

FINAL RPPR

COVER PAGE

Project Title: Enhanced Safety and Health Training for Western Mine Workers	
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Change of Contact PD/PI: No	
Human Subjects: No	Vertebrate Animals: No
hESC: No	Inventions/Patents: No

B. ACCOMPLISHMENTS

B.1. What are the major goals of the project?

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 primary focus of this training program is to meet the needs of underserved groups, such as suppliers, contractors, consultants, equipment manufacturers, and small mine operators. This aim is also designed to supplement and enhance current training activities sponsored through the Colorado MSHA State Grants program. The annual course offerings are presented below. The actual number of courses conducted for each type of training is determined by demand.

- MSHA Part 48 New Miner Courses (Surface and Underground) -- 6 times/year
- MSHA Part 48 Annual Refresher Courses (In-person and remote format) -- 12 times/year
- MSHA Part 48 Instructor Courses -- 2 times/year
- Part 48 training tools -- 1 tool/year

The effectiveness of the Part 48 training will be evaluated by requiring each student to complete a pre/post examination and a course evaluation assessment. 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 may be 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 students 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 companies with the implementation of their health and safety management systems. The annual course offerings are presented below. The actual number of courses conducted for each type of training is determined by demand.

- Train-the-trainer presentations on emerging health, safety, and training topics -- 2-3 times/year
- Short courses that target and augment Part 48 topics or improve the effectiveness of health and safety management systems/programs -- 1 time/year
- Webinar series that focuses on contemporary safety and health topics of industry interest -- 4 times/year

Specific Aim 3: The development and implementation of innovative and interactive safety and health educational experiences for university students, faculty, and staff that utilizes effective pedagogies to instill an appreciation of the importance of a safety ethic within mining engineering, economic geology, geological engineering, and the extractive industries. The program will target select universities and colleges in the Western United States. The annual course offerings are presented below. The number of experiences conducted is determined by the demand.

- Safety and health for-credit courses, short courses, guest lectures, and other educational experiences at CSM -- 2 times/year
- Safety and health guest lectures and other educational experiences at Western Universities -- 4 times/year

B.2. What did you accomplish under these goals?

Please see below

B.3. Competitive Revisions/Administrative Supplements

No

B.4. What opportunities for training and professional development did the project provide?

Please see below

B.5. How did you disseminate the results to communities of interest?

Results were disseminated through journal articles, conference presentations, and the EMCIS website. Detailed information can be found in the accomplishments section B.2.

B.6 What do you plan to do during the next reporting period to accomplish the goals?

The reporting period for this award ended August 31, 2023. Detailed information on accomplishments can be found in section B.2.

B.2 What did you accomplish under these goals?

The following accomplishments are for the reporting period September 1, 2020, through August 31, 2023. An overall summary can be found in Table 1. Proposed and Completed Activities.

Table 1. Proposed and Completed Activities

Courses	Proposed 9/1/20 - 8/31/23	Completed 9/1/20 - 8/31/23
	Number of Activities	Number of Activities
Specific Aim 1: MSHA Required Courses		
New Miner Surface Only	18	11
New Miner Surface/Underground*	18	14
New Miner UG for Experienced Surface	0	3
Annual Refresher	36	47
Instructor Training	3	6
Specific Aim 2: Professional Development		
Presentations	8	20
Short Courses	3	3
Recorded Presentations and Training	6	6
Webinars	12	14
Publications	0	6
Specific Aim 3: University Educational Experiences		
Presentations at Universities (UG and Grad)*	18	22
TOTAL	122	152

*MNGN308 is included in Specific Aim 1 and not Specific Aim 3 to avoid duplication.

Specific Aim #1

During the reporting period, CSM conducted eighty-one (81) 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. Unfortunately, the COVID-10 pandemic provided many challenges related to the delivery of training courses and the number of trainees in each course. Section 4.2 describes the challenges and how CSM resolved them. Unfortunately, because New Miner courses are not conducive to remote delivery and, given the pandemic constraints, CSM was forced to cancel four (4) Surface and Underground New Miner courses and one (1) Underground New Miner course during the reporting period. Conversely, demand for Annual Refresher and Instructor Training courses increased during the reporting period, and CSM increased the number of Annual Refresher courses by eleven (11) and Instructor Training courses by three (3). CSM was also able to provide three (3) trainees with New Miner Underground for Experienced Surface training, which was not originally proposed. Please see Table 2 - Completed Trainings for specific details.

