively trainees are not scoring as expected, CSM evaluates the training method for that topic(s) and adjusts it accordingly.

New Miner Follow-up Survey (Level 3) – Each New Miner trainee was sent a survey by email approximately six months after the completion of the course. The follow-up survey (sent using Survey Monkey) requested feedback regarding the applicability and value of training on the trainees' experience working (directly or indirectly) on mine sites. The data collected from the follow-up survey helped provide a better understanding of the lasting effects of the training through trainee self-reporting. Not only was the data collected used for reporting purposes, they were subsequently used to

evaluate and improve the training pedagogy, materials, course instructors, and the types of courses offered. New Miner follow-up survey questions can be found in Appendix D.

Results and Discussion

The following section details results and discussion concerning grant activities. Supporting evidence is also included in Appendices following this report.

Training Courses and Health & Safety Related Outreach

The following table summarizes results and impact concerning each of the specific aims described earlier. With regard to Specific Aim 1, CSM staff met or exceeded the number of proposed activities in all but one area (MSHA Instructor Courses), which was due to a lack of enrollment for the course. Otherwise, five additional New Miner courses were offered during the grant period, seven additional Annual Refresher courses, and four Training Tools were developed to enhance the course offerings.

Regarding Specific Aim 2, four additional conference presentations were delivered, two recorded presentations, three webinars, as well as a total of five Train-the-Trainer short courses. Many of these activities were not proposed initially, but were completed to promote compliance and best practices in ensuring a safe and healthy workforce in the mining industry. Similarly, activities listed under Specific Aim 3 exceeded the proposed expectations regarding outreach and providing quality educational experiences for students at CSM and other Western universities. Two additional educational experiences were provided for CSM students during the grant period and nine at other Western universities. Additional detail regarding all activities categorized under Specific Aim 2 and Specific Aim 3 is included in Appendix E.

	Proposed	Actual	Length of Time	Number of Trainees	Number of Training Days
Specific Aim 1					
New Miner Courses*	12	17	3 days/4 days	241	937
Annual Refresher Courses (In-person and Remote)	36	43	1 day	646	646
MSHA Instructor Courses	3	2	2.5 days	11	27.5
Training Tools	0	4	NA	NA	NA
Specific Aim 2					
Conference Presentations	3	7	1 hr/20 min	357	39.5
Recorded Presentations	0	2	1 hour	NA	NA
Online Train the Trainer Short Courses	0	5	35 min-2 hr	NA	NA
Webinars	0	3	1 hour	58	7.3
Specific Aim 3					
Educational Experiences @ CSM*	3	5	1 hr-4 days	92	268.4
Educational Experiences @ Western Universities*	0	9	1 hr	153	24.9
* Includes CSM MNGN308/New Miner 3 Courses, 65 Students, and 305 Training Days					

The number of trainees or individuals reached, and the number of contact or training days met through these efforts serve as a measure of impact over the past three years. Among the Annual Refresher and New Miner courses, a total of 898 individuals were served over 1610.5 days of training. Additionally, 415 individuals were reached through conference presentations and webinars spanning a total of 46.8 days. Finally, through educational experiences provided between 2017 and 2020, 245 students were contacted over 293.3 days.

Evaluating the WMTC

Both quantitative and qualitative data were collected to measure the effectiveness of Annual Refresher and New Miner (Surface and Underground) training delivered between 2017 and 2020. The following 14 survey items were used to solicit ratings and perceptions from trainees:

1. How was the **content** of this course? (5-point Likert Scale: Excellent to Poor)

2. How was the **pace** of this course? (5-point Likert Scale: Excellent to Poor)

3. How was the **level** of this course? (5-point Likert Scale: Excellent to Poor)

4. How were the **visual aids** of this course? (5-point Likert Scale: Excellent to Poor)

5. How was the **course material** of this course? (5-point Likert Scale: Excellent to Poor)

6. How was the **opportunity for discussion** of this course? (5-point Likert Scale: Excellent to Poor)

7. How was the **opportunity to interact with instructors** of this course? (5-point Likert Scale: Excellent to Poor)

8. How was the **opportunity to interact with participants** of this course? (5-point Likert Scale: Excellent to Poor)

9. What was your **overall evaluation** of this course? (5-point Likert Scale: Excellent to Poor)

10. Will the training you received be **useful in your job**? (Yes or No)

11. Will the training you received be **useful in training others**? (Yes or No)

12. In your opinion, what were the most **significant strengths** of this training? (Short Answer)

13. In your opinion, what were the most **significant weaknesses** of this training? (Short Answer)

14. Any **additional comments**? (Short Answer)

Data were analyzed based on each individual grant year, as well as aggregated, to provide a total three-year representation of training effectiveness. Findings and discussion are detailed below.

Annual Refresher Training

Among 646 individuals completing a total of 43 Annual Refresher training courses between 2017 and 2020, 95% reported an overall evaluation rating of 'Excellent' or 'Very Good.' The technical areas measured include quality of instruction (pace, level, opportunity for discussion, opportunity to interact with instructors and participants), as well as the quality of the subject matter (content, visual aids, course material). Findings indicated a high level of effectiveness of Annual Refresher trainings delivered between 2017 and 2020. Among all content areas, the only element measured that received less than 90% of respondents reporting either 'Excellent' or 'Very Good' concerned the use of visual aids, which was rated 'Excellent' or 'Very Good' by 89% of trainees (Figure 1). These findings were further supported by qualitative data, which is summarized below.

Annual Refresher Evaluation (2017-2020) N=646 trainees among 43 courses	Excellent or Very Good
Content	95%
Pace	91%
Level	92%
Visual Aids	89%
Course Material	91%
Opportunity for Discussion	93%
Opportunity to Interact with Instructors	93%
Opportunity to Interact with Participants	91%
Overall Evaluation	95%

Figure 1: Annual Refresher Evaluation

Steady Improvements

Based on a 5-point Likert scale, with 5 being 'Excellent' and 1 indicating 'Poor," the average rating score among each evaluation content area was found to be highly-rated continuously each year, with slight improvements made annually in several areas (Figure 2). For example, regarding the overall evaluation rating, the average score increased from 4.51 in 2017/2018 to 4.52 in 2018/2019 and to 4.64 in 2019/2020. Among all evaluation criteria, this annual improvement analysis revealed enhancements were made over three years in all

Figure 2: Annual Refresher Improvements (2017-2020)

but three areas. Regarding 'opportunity for discussion,' mean ratings remained the same (4.64 out of 5) in 2017/2018 and in 2019/2020. The only areas that showed a decline concerned the 'opportunity to
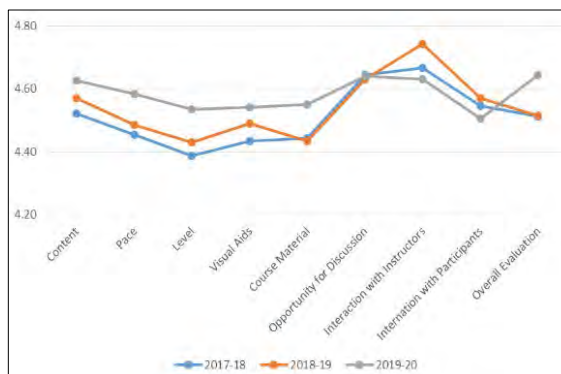
interact with instructors,' (4.67 in 2017/2018 to 4.63 in 2019/2020) and 'opportunity to interact with participants' (4.55 in 2017/2018 to 4.51 in 2019/2020).

Qualitative Insights – Annual Refresher

More than 2800 narrative comments were collected from trainees completing Annual Refresher courses between 2017 and 2020. Figure 3 shows a word cloud of most common words represented among 1166 comments about the perceived strengths of the training. Themes from the narrative data revealed trainees' positive perception regarding the use of games and other interactive training methods used to keep participants engaged. Sample comments illustrating these strengths are as follows:

Figure 3: Annual Refresher Strengths (2017-2020)

"I enjoyed the interactions with others and the game style trivia format. It kept me engaged and I learned more as a result."

"Interaction. It's not just PowerPoint slides but group work to learn via games and discussion."

"Course interaction. You have eliminated a lot of power point presentations. I really enjoyed the course this year."

"Enjoyed the "games" which made it fun while we were learning - time went fast."

"The interactive training components was helpful to engage the students and drive participation."

"Hands on and the jeopardy. Interaction with others in class. Nice to have different instructors makes the material presented better."

"Hands on and the games to keep everyone interested. This made it fun."

"Engaging instructors delivering information well."

"Games are a fun way of learning."

"The training games made the course more enjoyable."

"I think keeping the environment interactive and fun was a huge strength and much appreciated."

"I believe the interactive games we played were the most beneficial. Keeps people

engaged and not dose off. Incorporating participation between others."

"Interactive! Jenga and trivia."

"Best MSHA training I have ever attended. Great interaction."

"Interactive nature of presentation made the day fly by!"

"Learning through play to keep students engaged."

"The interactive nature of the training makes it memorable."

Another theme from the qualitative data collected regarding strengths of Annual Refresher training involved the quality of instruction; specifically highlighting the competencies and experience of instructors. For example:

"Knowledge base and real world applications."

"Content and instructors knowledge."

"Great instructors."

"Knowledgeable instructors who present in an interesting exciting manner."

"Very knowledgeable on subject matter."

"Instructors had good energy while teaching a dry subject."

"Instructors had real life experience."

"The knowledge of the instructors!"

"Love the knowledgeable instructors."

"The instructors are engaged and clearly enjoy their work."

Among 965 narrative comments collected by Annual Refresher trainees between 2017 and 2020, no major themes were revealed (Figure 4). Instead, the qualitative feedback focused on structural or environmental influences. For example, some trainees noted that the lunch break was too long or the desire to work through lunch or to have lunch provided. Other examples of environmental weaknesses pertained to some trainees reporting that traffic was bad, chairs were too hard, or that the training room was too cold.

A minor theme regarding perceived weaknesses concerned the platform used to complete the evaluation for the training. As such, discussions are
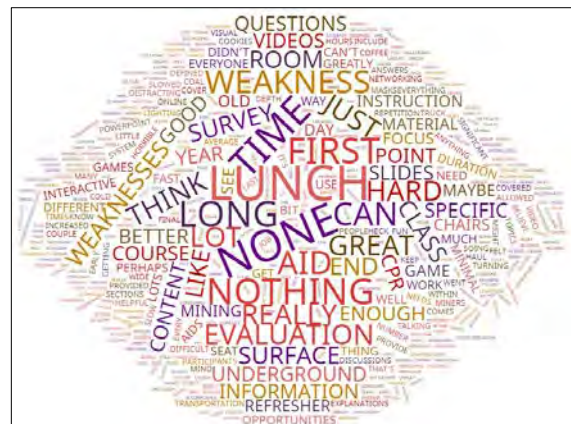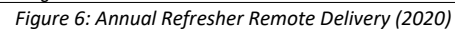

Figure 4: Annual Refresher Weaknesses (2017-2020)

currently underway to compare options for conducting training evaluation in the future. Below are examples of trainees' comments regarding evaluation techniques as a weakness about the training:

> "Honestly I really don't like the way we complete the evaluation. It's time consuming and irritating waiting for everyone to get to the same point."

> "The final evaluation on Turning Point is horrible."

> "I hate this evaluation system."

> "The electronic evaluation form."

Among the remaining 714 narrative comments collected in response to the final item, 'Any additional comments?' a major theme involved trainees' expressed appreciation for the training and the quality of instruction (Figure 5). In addition, numerous comments illustrated a pattern concerning trainees coming back to complete Annual Refresher training year after year. Trainees further noted satisfaction for efforts to update the training delivery each year. For example:

Figure 5: Annual Refresher Additional Comments (2017-2020)

> "Great improvements this year, and fresh instructor perspectives!"

> "Over 30 years of MSHA training and this is the best course in terms of techniques used, variety and interaction. This is 3rd year and has something different each time."