Table 2. Specific Aim #1 Completed Trainings

Courses	Completed 9/1/20 - 8/31/23			
	Number of Activities	Number of Trainees	Number of Training Days	Mining Sector/ Participant
Specific Aim 1: MSHA Required Courses				
New Miner Surface Only	11	34	102	Contractor*
New Miner Surface/Underground	14	122	614	Contractor*
New Miner UG for Experienced Surface	3	3	3	Contractor*
Annual Refresher	47	529	529	Contractor*
Instructor Training	6	32	80	Contractor*
TOTAL	81	720	1328	Contractor*

*The contractors attending our training come from various mining industry constituents including, but not limited to contractors, consultants, equipment manufacturers and suppliers.

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 topics were solicited from trainees and broadly from industry stakeholders through training needs assessments. CSM applied the following three levels of Kirkpatrick's four-level evaluation model to the training offered in Specific Aim #1.

Table 3. Kirkpatrick Evaluation Model (Levels 1-3)

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 training.
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.

Level 1 Evaluation

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 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 result in revisions in materials, training

content and teaching methodology. Incorporating these revisions as well as adult learning principles and Part 48 training requirements resulted in a better product. Table 4. Level 1 Evaluation Data provides the percentage of trainees who rated the training as *Excellent* or *Very Good*. The remaining participants rated the training as *Good*.

Table 4. Level 1 Evaluation Data

Courses	Excellent/Very Good Rating
New Miner Surface Only	86%
New Miner Surface/Underground	84%
Annual Refresher	95%
Instructor Training	93%
TOTAL	92%

Surface New Miner courses received an overall rating of *Excellent* or *Very Good* by eighty-six percent (86%). The most memorable and best liked aspects of these courses included the variety of training methods (lectures, stories, videos, games, and activities), the use of a variety of instructional methods (lectures, stories, games, and activities), the specific topics covered (confined space, first aid, energy-based hazard recognition, cognitive biases and blind spots, and firefighting), the experience and knowledge of instructors, and the interactions with the instructors and participants. Examples of narrative comments collected include: *“Great interaction and material used. It was easy to focus and pay attention to all aspects of the training. Instructors involvement was very nice and all were friendly. Discussions were helpful.”* *“The staff is very well educated and understands the key import aspects on each area of training along with real world knowledge and experience.”* *“Instructors made the content interesting and easy to follow. The content was presented clearly. I learned a lot of new topics that I can apply to my work.”*

Surface/Underground New Miner courses, including Underground for Experienced Surface New Miner, received an overall rating of *Excellent* or *Very Good* by eighty-four percent (84%) of the attendees. The most memorable and best liked aspects of these courses included the experienced instructors, hands-on learning, and visiting the Edgar Mine. Examples of narrative comments collected include: *“The underground portion is easily one of the most memorable experiences. Another thing that stuck with me a lot had to do with the safety training involving CPR and other things such as watching out for strokes and heart attacks.”* *“The emphasis on hazards was great. The focus on safety and preventative measures is so beneficial.”* *“The diversity of instructors' experience and the interactivity.”* *“Different voices and perspectives from the variety of instructors.”* *“Having different professors to discuss their expertise and keep us from getting disinterested.”* *“I liked that the games were really helpful in ensuring I knew the material. I realized that I missed a few things from the actual lectures, so the games were really useful in teaching.”* *“I think the training was very well organized and everyone was incredibly knowledgeable.”* *“Great training overall; I enjoyed it.”* *“Retention of material much higher than any other MSHA training I have received to date.”*

Annual Refresher courses (remote and in-person) received an overall rating of *Excellent* or *Very Good* by ninety-five percent (95%) of the attendees. The most memorable and best liked aspects of this course were the knowledge, experience, and use of multiple instructors. The attendees also liked the variety of content (videos, interactive group discussion, games, and personal stories) that changes each year and keeps the training interesting. Examples of narrative comments collected include: *“Interactive, practical and educational. Amazing team with great experience.”* *“Excellent*

presentation and material covered.” “The manner in which the training was provided encouraged active participation.” “Excellent presentation and material covered.” “I think it is a good training.” “Good interaction with attendees.” “Good pacing and break opportunities, never got too dull.” “Good participation activities.” “Interactive problem-solving.” “Activities within training to increase student engagement.” “Keep mixing it up new stuff this year was good.” “Well designed, participatory, engaging, interesting case stories, instructors had relevant experience and are passionate about the topics.”