> "Best yet - every year your content improves. Excellent, knowledgeable instructors."

> "I like that the course is refreshed every year and not stale. Thanks so much."

> "Good the way they mix it up each year, and make it different, relevant and practical."

> "I've been taking this class for several years and it seems to be getting better each year. It covers the material in an interesting way and makes the 8 hours go by much faster. Thanks for the great work!"

> "I have been to probably 15 of these… been to this one the last 4 years and it's the best I have been to."

Remote Delivery Results

In March 2020, stay-at-home orders due to the COVID-19 pandemic required the remote delivery of previously-scheduled Annual Refresher training. Between March and August 2020, four remote trainings were delivered and 57 individuals trained. Evaluation data were analyzed separately due to the substantial differences involved in delivering training in a synchronous and remote environment. Figure 6 displays the positive ratings among trainees concerning all evaluation areas measured. It is noteworthy that the overall evaluation was rated higher (98% reported 'Excellent' or 'Very Good') by trainees from the remote delivery sessions compared to the larger sample of trainees who completed Annual Refresher training in person (95% reported 'Excellent' or 'Very Good').

Figure 6: Annual Refresher Remote Delivery (2020)

When analyzing the narrative data collected from trainees who completed the remote trainings, findings were similar to the qualitative themes presented above. Figure 7 shows various themes represented in the data, included the value of using games to maintain participant interaction and the knowledge and expertise of instructors. Trainees also expressed satisfaction with being able to complete the training remotely, rather than having to cancel and reschedule their Annual Refresher. Examples of narrative comments collected illustrating these themes include the following:

Figure 7: Annual Refresher Remote Delivery Strengths (2020)

"Interaction and quality of teaching material."

"I thought that the on-line format actually work well less a couple of minor technical glitches. The knowledge of the instructors is excellent."

"I like the online version. I like the fact it was in one day and I was able to just leave my jobs for one day."

"I really appreciate how well done the interaction was for an online course. It kept me interested and was fairly easy to sit through. The presentations were very organized. Clean and neat."

"Being able to access from remote." locations. Many people are unable to travel during COVID situation. The instructors were also very knowledgeable in the topics they presented."

"The games to keep it interesting."

"Games and stories that are interactive is great."

"Being able to still do interactive games, quizzes and breakout sessions was great!

"Being a virtual course I had my reservations about how to engage, but the engagement pieces (jeopardy, soccer, etc.) actually worked very well. I liked being called on randomly. The engagement side surprised me."

Given that physical distancing requirements are currently still in-place, discussions are underway regarding expanded remote delivery options for Annual Refresher training. Evaluation data will continue to be collected and analyzed to support decisions regarding remote and in-person training offerings.

New Miner Training (Surface and Underground)

Between 2017 and 2020, New Miner training was delivered to 176 individuals with a distinction for either surface or underground, or both. An additional 65 individuals were trained using the New Miner curriculum that follows the MSHA-approved training plan currently in use. These 65 individuals completed the New Miner training for course credit associated with their degree program requirements in Mining Engineering at CSM. In total, 937 training days were conducted across 62 New Miner courses, reaching a total of 241 individuals between 2017 and 2020.

The evaluation findings for New Miner training remained significantly high, similar to findings from the Annual Refresher evaluation presented previously. Among the sample of 241 New Miner trainees, 91% reported an overall evaluation to be 'Excellent' or 'Very Good.' Figure 8 shows the percentage of trainees who offered the highest rating in each technical area measured. The most favorable ratings were received regarding training 'Content' (93%) and the 'Opportunity to Interact with Instructors' (92%). It is interesting to note the areas least likely

New Miner Evaluation (2017-2020) N=241 trainees among 62 courses	Excellent or Very Good
Content	93%
Pace	83%
Level	85%
Visual Aids	88%
Course Material	86%
Opportunity for Discussion	90%
Opportunity to Interact with Instructors	92%
Opportunity to Interact with Participants	86%
Overall Evaluation	91%

Figure 8: New Miner Evaluation (2017-2020)

to be rated high by trainees pertained to 'Pace' (83%) and 'Level' (85%). As a point of discussion, these findings are not surprising. A major difference between Annual Refresher and New Miner training is the MSHA-required training hours to be certified (8-hours for Annual Refresher; 24-hours for New Miner-Surface; and 40-hours for New Miner-Underground). Qualitative data, presented below, revealed a moderate perception held by trainees regarding training hours for New Miner training, as well as the level of the curriculum intended to reach trainees seeking a surface or underground training certificate. Still, in comparing the total New Miner and Annual Refresher evaluation data, trainees consistently provided high ratings among all technical areas and the training overall, indicating a high level of effectiveness of the WMTC.

Qualitative Insights – New Miner

Nearly 1900 narrative comments were collected from trainees completing New Miner courses between 2017 and 2020. Figure 9 shows a word cloud of most common words represented among all qualitative data collected, whether pertaining to strengths, weaknesses, or additional comments. As shown, the major themes concerned trainees' favorable ratings of the course overall and the training content to

Figure 9: New Miner Total Qualitative Data Analysis

prepare them for working on a mine site. The word clouds in Figure 10 compares the most common strengths identified among trainees from New Miner-Surface courses and New Miner-Underground
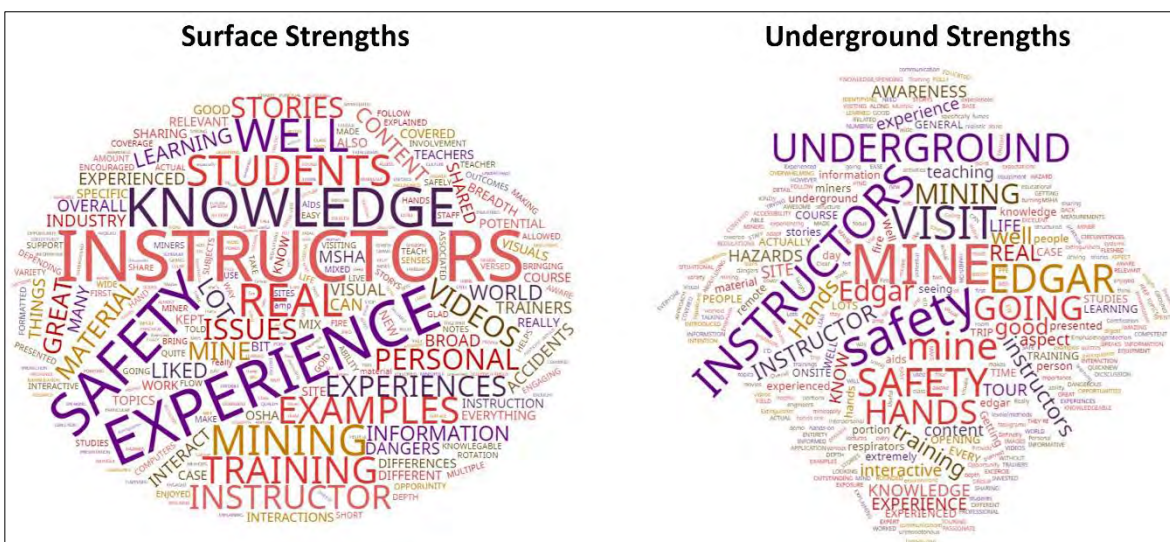
Figure 10: New Miner-Surface and New Miner-Underground Strengths (2017-2020)

courses. Major themes about perceived strengths were more evident among the 526 comments collected from New Miner-Surface trainees, as compared to the 369 comments collected from New Miner-Underground trainees. Additional detail regarding qualitative themes is presented below.

Surface Strengths

The most prominent theme revealed in analyzing trainees' perceived strengths of the New Miner-Surface course concerned the effectiveness of using multiple instructors and their credibility as experienced trainers and safety professionals. A sub-theme was also revealed regarding the use of stories lending to the effectiveness of the training. For example:

"The depth and breadth of knowledge brought by the instructors."

"Knowledgeable instructors with real-world site experience."

"The passion and direction of the instructors throughout the program."

"Breadth of instructor knowledge."

"Great course overall, appreciated the mix of instructors and vast knowledge and experience!"

"Multiple instructors with different backgrounds in mining."

"Having experienced instructors with real world experience."

"The instructors bring a lot of knowledge and experience and shared quite a bit of it."

"Great instructors with a lot of knowledge and first-hand information to share."

"Multiple instructors kept the class interesting and different instructor backgrounds helped add additional value."

"The instructors were knowledgeable & encouraged discussions."

"The knowledge of the instructors and the live stories they shared."

"Knowledge of instructors and stories told to make the content real."

Underground Experience

A major difference between the New Miner-Surface and New Miner-Underground training involves a mine tour at the Edgar Experimental Mine, operated by CSM. A major theme in the qualitative data collected from trainees completing the New Miner-Underground course illustrated the value of this tour to provide real-world experience. Further, the effectiveness of instructors was noted by trainees as a

strength of the New Miner-Underground training program. A sample of comments representing these two major themes is including below:

"Hands on approach and real world experience of instructors."

"Actual mine visit."

"Going into the Edgar mine and seeing how to escape."

"Onsite training at Edgar mine."

"Use of experienced miners and their stories."

"Hands-on experience at a mine."

"Going to Edgar mine and experiencing the underground and seeing the potential dangers."

"The interactive educational mine tour at the Edgar mine."

"Underground mine visit. Very experienced, educated and professional instructors."

"Hands on mine visit was outstanding."

"Visiting the mine, very informative, hands on learning."

"Instructors know what they're talking about."

"Mine visit at Edgar."

"The instructor's knowledge as well as being able to go into a real mine."

"Truly appreciate the instructors' discussion and expertise in the field."

"Instructor knowledge and spending time in the mine."

"The instructors were very competent and conveyed the information with ease and with every intention to make everyone more safe."

Pre- and Post-Test Evaluation

In order to measure training effects on learning, a pre-test is administered to New Miner trainees on the first day of class, prior to the beginning of instruction. The pre-test consists of 26 items pertaining to MSHA standards and the objectives of the training. Topics include, but are not limited to: MSHA-requirements, health hazards, rigging, electrical safety, first-aid, workplace examinations, and hazard communication. Ten (10) additional items are included for New Miner-Underground trainees, including topics such as escapeways, self-rescue devices, ground control, ventilation, methane, refuge chambers, and Diesel Particulate Matter.

At the end of the final day of training, an identical post-test is administered and results are compared against the trainees' pre-test to determine the level of learning that occurred as a result of the training. An audience response system is used to administer the pre- and post-test electronically, which allows the instructor to monitor the responses and the number of trainees whose answers are incorrect for a specific item. If several trainees miss the same item, a discussion is facilitated to ensure trainee comprehension of the subject matter.

A comparison of results from classes held between September 1, 2017 and August 31, 2019 showed class average scores of 66% on the pre-tests and 87% on the post-tests, translating to an average overall improvement of 21%. Figure 11 includes the average pre- and post-test scores, as well as the improvement ratio for New Miner training relative to the total and by
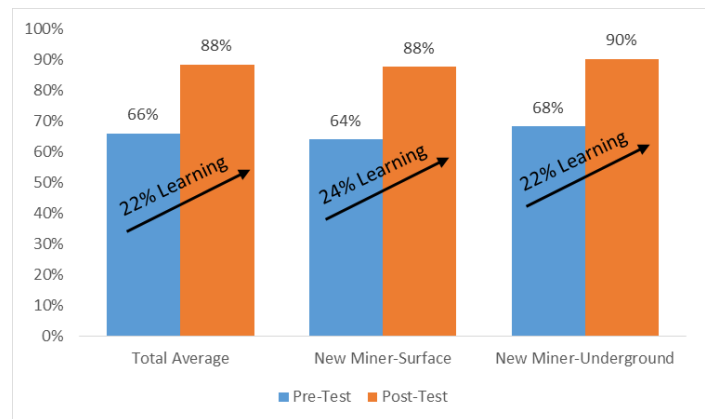
Figure 11: New Miner Trainee Pre- and Post-Test Learning (2017-2019)

surface or underground distinction. It is interesting to note that while New Miner-Underground trainees scored higher on pre-test assessments (68% compared to New Miner-Surface trainees at 64%), learning among New Miner-Surface trainees was greater (24% compared to New Miner-Underground trainees at 22% learning).