Separately, the seven (7) Remote Annual Refresher courses received an overall rating of *Excellent* or *Very Good* by ninety percent (90%) of the attendees. The most memorable and best liked aspects of this course were the multiple instructors, adaptation to the remote environment, and interactive activities. *“The training was quite interactive. Went on a good pace with effective communication. Instructors are amazing.” “It was very interactive and well managed for zoom.” “Open discussions very useful.” “Instructors are very engaged, and the activities make the class go by faster.” “The group activities and games.” “Well paced, not just listening to speakers, but interactive sessions.”*

Level 2 Evaluation

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. 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 and adjusts it accordingly. Historically, CSM has seen an improvement of approximately 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. Detailed data is presented in Table 5. Level 2 Evaluation Data and exhibits this same trend.

Table 5. Level 2 Evaluation Data

Courses	Pre-Test	Post-Test	Improvement
Surface New Miner	61%	88%	27%
Surface/Underground New Miner	73%	93%	20%
Underground for Experienced Surface Miner	88%	100%	12%

Level 3 Evaluation

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 as it contributed to their experience while working (directly or indirectly) at their 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, but they were also subsequently used to evaluate and improve the training pedagogy, materials, course instructors, and the types of courses offered. During the reporting period, nineteen (19) trainees responded to the follow-up survey with no negative responses. Table 6. Level 3 Evaluation Data provides detailed responses.

Table 6. Level 3 Evaluation Data

Question	Response	Qualifier
Have you visited/worked on a mine site since completing your New Miner training?	63%	Yes
How well do you feel the training prepared you for the hazards encountered on a mine site?	72%	Extremely Well or More Than Expected
Are there any additional topics you feel should have been covered that would have better prepared you?	Working around ball mills, crushers, thickeners, flotation cells, etc.	
Would you recommend this training to others?	100%	Yes

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 seeks to build upon in the future. During the reporting period, emphasis was placed on professional development opportunities designed to enhance the skills of trainers working at Western mines by improving their effectiveness and technical capabilities. The opportunities were specifically oriented towards meeting their needs as identified through needs-based assessments and industry advisory meetings. Additionally, CSM leveraged strategic partnerships and collaborations to provide a means to disseminate best practices and to enhance capacity building through training and other professional development opportunities. Table 7. Specific Aim #2 Completed Activities summarizes the accomplishments of this specific aim while Tables 8, 9, 10 and 11 provide details describing the accomplishments.

Table 7. Specific Aim #2 Completed Activities

Courses	Proposed 9/1/20 - 8/31/23	Completed 9/1/20 - 8/31/23
	Number of Activities	Number of Activities
Specific Aim 2: Professional Development		
Presentations	8	20
Short Courses	3	3
Recorded Presentations and Training	6	6
Webinars	12	14
Publications	0	6
TOTALS	29	49

Presentations

A list of presentations can also be found in section C.1 Publications, conference papers, and presentations.