Additional Measures of Impact

As an additional measure of evaluation and impact of the WMTC, trainees were asked, 'Will the training you received be useful in your job? (Yes or No)' and 'Will the training you received by useful in training others? (Yes or No).' Figure 12 shows that more than 98% of all trainees between 2017 and 2020 indicated that the training would be useful in their jobs. Additionally, when asked whether the training received would be used to train others, New Miner trainees were slightly more likely to answer 'Yes' (89% compared to 88% of Annual Refresher trainees). These findings are encouraging and indicate a level of effectiveness based on Kirpatrick's (1994) Level 3 concerning the impact that training may have on one's behavior. While it is not possible to directly measure effects on behavior, these data suggest

that trainees have a high level of confidence that the training received at CSM will be used in their job, as well as to train others.
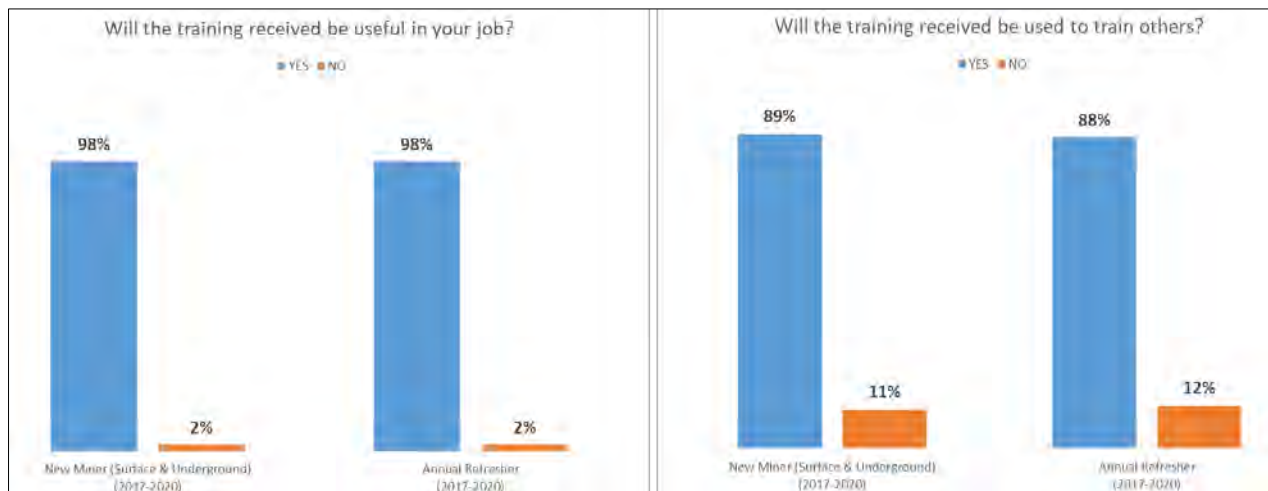

Figure 12: Trainees Reporting of Relevance and Plan to Train Others (2017-2019)

A final evaluation activity leading to insights regarding Kirkpatrick's (1994) Level 3 or behavior effects comes from a follow-up survey administered remotely to trainees from New Miner courses six-months following their completion of the training. Between 2017 and 2020, 75 former trainees completed this brief follow-up survey that includes four items:

1. Have you visited/worked on a mine site since completing your New Miner training?

2. How well do you feel the training prepared you for the hazards encountered on a mine site?

3. Are there any additional topics you feel should have been covered that would have better prepared you?

4. Would you recommend this training to others?

A total of 73 trainees (81%) responded to the first question concerning whether they had visited or worked on a mine site since completing the training. On a scale of 1-5, with 1 indicating 'Not at all' and 5 indicating 'Extremely well,' 68% of the responses reported 'Extremely well' or 'More than expected' when asked how well they felt the training prepared them for hazards on a mine site. Only nine narrative comments were collected from the follow-up survey regarding additional topics that trainees thought should have been covered during training. These comments are as follows:

"I work for EPA and we deal with Abandoned Mines more than Active ones, I realize those aren't necessarily a MSHA topic, but some additional focus on safety in abandoned mines or even ones that are going to be refurbished/reopened would be useful to folks like me."

"It's been long enough that I cannot remember all topics covered. Although I do recall that they were presented in a way that kept my focus."

"Don the new self-rescuer."

"More training in the mine. Possible mining companies willing to allow students to get their underground safety onsite training."

"If time was available, maybe a bit more first aid - Just makes us better prepared even when not on a mine site."

"Potentially hazardous unique situations in different types of mines (aggregates, coal, metal mining)."

"It might have been nice to have some additional discussion around equipment blind spots."

"My experience is that health hazards are not well understood by miners. Basic hazard communication program elements appeared weak at some mines I have been to."

The final item on the follow-up survey concerned whether trainees would recommend the CSM training to others and a total of 71 out of 74 (96%) respondents indicated 'Yes,' which is considered a measure of effectiveness.

Summary and Key Takeaways

CSM leadership and staff are proud to share the results and discussion of impact made to promote compliance and best practice in health and safety among the Western mining industry. The main activities of the WMTC have to do with providing regulatory training to underserviced populations working on mine sites, including contractors, suppliers, consultants, equipment manufacturers, and small mine operators. With the support and collaboration of NIOSH and other mining stakeholder groups, CSM continues to develop and deliver highly effective training, as detailed in this final report.

Based on the data presented, the following are the major takeaways identified from the overall evaluation, as well as analysis of technical aspects of the EMCIS training program.

1. Utilizing instructors with mining experience, who are technical experts in the topic they teach, provided credibility to the courses.

2. Incorporating multiple instructors during training courses, either as team instructors or sequentially changing throughout the training, increased the attention span of trainees.

3. Integrating personal safety and hazard recognition through stories and case studies provided real-life, relatable examples for trainees.

4. Allowing opportunities for discussion with both instructors and trainees increased learning as trainees learn valuable insights through non-structured conversations with peers and instructors alike.

5. Structuring training around active learning techniques such as competitive games, interactive polling, small group exercises, hands-on activities, and practical demonstrations improved participation and learning.

6. Re-imagining routine training systematically enhances the quality of the training.

Conclusions

The NIOSH Mining Program exists "to eliminate occupational diseases, injuries, and fatalities among workers in the mining industry" (National Institute of Occupational Safety and Health, 2019). CSM works to compliment and support this overall mission by providing regulatory training and other health and safety activities toward the goal of reducing and ultimately, eliminating health hazards, injuries, and fatalities in the mining industry.

According to Childers (2020), "In 2019, 24 mining workers were killed, the fewest number of fatalities ever recorded and only the fifth year in MSHA's 43-year history when mining fatalities fell below 30" (Childers, 2020). While the number of fatalities is declining, it may be assumed that the increased safety performance in mining is related to more effective training. CSM is motivated by the belief that training matters and that effective training can influence worker safety within the mining industry. Although it is difficult to identify a direct correlation between the quality of regulatory training and worker behavior, it is important to maintain the prescriptive requirement of New Miner and Annual Refresher training to maximize the likelihood of safe worker behavior and continue to improve the safety performance of mines across the industry. Additionally, while the mine safety and health training may be directed towards mining workplace hazards, those individuals who are able to apply what they have learned to other aspects of their life will be proficient in identifying hazards and avoiding injuries. These individuals

will also convey this knowledge to others creating a cumulative effect which is often overlooked but represents an important outcome of work-related safety and health training.

Publications

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Note: Full article can be found in Appendix F

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Appendix A – 2017 Training Needs Assessments

Training Needs Analysis – Energy Mining & Construction Industry Safety Program

In 2017, the Energy Mining & Construction Industry Safety Program at CSM conducted a training needs analysis focused on safety and health training (McDaniel, 2017). The survey was conducted exclusively by telephone with EMCIS staff contacting each mine and requesting the participation of mine safety and training personnel. Contact information was obtained from publically available sources, including MSHA databases, SME, the Colorado Mining Association, and a commercially purchased list, and focused on safety and training directors and managers.   In general, where EMCIS staff was successful in connecting with the correct party for a particular mine or organization, those parties were willing to participate in the survey and to provide valuable input regarding their training needs.

The survey pool of possible contacts covered surface and underground facilities, as well as coal, metal/ non-metal, and one industrial mineral facility. The pool included 49 coal operations comprised of 33 (67%) that operated surface mining facilities (one of which also identified as also having underground operations) and the balance (33%) represented operating underground mines. The pool included 52 metal/non-metal operations comprised of 38 (73%) that operated surface mining facilities (6 of which also identified as having underground facilities) and the balance (27%) were operating underground. Materials mined at operations included in the survey included: Gold, Copper, Silver, Molybdenum, Uranium, Platinum, Lead, and Zinc. Additionally, 10 mining industry service providers were included in the survey given that they often need training but lack the dedicated facilities or staff necessary to complete it.

Of the 112 attempted contacts in the survey pool, CSM received input from 32 parties for a response rate of 29%. Of the responding parties:

- Twenty-three (72%) identified as surface operations,
- Six (19%) identified as underground, and
- Three (9%) operated both surface and underground operations.

Within that same group of responders:

- Twenty-one (66%) identified as coal operations,
- Nine (21%) identified as metal/non-metal operations, and
- Two (6%) identified as contractors that work in both commodities.

Difficulties in the response rate included getting valid contact information, determining the correct party to connect with, working through endless electronic firewalls and dial-by-number options, and getting parties to return messages.

The survey was comprised of six questions, where each of had one or more sub-parts and/or pre-determined answer choices. These questions included:

1. Do you conduct MSHA-required training for your employees?
2. Who provides the MSHA required training?
3. What training materials are being used in your training?
4. What other types of employee training would be beneficial to your employees?
5. What do you need to improve your employee training?
6. What types of Professional development training courses would you be most interested in?

Note: The compiled results represent an aggregate and may exceed 100% as companies responded positively to move than one category (i.e. they conduct New Miner <u>and</u> Annual Refresher Training). Also, it is important to note that the results represent the number of operations that responded.

The results of this training needs analysis indicated that:

• One-hundred percent of the mines conducted some form of MSHA-required training. The breakdown of the results showed that mines conduct New Miner (79%), Annual Refresher (85%), Mine Specific (79%), and Task Specific (76%) trainings.

• This training was mostly provided by internal on-site personnel, including trainers and representatives of the safety and health staff (82%), or headquarters/regional safety and health staff (15%). The survey showed that 45% of the responders used external trainers for some component of their training needs. This need was met by a combination of private and state agencies on roughly an even basis where identified.

• Training materials needed, included CD/DVDs (76%), toolbox training (52%), interactive exercises (52%), and PowerPoint training presentations (79%). Twenty-seven percent of respondents indicated that they also use some other form of training material besides those four categories. Examples of this included staging equipment and emergency exercises for employees to work through pre-determined problems.

• For employee training, mines were interested in receiving an array of additional training. This included age awareness training (9%), ergonomics (27%), and heavy lifting (15%). The category of greatest interest was in the area of risk management/hazard awareness (27%). The author notes that the survey response are skewed as many respondents indicated that these are topics that they have self-identified and proactively incorporated into their training curriculum.

• When asked what else they needed to improve their employee training, many replied:
  o Provide new training materials at no or low cost (39%) that:
    ▪ are updated, fresh, fun, interactive, interesting, and specific to mining;
    ▪ can be used for safety meetings;
    ▪ cover topics such as, health hazards, hearing conservation, hazard communication, surface ground control, respiratory protection, and task hazard analysis.
  o Provide Safety Specialist training courses (36%)
  o Provide MSHA Instructor courses (33%)
  o Provide Train-the-Trainer courses (39%)
  o Assist mines with developing site-specific training programs (15%)

• When asked what locations were preferable for training, responses varied. The respondents gave multiple comments on the current difficulties of travel for dedicated training activities.
  o Provide training at conferences (30%)
  o Provide training off-site (but not at a conference) (18%)
  o Provide dedicated on-site classroom training (21%)

- Provide Web based training (30%)When asked what else they needed to improve their professional training, responses included:
  - o Offer courses that are closer to mines, at conferences, and on the internet (webinars);
  - o Make information readily available, such as placing training on-line so it can be accessed by multiple employees;
  - o Provide training that covers various topics related to safety management (roles and responsibilities of safety management, accident investigation, work area surveys /inspections, behavior-based safety, implementation of safety interventions, workers' compensation, integration of safety with business model, and review of MSHA standards); health (industrial hygiene, hearing conservation, and asbestos), adult learning, and mining.

Appendix B – 2020 Training Needs Assessment

REGULATORY TRAINING NEEDS ASSESSMENT IN MINING

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Colorado School of Mines

EMCIS Program

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OVERVIEW

The Colorado School of Mines (CSM) Energy, Mining, and Construction Industry Safety (EMCIS) program has been providing MSHA-required training to students, individuals, and companies throughout the United States for more than 20 years. The program is particularly critical for underserviced populations working on mine sites, including contractors, suppliers, consultants, equipment manufacturers, and small mine operators. In this new decade of 2020, the EMCIS program is working to support current and future efforts to increase the quality, availability, and delivery of MSHA-required training. Effective regulatory training, strategic partnerships and outreach, and research efforts to support this work are important to ensure the competencies of mining professionals. These activities also serve to promote compliance and best practices to ensure a safe and healthy workforce in the mining industry.

In January 2020, a training needs assessment survey was conducted to solicit feedback regarding MSHA-required training. The results from this survey will be used as a continuous improvement mechanism to ensure that that training and other services provided through EMCIS are meeting the needs of the industry and prospective trainees.

A convenience sample was used to solicit participation through social media platforms (LinkedIn and the CSM Mining Engineering department's Facebook page). A purposive sampling technique was also used, by sending a request for participation to a contact list of more than 700 former trainees. The survey contained a total of 19 items and was open for a total of seven weeks. Feedback was collected from a total of 68 respondents.

Key Takeaways
- MSHA-required training is needed among a wide variety of direct and indirect mining industry jobs.
- While work in the Metal/Non-metal sector was represented more than Coal or Construction, overlap exists in trainees serving both Surface and Underground mining.
- Companies with less than 100 employees are more likely to use external trainers for MSHA-required training.
- Instructional methods most commonly used in MSHA-required training include: *lecture provided by main trainers* (84%), *PowerPoint presentations* (78%), and *Videos (DVDs, YouTube, etc.)* (65%). Approximately 19% of participants reported that *online delivery* was used.
- A need exists to use instructional methods and facilitation that encourage participation and interaction among trainees.
- Qualitative insights from narrative comments collected include: 1) value of interactive instructional methods; 2) value of games to encourage active participation; 3) value of experienced and knowledgeable trainers; 4) specific training content matters; 5) value of real-life stories to communicate safety; and 6) importance of training content being current and relevant.

DESCRIPTION OF THE SAMPLE

The majority of respondents were affiliated with a *Mining Company* (36%) or identified themselves as a *Consultant* (31%). Figure 1 shows a wide range of direct and indirect mining positions including *Equipment Manufacturer* (15%), *Mining Supplier* (12%), *OEM* (9%) and *Academia* (6%). This finding supports EMCIS's efforts to provide training and services to a wide variety of underserviced populations working on mine sites.

With regard to position, the majority of respondents identified as a *Safety Professional* (35%), followed *by Senior Leader or Middle Manager* (32%) and nearly 24% of the sample reported working in *Engineering*. An additional 13% of respondents selected *Training Department* to describe their position;

Figure 1: Respondents' Occupation or Affiliation

9% reported *Administrative or Technical Staff*; 9% reported *Hourly Employee*; and 4% reported as *Frontline Supervisor*. The remaining 10% that reported *Other* described themselves as: *Photographer, Owner/Operator; Territory Sales Rep; Business Development Mgr.;* and *Geologist/Surveyor/Equipment Operator/Mechanic* (*see Figure 2*).
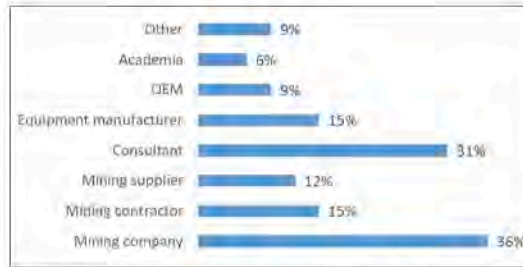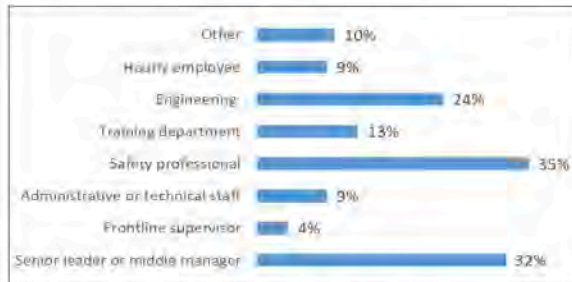

Figure 2: Respondents' Position or Department

Nearly 78% of respondents reported working in the *Metal/Non-Metal* sector and 44% reported working in *Coal*. In addition, 31% of respondents reported working in *Aggregate or Construction Materials*, and 19% in *Industrial Minerals* (*see Figure 3*). Among the 13% of respondents that reported "*Other*," narrative descriptions provided included: Oil & Gas, Tire Repair & Sales; Power Hydro; Abandoned Mine Cleanup/Rehab; Water Management, Reclamation/Environmental; and Nuclear Waste Disposal.

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When asked "What type of mining do you work in? (select all that apply)," the majority of respondents reported working in both *Surface* (76%) and *Underground* (69%) Mining.
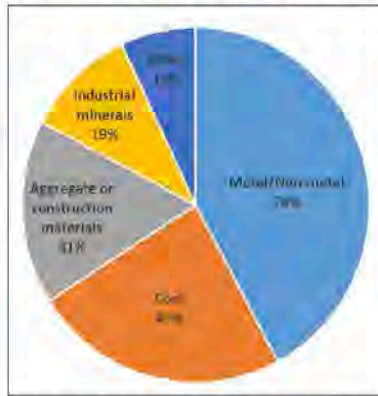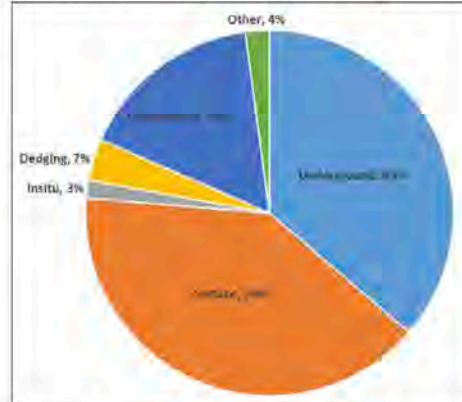

Figure 3: Respondents' Commodity

Figure 4: Respondents' Mining Sector Affiliation

Nearly 31% of respondents reported working in *Construction*. Other types of mining that respondents reported working in included *Dredging* (7%), *Insitu* (3%), and *Other* (4%) with narrative descriptions including: Exploration and Reclamation (*see Figure 4*).

Among the total sample, the size of organizations they were affiliated with was somewhat evenly distributed with 34% of respondents coming from organizations with less than 100 employees, 22% from companies with 250-500 employees, 15% from companies with 500-1000 employees, and nearly 21% from companies with more than 1000 employees (*see Figure 5*).

Figure 5: Respondents' Organization Size

When asked "What percentage of employees in your company is required to receive regulatory training," more than 51% of the sample reported 76-100%, which indicates an existing demand for New Miner and Annual Refresher Training (*see Figure 6*). With a more even distribution among other percentages reported (12% reported 24-49%, 10-24%, and 9% or less), it is also worth noting that individual needs for training exist for employees working in indirect mining or roles and professions.
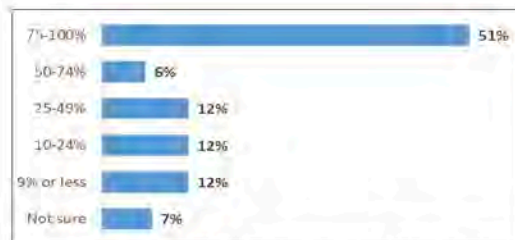
75-100%		51%
50-74%	6%	
25-49%	12%	
10-24%	12%	
9% or less	12%	
Not sure	7%	

Figure 6: Percentage of Respondents' Company that

With regard to who provides the MSHA-required training, data collected revealed an even distribution reported for *Internal Company Trainers* (onsite or corporate trainers) (32%) and *External Trainers* (consultants or state-sponsored training organizations) (32%). This finding is further supported by 28% of respondents reporting that MSHA-required training is provided by *A Balanced Mix of both Internal and External Training Resources* (see Figure 7).

Figure 7: Training Resources Used by Respondents'

Of particular interest, respondents who reported working for a company with less than 100 employees were most likely to report that training is provided by external trainers (61%), compared to internal trainers (17%) or a mix of internal and external trainers (13%). Respondents from companies of 250 – 500 employees reported using more of a balanced mix of internal and external trainers (46%) and only 20% of training provided mainly by external trainers. Respondents from companies of over 1000 employees reported that approximately 14% of training is provided by external trainers and 28% by a balanced mix of external and internal trainers.

INSTRUCTIONAL METHODS

When asked to note which instructional methods are used in respondents' experience with regulatory training, several common methods were identified. Nearly 84% of all respondents indicated that *lecture provided by main trainers* was used, followed by *PowerPoint presentations (78%)*, and *Videos (DVDs, YouTube, etc.) (65%)*. Nearly 53% of respondents reported that *interactive exercises or games (small or large group activities)* and *hands-on techniques* were used, followed by *quizzes or tests (43%)*, *live demonstrations (32%)*, and

special guest presentations (29%). Approximately 19% of participants reported that *online delivery* was used. This data aligns with narrative data collected that reveal the potential for increased use of more interactive instructional methods, compared to traditional lecture, PowerPoint presentations, and videos (*see Figure 8*).
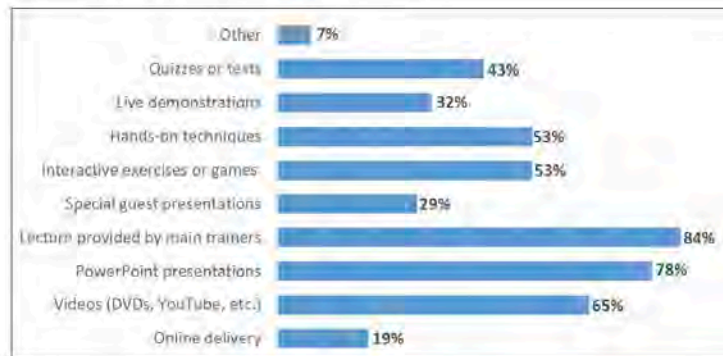