Table 8. Presentations

Presentation Title	Venue	Date	Attendees	Length
NORA Working Group Outcomes: Automation and Autonomy	SME Annual Conference 2021 (Virtual)	3/1/2021	36	30 mins
Best Practices from BBS: Motivating Miners to "Do the Right Thing"	SME Annual Conference 2021 (Virtual)	3/2/2021	24	30 mins
Safe Alternatives in Shotcrete Liner Removal	SME Annual Conference 2021 (Virtual)	3/2/2021	17	30 mins
Surviving Shiftwork	Master Builders Solutions: Underground Construction North America Team - Bi-weekly safety meeting	5/6/2021	12	45 mins
Surviving Shiftwork	Mine Safety and Health Conference (Las Vegas, NV)	10/26/2021	16	60 mins
Hazard Recognition Challenge/EXAMiner	Safety Fest (Virtual)	2/25/2022	8	2 hours
Cognitive Blind Spots (2 Sessions)	Training Resources Applied to Mining Conference (Beckley, WV)	10/12/2022	48	60 mins
Showing Your Hand: Card-based and Tabletop Games for Part 48 Training (2 sessions)	Training Resources Applied to Mining Conference (Beckley, WV)	10/12/2022	50	60 mins
Incorporating Games in Part 48 Training (2 Sessions)	Training Resources Applied to Mining Conference (Beckley, WV)	10/12/2022	45	60 mins
Total Exposure Health	Mine Safety and Health Conference (Phoenix, AZ)	10/25/2022	26	60 mins
Management of Change	Mine Safety and Health Conference (Phoenix, AZ)	10/26/2022	42	60 mins
Incorporating Games in Part 48 Training	Mine Safety and Health Conference (Phoenix, AZ)	10/26/2022	46	60 mins
Is Your Brain Keeping You from Recognizing Hazards?	Mine Safety and Health Conference (Phoenix, AZ)	10/26/2022	60	60 mins
Energy Based Hazard Recognition (2 Sessions)	Goodfellow Brothers Kona and Maui	1/24/2023	71	60 mins
Is Your Brain Keeping You from Recognizing Hazards? (2 Sessions)	Goodfellow Brothers Kona and Maui	1/24/2023	71	60 mins

Webinars

Table 9. Webinars

Webinar Title	Venue	Date	Attendees	Length
Surviving Shiftwork in Mining	SME (Virtual)	6/22/2021	4	60 mins
Job Hazard Analysis	SME (Virtual)	7/15/2021	10	60 mins
Fitness for Duty in Mining Operations	SME (Virtual)	7/27/2021	10	60 mins
Sleep: The most important component of safe behavior	SME (Virtual)	8/5/2021	11	60 mins
Energy Wheel Framework for Hazard Recognition	SME (Virtual)	3/17/2022	17	60 mins
Incorporating Games in Part 48 Training	SME (Virtual)	5/10/2022	14	60 mins
Management of Change	SME (Virtual)	6/29/2022	9	60 mins
Interactive Tools for Hazard Recognition	SME (Virtual)	8/17/2022	11	60 mins
Sleep: The most important component of safe behavior	Bowen EHS	1/11/2023	57	60 mins
Cognitive Biases and Blind Spots	SME (Virtual)	3/23/2023	20	60 mins
Total Exposure Health: What is it and should we care?	SME (Virtual)	5/4/2023	5	60 mins
Surviving Shiftwork in Mining	Bowen EHS	5/18/2023	34	60 mins
Competencies and Characteristics of Effective Trainers	SME (Virtual)	6/15/2023	8	60 mins
Keeping our contractors safe: A discussion on challenges of contractor management in mining	SME (Virtual)	8/3/2023	6	60 mins

Recorded Presentations and Training

Table 10. Recorded Presentations and Training

Recorded Presentations and Training	Type	Location	Length
Cognitive Biases and Blind Spots	Recorded Presentation	EMCIS Website	35 mins
Diesel Particulate Matter in Mining	Interactive Module	EMCIS Website	45 mins
Fitness for Duty	Recorded Presentation	EMCIS Website	35 mins
Incorporating Games in Part 48 Training	Recorded Presentation	EMCIS Website	40 mins
Management of Change	Recorded Presentation	EMCIS Website	45 mins
Surviving Shiftwork	Recorded Presentation	EMCIS Website	40 mins

Short Courses

Table 11. Short Courses

Short Course Title	Venue	Date	Attendees	Length
Mining Health and Safety	Edgar Mine (AIHA RMS Section Tour)	12/14/2021	7	3 hours
Mining Health and Safety	Edgar Mine (AIHA RMS Section Tour)	3/11/2022	13	3 hours
Customized Mining Safety Instructor Training for Michigan Mine Safety & Health, Michigan Tech	Taught at CSM	3/2/2023	4	4 hours

Publications

This purpose of the NIOSH U60 grant is first and foremost to enhance the quality and complement the availability of health and safety training for miners in the Western United States. CSM has worked tirelessly over the years to create a respected training program that provides MSHA regulatory training, as well as professional training on current, emerging, and contemporary health and safety topics. While publishing is not an outcome of the specific aims, CSM has completed the following publications. A list of publications can also be found in section C.1 Publications, conference papers, and presentations.