Figure 8: Instructional Methods used in Respondents' Past MSHA-Required

TRAINING EFFECTIVENESS

Seven survey items were used to measure respondents' perception of training effectiveness. Responses collected were based on a Likert-type agreement scale of 1 to 5 with 5 indicating the most favorable response of "Strongly Agree." Based on Kirkpatrick's (1994) model of training evaluation, *Level 1* or *reaction data* collected were overwhelmingly positive (either a "4" or "5") for each of the items. Figure 9 shows the percentage of the sample that disagreed, were neutral, or agreed with the item statements regarding: 1) clearly communicated training objectives (88% favorable); 2) training content being organized and easy to follow (90% favorable); 3) the facilitator being knowledgeable about the content (85% favorable); 4) the facilitator being well-prepared (82% favorable); 5) participation and interaction being encouraged (76% favorable); 6) topics considered relevant (81% favorable); and 7) the effectiveness of instructional methods used (82% favorable). These finding suggest that one area for improvement in MSHA-required training is the use of instructional methods and facilitation to ensure participation and trainee interaction.
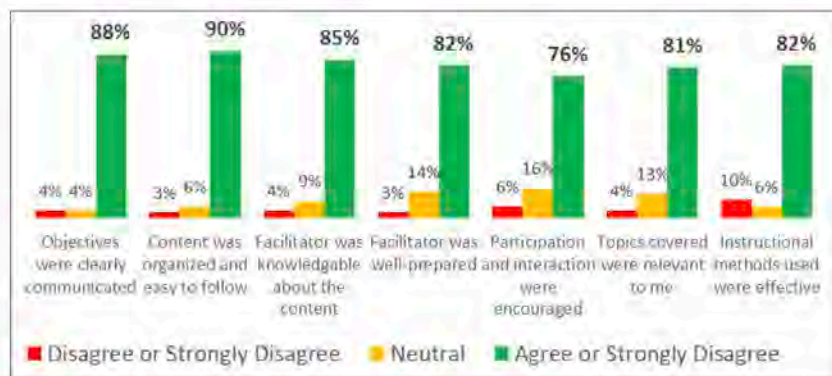
Figure 9: Respondents' Perception of Past MSHA-Required Training Effectiveness

QUALITATIVE INSIGHTS

Four qualitative items were included in the survey to gain a deeper understanding of respondents' perceptions and needs regarding regulatory training. These items included:

1. What will you remember most about past MSHA-required training you have received?
2. What was the best part about past MSHA-required training you received?
3. What suggestions do you have for improving past MSHA-required training?
4. What are other types of training (or topics) you are interested in? Are there other safety-related services your company could benefit from (such as audits, perception surveys, etc.)?

Thematic analysis was conducted based on 265 narrative comments collected, and several dominant themes were revealed: 1) value of interactive instructional methods; 2) value of games to encourage active participation; 3) value of experienced and knowledgeable trainers; 4) specific training content matters; 5) value of real-life stories to communicate safety; and 6) importance of training content being current and relevant.

Theme 1: Value of Interactive Instructional Methods
Approximately 39% of respondents' comments collected for qualitative items 1 and 2 concerned the importance of using interactive instructional methods in MSHA-required training. Examples of narrative data collected include:

Presentations in a format that was interactive and not boring.

If the content was engaging and interactive.

When the classroom was engaged in an activity, the actual training stuck much longer than a PowerPoint.

The training I received was done by contractor and it has gotten better and more interactive.

Non-traditional presentation using games, group activities and challenges.

The hands on "games" and activities do a lot to alleviate "death by PP."

20 to 30 years ago it was all over head and not clearly communicated, technology has made training streamline, hands on with visual aids.

A few have been boring and I remember very little. The ones that actually got me to interact I remember much more.

The trainer makes it memorable by the interaction and games, and helps make the content less boring by application and stories.

The training competitions – we had fun and learned valuable information.

Interactive sessions that engaged students in the learning/teaching process.

I appreciate the interactive nature of the training to make it more interesting.

The interactive nature versus just being lectured.

Again, being engaged. Feedback and participation.

Interactive participation.

The ones that are engaging and entertaining.

It was interactive, not just a PowerPoint presentation.

Interactive lessons.

When asked to provide suggestions for improving past MSHA-required training, nearly 42% of 67 responses encouraged using interactive methods, as opposed to conventional lecture, PowerPoint and videos. Examples of respondents' comments include:

Be sure it is interactive – every chance you get.

More engagement for attendees rather than lecture or slide show presentation.

More going underground and doing hands on training.

Making the training game-based or interactive whenever possible. Engagement improves retention.

More interaction and informational handouts for reference materials to review later.

Keep attendees engages.

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More out of the seat work or demonstrations.

There is a need for consistency. I've had really good training and I've some of the worst training I've ever had was an Annual refresher. I prefer the in-person but the newer computer animated on-line ones are getting pretty engaging for younger staff. The games you guys are giving and interactive activities are cutting edge for smaller classes.

Try more "flipped classroom" elements where students teach other students

Don't run videos and then forget about it – we want interactive training with current information and technology.

Less classroom style, more hands on, engage the employees. Some haven't seen a salaried person in many months and morale is lacking.

Hands on training when it applies

Scenarios requiring employees to research regulatory requirements.

More out of the seat work or demonstrations.

Do not just read from slides or handouts.

Less PP and more discussion / activities.

Mix it up, PPT is dead

Competency based vs prescriptive

Get skilled presenters. Adult learning techniques. No lecture. No slideshows.

A final indication of the value of interaction in MSHA-required training was gleaned from a minor theme in the narrative data concerning the value of networking and interaction with other trainees and industry professionals. For example:

Interaction with industry professionals.

Opportunity to interface with other workers that didn't always see daily.

That there was time for group discussions that brought home the points that the instructor had just taught. Usually it is a very diverse group at these classes which can teach us even more.

Networking and discussing safety issues with others.

Interacting with co-workers.

Team setup, development of leadership and getting out of your comfort zone

Recommendations / critical review of my performance from other miners.

Theme 2: Value of Games and Hands-On Activities to Encourage Active Participation

A second dominant theme in the qualitative data revealed respondents' favorable perception about the use of games and hands-on activities to engage trainees and encourage active participation. Examples of comments concerned the value of games include:

Active gamification of material with hands-on components.

Answers to questions asked during games.

Games and opportunity to interact with other participants.

Mine-opoly and multiple presenters.

The trivia interactive games.

Games to keep the day interesting.

Gamification to enhance retention of material.

Interactive games.

MSHA Jeopardy questions.

The games make it easiest to learn.

The games as reminder tools.

Giant Jenga.

Games. Getting up. Hands-on fire extinguisher training. Funny videos.

In addition, more than 20% of respondents' comments regarding favorable past experiences with MSHA-required training concerned the use of hands-on activities, including the opportunity to tour a mine. For example:

When we got hands on training.

Hands-on application.

Hands-on or interactive training.

Hands on at the Edgar Mine.

Topics presented in the mine environment itself has been very effective.

Actual mine walk through.

Theme 3: Value of Experienced and Knowledgeable Trainers

Another theme from the narrative comments regarding favorable recollection of past MSHA-required training involved the importance of having experienced and knowledgeable trainers. Examples of respondents' responses include:

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The knowledgeable and friendly trainers are what I remember most.

Well-delivered presentation from presenters that were well-engaged with the industry (experienced). They were professional and direct. Not a lot of fluff which was good.

Knowledgeable and experienced instructors.

The subject matter can be presented in an interesting manner by an instructor who genuinely cares about getting the information across to the course attendees.

Knowledge of instructor.

Real-life stories from the instructors help to make the training memorable.

Very knowledgeable instructors.

Really dependent on how innovative the instructor was. Most instructors though are only following the regs and not familiar with adult learning concepts.

I really enjoyed the presenter. She was very professional and direct despite information that is typically dry.

Top quality instructors.

Mixing up instructors so it's not a single person talking the entire day.

The trainer makes it interesting.

Theme 4: Training Content Matters

In sharing examples of what respondents remembered most and considered positive aspects of past MSHA-required training, nearly 20% of comments had to do with specific topics or content areas, including emergency preparedness (i.e., first-aid/CPR) and occupational health. This theme indicates the importance of delivering specific training content that trainees remember. Examples of narrative comments include:

First aid and emergency situation response.

Update on First Aid, New MSHA Regulations.

CPR & FIRST AID UPDATES WERE GOOD.

Changes in ventilation, refuge chambers, etc. Donning self-rescuer.

First-Aid Related Training.

The first-aid training.

How to be safe around the high wall and to watch for signs of instability in both types of mines.

Highest NRR rating of hearing protectors plus 5 is maximum protection for noise exposure.

The industrial hygienist explaining how to handle night shifts, long hours, dust and noise exposure.

Theme 5: Specific Value of Real-Life Stories to Communicate Safety

Another theme regarding what respondents remembered most and reflected on positively involved the value of analyzing real situations (i.e., fatalgrams) and using real-life stories to communicate safety. For example:

Stories or videos about mine accidents and how people were able to get out of the mine safely and those that didn't.

Fatalities and how quickly they happen. One should never be complacent in this or any industry.

Fatal-grams.

The reduction of deaths since the implementation of MSHA.

Fatality reviews.

Special guest lectures by individuals in an accident.

Discussions of accidents and near misses, illustrating bad and best practices.

Real life stories and experiences shared.

The communication of real life examples.

Seeing other mine scenarios and real life activities that apply to safety.

Real-life examples that were shared

The instructors usually had cool stories.

Theme 6: Importance of Training Content being Current and Relevant

Nearly 20% of narrative comments collected regarding suggestions to improve MSHA-required training had to do with a need to ensure training content is regularly refreshed and relevant. Several respondents suggested that training topics be more applicable to the hazards or type of work to which trainees are exposed. Examples of respondents' comments include:

MSHA regs requiring overview of certain subjects each year even for employees that do not ever deal with that hazard area --- would be better if training focused more on hazards employees ARE exposed to.

Keeping content as relevant as possible; keeping the class interactive.

Understanding more of the attendees need for training and company role.

More emphasis on clear communication between miners and requirements for acknowledgement so everyone knows what others are doing, what, when and where to expect traffic, and encounters with contractors, pedestrians and other changing conditions.

I believe the current approach of having all mines address the same topics, as listed in the regulation, is a flawed approach. For example, we must address the topic of explosives/blasting because it is on that list. We have no explosives on site, have no permit to have explosives on site nor any intent to change this. The training topics and time allotted really need to be more aligned with the hazards and conditions at each mine, rather than a cookie cutter training topic list.

New material.

Make it shorter...it's the same thing every year and when you have been in the business so long... it's a bit repetitive.

Further analysis of the narrative data revealed a minor theme regarding negative perceptions around the use of dated videos. For example:

Watching same video each year gets dry

Either update the old videos or add more games.

Stay away from old out of date videos.

Some of the videos were very old in some of the training classes I've been in. Yes, they are still relevant but they don't keep some people focused.

Update the videos, although the content is still relevant, a 40-year-old video is hard to relate to.

Watching the same video each year gets dry.

Fewer videos.

Additional Training Needs

The final survey items asked respondents to identify additional types of training (or topics) they may be interested in or other safety-related services their company could benefit from. A total of 65 responses were collected, of which, nearly 45% answered either "n/a," "none," or "no."

Of the remaining data, more than 21% of the comments indicated an interest in specific health and safety related topics, such as chemical safety or industrial hygiene, as well as interest in MSHA compliance topics, emergency response, and general hazard recognition skills. For example:

> *I am generally interested in training and safety. Driving is a particular aspect that is of special interest and focus within my company.*

> *Hazwoper.*

> *Cyanide.*

> *Ground control.*

> *Fatigue management is a huge issue right now.*

> *More in-depth training on subjects like emergency response in mining.*

> *Winter driving training.*

> *Self-rescue devices.*

> *SPE/accident investigation.*

> *Construction training, contractor safety issues, crystalline silica.*

> *Raise Mining Training.*

> *Keeping up-to-date with MSHA regs and onsite inspections.*

> *What inspectors look for and what their focus areas are.*

> *Also, basic hazard recognition is needed for younger and less experienced workers.*

> *Risk management / hazard recognition.*

> *"What's wrong with this picture" discussions that train student's eyes to spot unsafe conditions.*

> *Safety Systems.*

Regarding additional safety-related services, approximately 21% of respondent's comments revealed interest in auditing, train-the-trainer skills, and perception surveys. This finding illustrates opportunity to develop training that responds to this need within the mining industry. Example of respondents' comments include:

> *Safety perception surveys, building safety-related forms, train-the-trainer, and computer-based learning programs.*

> *Audits, guest speakers, MSHA inspector.*

> *Safety audits.*

> *Targeted safety campaigns.*

Mobile trainings would be a nice option and one we'd pay for. From time to time we need a one-time training.