- Bourgeois, J. P., 2020, “Characterizing the Dynamics Associated with the Hydro-Excavation of Reinforced Shotcrete and Concrete Lines in Underground Mines and Tunnels”, Ph.D. Thesis, Colorado School of Mines, Mining Engineering Department, Golden, CO.
- Guasta, L., Miller, H., & Reiher, M. (2020). Regulatory training needs assessment: Survey highlights industry trends and best practices. *Mining Engineering*, 72(10), 32-36.
- Powers, J. (2020). Safety Share: COVID-19 PPE. *Mining Engineering*, 72(12), 6.
- Vault, K. (2021). Safety Share: Sleep Deprivation. *Mining Engineering*, 73(2), 6.
- Lauriski, D. (2021). Total Worker Health. Mining industry stands to benefit from NIOSH’s initiative. *Mining Engineering*, 74(3), 56.
- Reiher, M. (2021). Surviving Shiftwork. *Mining Engineering*, 74(5), 6.

Specific Aim #3

The focus of Specific Aim 3 was to provide fundamental learning opportunities in occupational safety and health for students majoring in disciplines related to mining and mineral resource development. CSM strongly believes that these educational experiences facilitate an understanding of safety that students can take with them into industry and establishes a life-long appreciation of the critical importance of safety in all facets of mine operations. Table 12. Specific Aim #3 Completed Educational Experiences provides a summary of the accomplishments of this aim, and Table 13. Educational Experiences provides details that support the accomplishments.

Table 12. Specific Aim #3 Completed Educational Experiences

Courses	Proposed 9/1/20 - 8/31/23	Completed 9/1/20 - 8/31/23
	Number of Activities	Number of Activities
Specific Aim 3: University Educational Experiences		
Colorado School of Mines	6	12
Western Universities	12	10
TOTALS	18	22

Table 13. Educational Experiences

Guest Lecture Title	School	Date	Attendees	Length
Safety Management (MNGN510)	CSM	10/5/2020	24	60 mins
Ventilation Safety	South Dakota School of Mines	10/15/2020	14	60 mins
Safety Management Systems (OSH224)	Montana Tech	11/4/2020	30	60 mins
Safety Management Systems (Ergo)	Montana Tech	11/9/2020	20	60 mins
ENID - Making Safe Decisions (Student Seminar)	South Dakota School of Mines	11/18/2020	10	60 mins
Safety Management Systems	New Mexico Tech	2/9/2021	14	75 mins
Stress, Fatigue and Your Brain	New Mexico Tech	2/16/2021	13	75 mins
Introduction to Safety and Health (MNGN210)	CSM	3/10/2021	14	2 hours
Introduction to Industrial Hygiene	New Mexico Tech	3/11/2021	10	75 mins
Stories from the White Pine Mine -- Making Safe Decisions	New Mexico Tech	3/16/2021	14	75 mins
Job Hazard Analysis	New Mexico Tech	3/30/2021	14	75 mins
Fitness for Duty in Mining Operations (MP-MEM)	CSM	5/3/2021	11	30 mins
Fitness for Duty in Mining Operations (MP-MEM)	CSM	5/7/2021	11	45 mins
Safety Management (MNGN510)	CSM	10/4/2021	14	60 mins
Fitness for Duty in Mining Operations (MNGN553)	CSM Online	Spq II 2022	12	75 mins
Mining Law (MNGN210)	CSM	3/30/2022	15	60 mins
Total Worker Health/Fitness for Duty	University of Utah	3/24/2022	13	60 mins
Introduction to Safety and Health (MNGN210)	CSM	4/25/2022	15	60 mins
Introduction to Safety and Health (MNGN210)	CSM	11/1/2022	33	60 mins
Basic Electrical Safety	CSM	2/28/2023	11	60 mins
Safety Management (MNGN510)	CSM	10/6/2022	17	60 mins
Introduction to Safety and Health (MNGN210)	CSM	4/3/2023	26	60 mins