Audits and perception surveys would be great.

Perception surveys.

Leadership training.

Already using audits, need to employ the use of employee satisfaction surveys.

We are always interested in new techniques for teaching adult learners. We believe if we can improve the capabilities of our trainers, we will get more out of the training investment that all mines must make every year.

SUMMARY & DISCUSSION

This training needs assessment was conducted to explore the perceptions and interests among professionals in the mining industry who have experience with MSHA-required training, such as New Miner or Annual Refresher Training. Based on a sample of 68 survey respondents, it was found that MSHA-required training is needed among a wide variety of direct and indirect mining industry jobs. While work in the Metal/Non-metal sector was represented more than Coal or Construction, a majority of trainees reported serving both Surface and Underground mining. It was also found that companies with less than 100 employees are more likely to use external trainers for MSHA-required training.

Instructional methods most commonly reported to be used in MSHA-required training include: *lecture provided by main trainers, PowerPoint presentations*, and *Videos (e.g., DVDs, YouTube, etc.)* (65%). Approximately 19% of participants reported that *online delivery* was used. Analysis of the survey data revealed that a need exists to use instructional methods and facilitation that encourage participation and interaction among trainees. This finding was strongly supported by qualitative insights gleaned from approximately 265 narrative comments. The findings revealed from the qualitative data included: 1) the value of using interactive instructional methods; 2) the value of using games to encourage active participation; 3) the value of experienced and knowledgeable trainers; 4) that specific training content matters; 5) value exists in using real-life stories and cases to communicate safety; and 6) a need exists to ensure training content is current and relevant to trainees.

Limitations of this research activity involve the use of convenience and purposive sampling, producing a sample of only 68 respondents. In addition, it is likely that approximately half of the sample included former participants in MSHA-required training delivered through the EMCIS program. While this characteristic of the sample may limit the ability to transfer findings to a larger population, data analysis and the findings from this research activity can be considered a type of evaluation measure for the EMCIS program.

Numerous favorable comments about MSHA-required training were collected that directly connect to EMCIS-specific training (e.g., use of Jenga, Mine-oplogy, and other specific games that EMCIS uses in training, as well as a mine tour to the "Edgar" training mine maintained by the Colorado School of Mines). Due primarily to the small sample size in this research activity, continued efforts are needed to collect training needs assessment data more broadly across the mining industry.

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Appendix C – A Very Good Day Review and Collaboration Feedback

A Very Good Day Game™

October 12, 2020

Prepared by:

Energy, Mining, and Construction Industry Safety (EMCIS) Program at the Colorado School of Mines, Mining Engineering Department

Submitted to:

Mining Safety & Health Resource Training Center, Lowell Institute for Mineral Resources at the University of Arizona

Background

In January 2020, representatives from the National Institute for Occupational Safety and Health (NIOSH) met with program leaders and staff associated with two cooperative agreement awardees under the *U60 Miner Safety and Health Training Program, Western United States*. In discussions regarding the value of collaboration and effectiveness of developed training materials, staff from EMCIS committed to conducting a formal review of the Mining Safety & Health Resources Training Center's card game, *A Very Good Day Game*™. An emphasis of the review included the scoring method and evaluation approach. The observations/findings from this review are presented below, as well as feedback solely intended to enhance the game for use in health and safety training in the mining industry.

The EMCIS review was originally scheduled to occur in March 2020 but was postponed based on physical distancing requirements and stay-at-home orders related to COVID-19.

Reviewers

Program leaders and staff of the EMCIS program met in person on September 10, 2020 to conduct a review of the card game. Among six professionals, the following demographics are interesting to note:

- Ages ranged from 27 to 70 (average age of 52)
- Three females and three males participated
- Professional certifications among participants include: PE, CSP, CMSP, CIH, QP
- Four of the six participants are MSHA-certified instructors
- 17 total University degrees held among the six participants, including three PhDs
- Participants possess approximately 140 years of professional and industry mining experience

Review Process & Observations/Findings

The initial step in the review process involved reading the Instructions to the group aloud, as well as the Evaluation Card, which is referred to in the final bullet in the Instructions. Per the directions on the Evaluation Card, time was recorded, as was each participant's "safety score."

Observations/Findings:

- In order for all six participants to play, two card decks were needed.
- It took approximately 10 minutes to read the instructions and confirm all participants' understanding of the rules and directions for playing the game (9:10-9:20am).
- The total time spent playing the game was approximately 45 minutes (9:20-10:05am).
- The resulting "safety scores" and the number of Control Cards left in participants' hand at the end of the game were:

Participant	Safety Score	Control Cards Left in Hand	
#1 (MR)	-2	5	
#2 (JB)	3	0	*winner
#3 (JP)	0	3	
#4 (KM)	3	5	
#5 (KV)	1	6	
#6 (LG)	0	5	

- Regarding the Evaluation Card and method, it is unclear how to gauge insight into players' learning or behavior outcomes from engaging with the game. Based on the "safety score" generated from players' Hazard and Control Cards at the end of the game, it could be assumed that a negative score indicates inadequacy in controlling hazards or a negative outcome from training. Finally, the Evaluation Card instructs players to "record time taken to play," yet it is unclear what the time factor indicates from an evaluation perspective.
- Note: Following this review, additional information about scoring was located in a technical report. According to Wilson, Brown, Reed, & Burgess (2020), "player's composite safety index for a match is taken as the sum of all hazard × control card pairings for the hazards he or she has successfully mitigated" (p. 4). It is recommended that this explanation be included in the Instructions of the game, as during this review, the safety score was determine using addition, rather than multiplication.

In the first round of game play, the Hazard Card presented involved an "Open Electrical Box -1," which a participant played a Control Card of "PPE 1" to mitigate the risk involved. This initial game play generated much discussion among the players, including additional review of the Instructions.

Observations/Findings:

- Review and discussion revealed the need to clarify the objective of the game and to refresh participants' knowledge and understanding of hazard recognition and risk mitigation techniques, including the Hierarchy of Controls.
  - It is worth noting that the subtitle of the game printed on the Instructions is "The Hazard Recognition Game," yet the stated Objective is to "Control the hazards" by having "no control cards left."
- An enhancement to the game could include an overview of the Hierarchy of Controls methodology to educate players about the successive levels of effectiveness, and the difference between controlling risk around a hazard and "fixing" a hazardous situation.

Further, without this clarification around the objective of the game, a threat of over-controlling hazards exists, as well as a misunderstanding of MSHA's guidance around "feasible control."

- Participants agreed that the use of a facilitator would significantly improve the flow of the game and would be beneficial in providing the overview regarding purpose, objective, and a better understanding of the Hierarchy of Controls.

Per the Instructions, each player's turn is subject to "The Challenge" where "another player (*The Challenger*) can choose to challenge the decision if they believe that they hold a more effective control card." The Instructions further state that a "consensus of majority vote" is needed to play a Control Card on a different player's Hazard Card, causing the initial player to return their Control Card to their hand. Another common action noted during game play involved the analysis of the point system involved.

Observations/Findings:

- The Challenge component of the game generated ample discussion during each player's turn regarding the effectiveness of controls to properly reduce risk to "As Low As Reasonably Possible" (ALARP).
- Hazards in the game were selected from three sources "representing a tier of risk severity" and assigned a related number value (-1, -2, or -3) (Tabletop Activities, 2020). Likewise, Control Cards are assigned a value ranging from 1 – 5.
  - Arbitrarily matching a number value from a Control Card to mitigate the risk involved with a Hazard Card value does not allow for proper assessment of a player's ability to recognize and control risk. In fact, it may lead a player to believe that a PPE card (1) adequately controls the Hazard card of Cracks in high wall (-1) (see photo below).

  - Discussion involved the importance of promoting the proper use of the Hierarchy of Controls methodology and reminding players that regardless of point value, certain controls are more effective than others. For example, in the first round dealing with the "Open Electrical Box -1" Hazard Card, a Control Card of "PPE 1" would not necessarily be the best way to properly control the hazard, yet the point system may lead players to believe that the use of PPE is sufficient because the 1-point value of the Control Card satisfies the -1 point-value of the Hazard Card.
  - If players are competitive and overly-focused on the scoring, they may lose focus on the overarching goal of the game to promote hazard recognition and risk control. These players may utilize a strategy to play PPE or Administrative Control Cards first and save their higher point-value Control Cards in an attempt to win the game. If

this technique is allowed, the game may be seen to promote substandard control mechanisms.

Additional Areas of Review

Aside from reviewing the purpose and practical application of *A Very Good Day Game*™, EMCIS players noted a number of areas where consideration may be given to enhancements or possible revision to how the game is played.

- The instructions could be revised for clarity and to remove reference to demographic distinctions ("The youngest player starts...").
- The workplace displayed in the Area Cards could be larger and possibly labeled. There were a few cards that only a few players were familiar with.
- Area Cards and Hazards could be combined, preventing the occurrence of a hazard not being relevant to a particular area. It was also found that some Hazard Cards did not pertain to any of the six Area Cards dealt to the players. A possible remedy is to assign more than one Area Card per player.
- Specific Area and Hazard content could be tailored more specifically for use in training for Surface and Underground operations.
- Some Hazard Cards were unclear in their intended meaning. For example, players could misinterpret or be unfamiliar with phrases like, "Equipment incorrectly propped up with repairs," "Improperly sized beam," and "Faulty straps/ poorly tied." A possible remedy may involve combining Hazard Cards and Area Cards into one.
  - If the game was developed using actual incident and fatality data, consideration could be given to creating one Hazard/Area Card that accurately depicts the referenced incident or fatality. This could facilitate additional value and impact from the game in training players how to prevent incidents from actual scenarios.

Summary

This review of *A Very Good Day Game*™ was conducted as an example of collaboration to improve and promote effective and engaging safety and health training for miners in the Western United States. A number of positive observations were made and areas for enhancements were observed as well.

Actively engaging adult learners through games and other interactive learning techniques is considered a best practice in training (Pike, 1994; Silberman, 1996; Tapp, 2007). *A Very Good Day Game*™ can be considered a tool to engage trainees through active learning. Further, while improvements may be made to the game as suggested in this review, the subject matter related to controlling hazards in the workplace is relevant and necessary in the mining industry. Suggested enhancements to the game will allow for increased awareness and understanding about how to use the Hierarchy of Controls to prevent incidents and fatalities that we know are possible. Risk assessment and management activities are systematic processes, which must be considered in an attempt to train using a game platform. It is important that trainees know that the application of risk controls is not a random process.

In an attempt to continue this collaboration, it is recommended that EMCIS and the Mining Safety & Health Resource Training Center develop and execute a plan to revise and republish *A Very Good Day Game*™ jointly with a focus on addressing the areas for enhancements described in this review. With an

emphasis on improving trainees' ability to recognize and control hazards in the workplace, *A Very Good Day Game*™ has the potential to be more widely-known and utilized as an active learning training tool in the mining industry. It may also serve as a template for other industries to develop training materials that more effectively engage trainees, further promoting the impact of this collaboration and of best practices in training the next generation of miners.

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Appendix D – Course Evaluation Forms

COURSE EVALUATION
Energy, Mining, & Construction Industry Safety Program
Colorado School of Mines
Golden, CO 80401

Course Title:

Date: **Instructors: EMCIS Staff**

This questionnaire is designed to help CSM maintain a standard of excellence in this program and others. You may or may not choose to sign the form. In either case, we appreciate your help and look forward to your participation in future programs at CSM.

1. Technical Aspects

	Excellent	Very Goo	Good	Fair	Poor	COMMENTS
Content						
Pace						
Level						
Visual aids						
Course material						
Opportunity for discussion						
Opportunity to interact with instructors						
Opportunity to interact with participants						
Overall evaluation						

2 a. In your opinion, what were the most significant strengths of the program?	b. In your opinion, what were the most significant weaknesses of the program?

3. Will the training you received be useful in your job? **Yes / No   Please comment**.

4. Will the training you received be used in training others? **Yes / No**

5. If yes, how many others do you anticipate training during the coming year? **Please estimate**.

6. Additional comments (e.g. new course, topics, speakers, etc.)

7. Name and address of others who should be added to our mailing list.

New Miner Training Follow-up Survey Questions

1. Have you visited/worked on a mine site since completing your New Miner training?

2. How well do you feel the training prepared you for the hazards encountered on a mine site?

3. Are there any additional topics you feel should have been covered that would have better prepared you?

4. Would you recommend this training to others?

Appendix E – Specific Aim 2 and 3 Activities

Specific Aim 2 Activities

	Title	Length of Time	Number of Trainees
Conference Presentations			
13th Annual Mine Safety and Health Conference (Reno, NV)	Challenges of Multi Generational Training	1 hour	53
14th Annual Mine Safety and Health Conference (Reno, NV)	Your Brain on Stress and Fatigue	1 hour	52
15th Annual Mine Safety and Health Conference (Reno, NV)	EMCIS MSHA Training: Fun not Funny	1 hour	44
15th Annual Mine Safety and Health Conference (Reno, NV)	Sleep: The Most Important Component of Safe Behavior	1 hour	46
2019 Nationa Safety Council Annual Congress & Expo (San Diego, CA)	Managing Fatigue in the Workplace	1 hour	100
2019 SME Annual Conference (Denver, CO)	Challenges of Multi Generational Training	20 minutes	42
2019 SME Annual Conference (Denver, CO)	Your Brain on Stress and Fatigue	20 minutes	20
Recorded Presentations			
CSM EMCIS Website*	Sleep: The Most Important Component of Safe Behavior	1 hour	NA
CSM EMCIS Website*	Stress, Fatigue, and Your Brain	1 hour	NA
Online Train the Trainer Short Courses			
CSM EMCIS Website*	Hazardous Particulates in Mining	1 hour	NA
CSM EMCIS Website*	Job Hazards Analysis	35 minutes	NA
CSM EMCIS Website*	Materials Handling	45 minutes	NA
CSM EMCIS Website*	MSHA 101 (Part 1 and 2)	1 hour each	NA
CSM EMCIS Website*	Safety Management Systems (Part 1 and 2)	1 hour each	NA
Webinars			
SME Webinar (September 19, 2019)	Behavior Science 101: Understanding and Influencing Workers' Behavior for Safety	1 hour	9
SME Webinar (June 24, 2020)	Stress and Fatigue	1 hour	30
SME Webinar (July 9, 2020)	Training Fun	1 hour	19
* https://emcis.mines.edu/training/other-courses/			

Specific Aim 3 Activities

	Title	Length of Time	Number of Trainees
Educational Experiences @ CSM			
2018 MNGN308 - 1 Credit Course	Mine Safety and Health	4 days	17
2019 MNGN308 - 1 Credit Course	Mine Safety and Health	4 days	28
2020 MNGN308 - 1 Credit Course	Mine Safety and Health	4 days	20
Guest Lecture @ CSM (September 23, 2019)	Mine Safety 101 (Intro to Mining Course)	1 hour	27
CSM Tour @ US Silver Galena Mine (December 4, 2018)	Safety Issues and Thermal Exposures in Narrow Vein Mines (Senior Offerning)	1 day	5
Educational Experiences @ Western Universities			
Guest Lecture @ University of South Dakota (September 18, 2019)	Mine Safety 101 Underground Mine Design Course)	1 hour	18
Guest Lecture @ University of South Dakota (September 18, 2019)	Mine Safety 101 (Intro to Mining Course)	1 hour	18
Guest Lecture @ University of Nevada-Reno (October 22, 2019)	Mine Safety 101 (Intro to Mining Course)	1 hour	20
Guest Lecture @ University of Nevada-Reno (October 23, 2019)	Mine Safety 101 (SME Student Chapter Meeting)	1 hour	30
Guest Lecture @ Montana Tech (November 20, 2019)	Accident Investigation and Root Cause Analysis (Mine Safety Course)	1 hour	15
Guest Lecture @ University of Arizona (February 8, 2020)	Incident Command and Safety (Mine Emergency Response Course)	1 hour	5
Guest Lecture @ University of Arizona (February 10, 2020)	Root Cause Analysis (Seminar Course)	1 hour	23
Guest Lecture @ University of Utah (April 7 & 9, 2020)	Leadership Development in Mining (Health and Safety Management Systems)	2 hours	11
Guest Lecture @ Colorado State University (April 24, 2020)	Introduction to Mine Health (Graduate Seminar)	1 hour	8

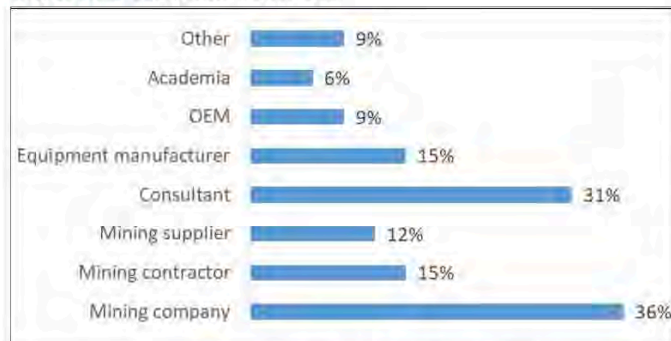# Appendix F – Regulatory Training Needs Assessment Article

Regulatory training-needs assessment:
Survey highlights industry trends and best practices

by Lori Guasta, Hugh Miller and Michelle Reiher

Figure 1

Respondents' occupation or affiliation.

Occupation/Affiliation	Percent
Other	9%
Academia	6%
OEM	9%
Equipment manufacturer	15%
Consultant	31%
Mining supplier	12%
Mining contractor	15%
Mining company	36%

The Colorado School of Mines' (CSM) Energy, Mining and Construction Industry Safety (EMCIS) program has been providing U.S. Mine Safety and Health Administration (MSHA)-required training to students, individuals and companies throughout the United States for more than 20 years. This training has been possible through NIOSH support under a U60 cooperative agreement. The program is particularly critical for underserviced populations working on mine sites, including contractors, suppliers, consultants, equipment manufacturers and small mine operators. In this new decade of 2020, the EMCIS program is working to support current and future efforts to increase the quality, availability and delivery of MSHA-required training. Effective regulatory training, strategic partnerships and outreach and research efforts to support this work are important to ensure the competencies of mining professionals. These activities also serve to promote compliance and best practices to ensure a safe and healthy workforce in the mining industry.

In January 2020, a training-needs assessment survey was conducted to solicit feedback regarding MSHA-required training. The results from this survey will be used as a continuous-improvement mechanism to ensure that training and other services provided through EMCIS are meeting the needs of the industry and prospective trainees.

A convenience sample was used to solicit participation through social media platforms (LinkedIn and the CSM Mining Engineering Department's Facebook page). A purposive sampling technique was also used by sending a request for participation to a contact list of more than 700 former trainees. The survey contained a total of 19 items and was open for a total of seven weeks. Feedback was collected from a total of 68 respondents.

Key takeaways

- MSHA-required training is needed among a variety of direct and indirect mining industry jobs.
- While work in the metal/nonmetal sector was represented more than coal or construction, overlap exists in trainees serving both surface and underground mining.
- Companies with fewer than 100 employees are more likely to use external trainers for MSHA-required training.
- Instructional methods most commonly used in MSHA-required training include: lecture provided by main trainers (84 percent), PowerPoint presentations (78 percent) and videos (DVDs, YouTube, etc.) (65 percent). Approximately 19 percent of participants reported that online delivery was used.
- A need exists to use instructional methods and facilitation that encourage participation and interaction among trainees.
- Qualitative insights from narrative comments collected include: 1) value of interactive instructional methods; 2) value of games to encourage active participation; 3) value of experienced and knowledgeable trainers; 4) specific training content matters; 5) value of real-life stories to communicate safety; and 6) importance of training content being current and relevant.

Description of the sample

The majority of respondents were affiliated with a mining company (36 percent) or identified themselves as a consultant (31 percent). Figure 1 shows a range of direct and indirect
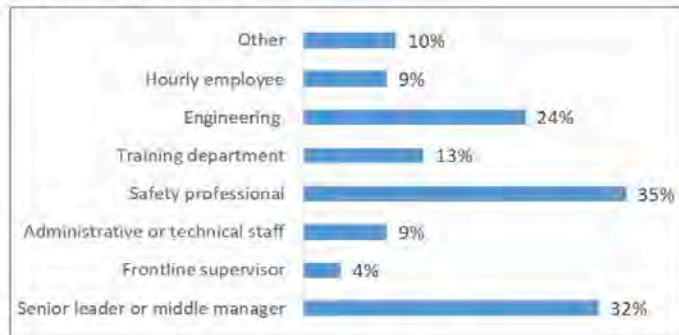
The authors are principal investigators and staff at the Energy, Mining and Construction Safety Program at the Colorado School of Mines in Golden, CO, email emcis@mines.edu.

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mining positions including equipment manufacturer (15 percent), mining supplier (12 percent), original equipment manufacturer (OEM) (9 percent) and academia (6 percent). This finding supports EMCIS's efforts to provide training and services to a variety of underserviced populations working on mine sites.

With regard to position, the majority of respondents identified as a safety professional (35 percent), followed by senior leader or middle manager (32 percent), and nearly 24 percent of the sample reported working in engineering. An additional 13 percent of respondents selected training department to describe their position; 9 percent reported as administrative or technical staff; 9 percent reported as hourly employee; and 4 percent reported as frontline supervisor. The remaining 10 percent that reported as other described themselves as: photographer, owner/operator; territory sales rep.; business development manager; and geologist/surveyor/equipment operator/mechanic (Fig. 2).

Nearly 78 percent of respondents reported working in the metal/nonmetal sector, and 44 percent reported working in coal. In addition, 31 percent of respondents reported working in aggregate or construction materials and 19 percent in industrial minerals (Fig. 3). Among the

Figure 2

Respondents' position or department.

13 percent of respondents that reported "other," narrative descriptions provided included: oil and gas, tire repair and sales; power hydro; abandoned mine cleanup/rehab; water management, reclamation/environmental; and nuclear-waste disposal.

When asked "What type of mining do you work in? (select all that apply)," the majority of respondents reported working in both surface (76 percent) and underground (69 percent) mining.

Nearly 31 percent of respondents reported working in construction. Other types of mining that respondents reported working in included dredging (7 percent), in situ (3 percent) and other (4 percent) with narrative descriptions including

Figure 3
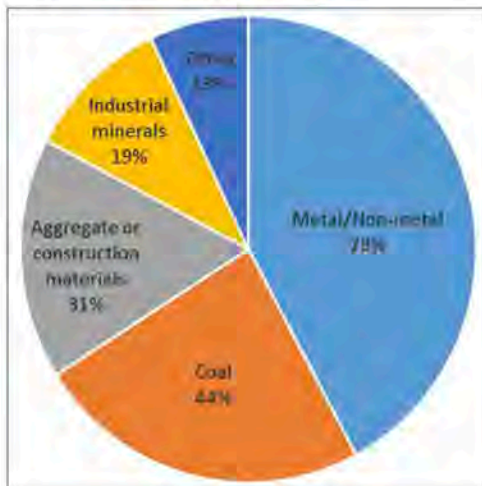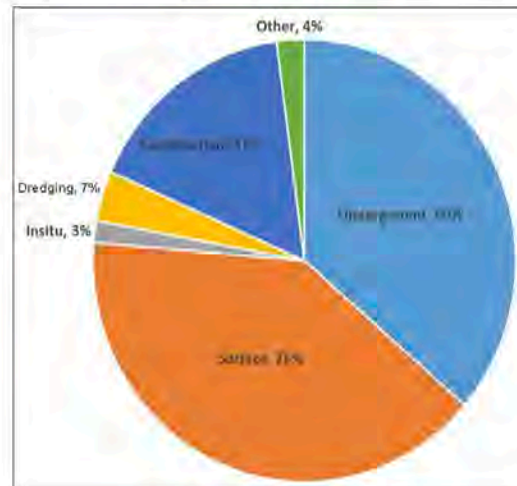
Respondents' commodity affiliation.

Figure 4

Respondents' mining sector affiliation.

Regulatory Training

Respondents' organization size.

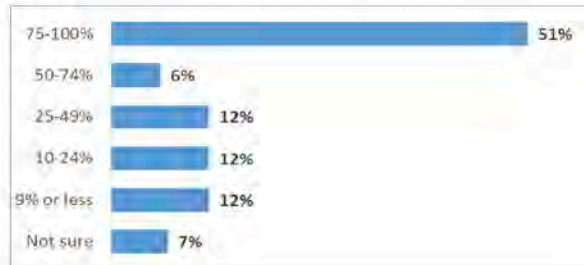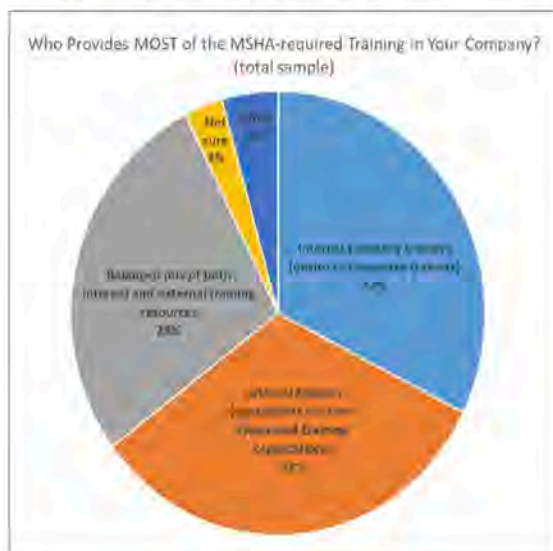Percentage of respondents' company employees that require MSHA training.

Training resources used by respondents' company.

exploration and reclamation (Fig. 4).

Among the total sample, the size of organizations they were affiliated with was somewhat evenly distributed with 34 percent of respondents coming from organizations with fewer than 100 employees, 22 percent from companies with 250-500 employees, 15 percent from companies with 500-1,000 employees and nearly 21 percent from companies with more than 1,000 employees (Fig. 5).

When asked "What percentage of employees in your company is required to receive regulatory training," more than 51 percent of the sample reported 76-100 percent, which indicates an existing demand for new miner and annual refresher training (Fig. 6). With a more even distribution among other percentages reported (12 percent reported 25-49 percent, 10-24 percent, and 9 percent or less), it is also worth noting that individual needs for training exist for employees working in indirect mining or roles and professions.

With regard to who provides the MSHA-required training, data collected revealed an even distribution reported for internal company trainers (onsite or corporate trainers) — (32 percent) and external trainers (consultants or state-sponsored training organizations) — (32 percent). This finding is further supported by 28 percent of respondents reporting that MSHA-required training is provided by a balanced mix of both internal and external training resources (Fig. 7).

Of particular interest, respondents who reported working for a company with fewer than 100 employees were most likely to report that training is provided by external trainers (61 percent), compared to internal trainers (17 percent) or a mix of internal and external trainers (13 percent). Respondents from companies of 250-500 employees reported using more of a balanced mix of internal and external trainers (46 percent) and only 20 percent of training provided mainly by external trainers. Respondents from companies of over 1,000 employees reported that approximately 14 percent of training is provided by external trainers and 28 percent by a balanced mix of external and internal trainers.

Instructional methods

When asked to note which instructional methods are used in respondents' experience with regulatory training, several common methods were identified. Nearly 84 percent of all respondents indicated that a lecture provided by main trainers was used, followed by PowerPoint presentations (78 percent) and videos (DVDs and YouTube) (65 percent). Nearly 53 percent of

Figure 8

Instructional methods used in respondents' past MSHA-required training.
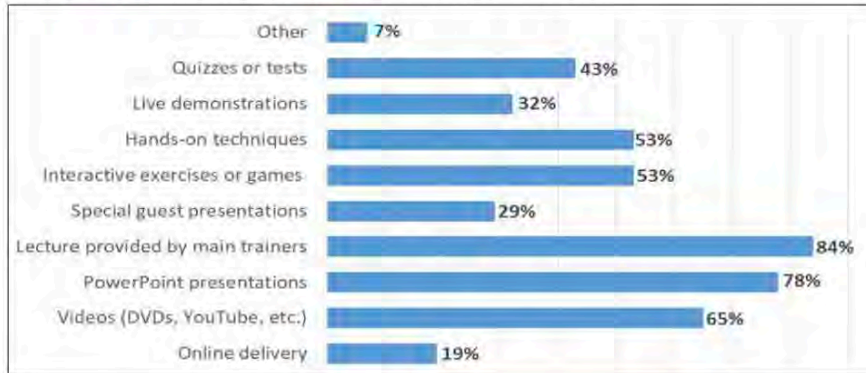
Instructional method	Percent
Other	7%
Quizzes or tests	43%
Live demonstrations	32%
Hands-on techniques	53%
Interactive exercises or games	53%
Special guest presentations	29%
Lecture provided by main trainers	84%
PowerPoint presentations	78%
Videos (DVDs, YouTube, etc.)	65%
Online delivery	19%

respondents reported that interactive exercises or games (small or large group activities) and hands-on techniques were used, followed by quizzes or tests (43 percent), live demonstrations (32 percent) and special guest presentations (29 percent). Approximately 19 percent of participants reported that online delivery was used. This aligns with narrative data collected that reveal the potential for increased use of more interactive instructional methods, compared to traditional lecture, PowerPoint presentations and videos (Fig, 8).
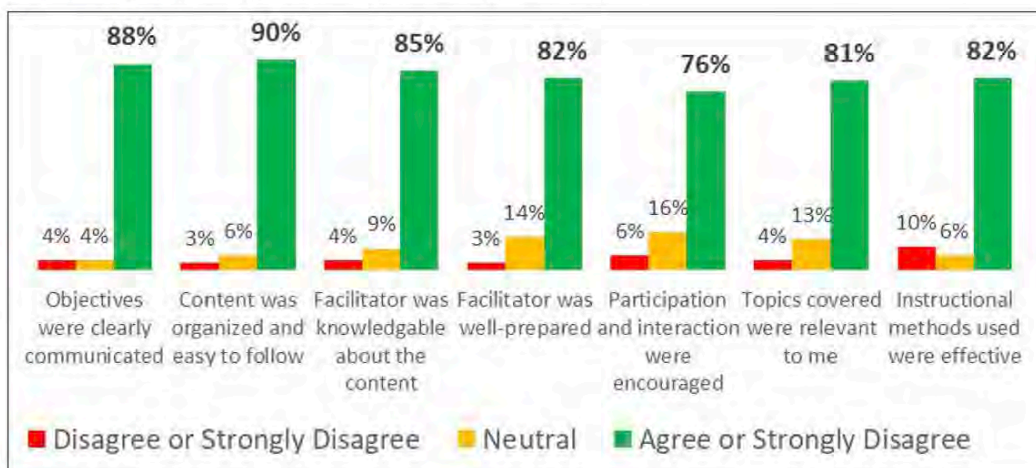
Training effectiveness

Seven survey items were used to measure respondents' perception of training effectiveness. Responses collected were based on a Likert-type agreement scale of 1 to 5 with 5 indicating the most favorable response of "strongly agree." Based on Kirkpatrick's (1994) model of training evaluation, Level 1 or reaction data collected were overwhelmingly positive (either a 4 or 5) for each of the items. Figure 9 shows the percentage of the sample that disagreed, were neutral or agreed with the item statements regarding: 1) clearly communicated training objectives (88 percent favorable); 2) training content being organized and easy to follow (90 percent favorable); 3) the facilitator being knowledgeable about the content (85 percent favorable); 4) the facilitator being well-prepared (82 percent favorable); 5) participation and interaction being encouraged (76 percent favorable); 6) topics considered relevant (81 percent favorable); and 7) the

Figure 9

Respondents' perception of past MSHA-required training effectiveness.

	Objectives were clearly communicated	Content was organized and easy to follow	Facilitator was knowledgable about the content	Facilitator was well-prepared	Participation and interaction were encouraged	Topics covered were relevant to me	Instructional methods used were effective
Disagree or Strongly Disagree	4%	3%	4%	3%	6%	4%	10%
Neutral	4%	6%	9%	14%	16%	13%	6%
Agree or Strongly Agree	88%	90%	85%	82%	76%	81%	82%

■ Disagree or Strongly Disagree   ■ Neutral   ■ Agree or Strongly Disagree

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effectiveness of instructional methods used (82 percent favorable). These finding suggest that one area for improvement in MSHA-required training is the use of instructional methods and facilitation to ensure participation and trainee interaction.

Qualitative insights

Four qualitative items were included in the survey to gain a deeper understanding of respondents' perceptions and needs regarding regulatory training. These items included:

1. What will you remember most about past MSHA-required training you have received?
2. What was the best part about past MSHA-required training you received?
3. What suggestions do you have for improving past MSHA-required training?
4. What are other types of training (or topics) you are interested in? Are there other safety-related services your company could benefit from (such as audits, perception surveys, etc.)?
5. Thematic analysis was conducted based on 265 narrative comments collected, and several dominant themes were revealed: 1) The use of interactive instructional methods lends to training effectiveness. 2) The use of games encourages active participation. 3) Experienced and knowledgeable trainers are key to training effectiveness. 4) Specific training content matters. 5) The use of real-life stories is important to communicate safety. 6) It is important to continually update training content for training effectiveness.

The qualitative data to support these themes are available upon request or can be accessed at the EMCIS website.

Summary and discussion

This training needs assessment was conducted to explore the perceptions and interests among professionals in the mining industry who have experience with MSHA-required training, such as new miner or annual refresher training. Based on a sample of 68 survey respondents, it was found that MSHA-required training is needed among a variety of direct and indirect mining industry jobs. While work in the metal/nonmetal sector was represented more than coal or construction, a majority of trainees reported serving both surface and underground mining. It was also found that companies with fewer than 100 employees are more likely to use external trainers for MSHA-required training.

Instructional methods most commonly reported to be used in MSHA-required training include: a lecture provided by main trainers, PowerPoint presentations, and videos (e.g., DVDs and YouTube) (65 percent). Approximately 19 percent of participants reported that online delivery was used. Analysis of the survey data revealed that a need exists to use instructional methods and facilitation that encourage participation and interaction among trainees. This finding was strongly supported by qualitative insights gleaned from approximately 265 narrative comments. The findings revealed by the qualitative data included: 1) the value of using interactive instructional methods; 2) the value of using games to encourage active participation; 3) the value of experienced and knowledgeable trainers; 4) that specific training content matters; 5) value exists in using real-life stories and cases to communicate safety; and 6) a need exists to ensure training content is current and relevant to trainees.

Limitations of this research activity involve the use of convenience and purposive sampling, producing a sample of only 68 respondents. In addition, it is likely that approximately half of the sample included former participants in MSHA-required training delivered through the EMCIS program. While this characteristic of the sample may limit the ability to transfer findings to a larger population, data analysis and the findings from this research activity can be considered a type of evaluation measure for the EMCIS program.

Numerous favorable comments about MSHA-required training were collected that directly connect to EMCIS-specific training (e.g., use of Jenga, Mine-opoly, and other specific games that EMCIS uses in training, as well as a mine tour to the Edgar training mine maintained by the Colorado School of Mines). Due primarily to the small sample size in this research activity, continued efforts are needed to collect training-needs assessment data more broadly across the mining industry.

References

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