Collaborations

A final activity for this reporting period included participation in the NIOSH U60 kick-off and annual meetings held remotely on October 7, 2020, November 10, 2021, and November 10, 2022. These meetings allowed CSM and the University of Arizona to collaborate with each other and NIOSH staff on current and future U60 training activities. The meeting was highly beneficial for all who attended and reinforced the importance of collaboration with NIOSH, the University of Arizona, and others in industry. Collaborations during this reporting period are as follows:

NIOSH

- CSM and NIOSH collaborated on the data analysis and research reporting concerning NIOSH's EXAMiner hazard recognition software. The primary goal of this collaboration was to produce a multiple case study evaluation report which was submitted for peer review and publication. A secondary goal of this collaboration was the identification of lessons learned and best practices concerning design utilization of the EXAMiner software for training purposes in mining.

- CSM and the NIOSH funded Center for Health, Work and Environment at the University of Colorado collaborated on the incorporation of Total Worker Health in Part 48 training. CSM successfully incorporated a one-hour Total Worker Health section from February 2021 through January 2022.

University of Arizona

- CSM conducted a technical review of a training card game (A Very Good Day Game™) developed by the University of Arizona and provided formal feedback including recommendations for enhancements. Discussions are currently underway about collaborative work to address the findings from the review.
- CSM and the University of Arizona created a working group to design and implement hybrid and mobile games (Coming Home Alive and Mining Strong) for use by the mining industry.
- CSM and the University of Arizona co-presented a presentation titled *Showing Your Hand: Card-based and Tabletop Games* at the 2022 MSHA TRAM conference in Beckley, WV.
- CSM regularly participates in the University of Arizona Learning Labs where representatives from industry discuss training needs and share ideas related to mining safety and health.

Society for Mining, Metallurgy & Exploration

- CSM partnered with the Society for Mining, Metallurgy & Exploration to present four (4) webinars each year for a total of twelve (12) over the course of this reporting period.
- CSM provided an Annual Refresher as a pre-conference short course at the 2022 and 2023 Annual Conference in Salt Lake City, UT and Denver, CO respectively.

References

Kirkpatrick, D. L. (1994). *Evaluating Training Programs: The Four Levels*. San Francisco: Berrett-Koehler.

B.4 What opportunities for training and professional development has the project provided?

Although providing opportunities for training and professional development is not a main objective of this project, it is the caliber of the CSM staff that makes the training program collaboration with the NIOSH U60 grant effective and successful. Professional development activities associated with this grant support certification and credentialing, professional memberships, and educational and training opportunities via conferences, short courses, seminars, and webinars. CSM believes supporting professional development helps foster an environment of continuous learning and skill development within our staff and exemplifies our commitment to providing the highest quality training possible to those who attend our courses.

Certifications:

The following certifications are held by CSM staff: Certified Mine Safety and Health Administration (MSHA) Instructor (IS, IU, and IN), Certified Industrial Hygienist (CIH), Certified Safety Professional (CSP), Certified First Aid professional, and Professional Engineer (PE) in mining engineering. Professional certifications identify an individual who has met the minimum requirements for education and experience, and through examination, has demonstrated a minimum level of knowledge and skills in specified areas. These certifications provide credibility to the CSM staff and thus the training program. While becoming a certified professional is the first step, maintaining certification requires continuing education to maintain and advance the knowledge and skill level and to ensure that staff remain current and relevant in the industry. During this reporting period, all certifications remain active.

Professional Organization Memberships:

Professional associations play an integral role in advocacy, networking, access to resources, and educational opportunities in the mining industry.

CSM staff have used their membership in professional associations to advocate for increased awareness regarding emerging health and safety issues in the mining industry as evidenced by participation on the NIOSH National Occupational Research Agenda (NORA) committee, the Society for Mining, Metallurgy & Exploration (SME,) Certified Mine Safety Professional (CMSP) certification panel, the SME Health and Safety Division, SME conference session chairs, American Industrial Hygiene Association – Rocky Mountain Section conference committee, and serving as past president for SME to name a few. This “group influence” is stronger at the association level than at the individual level, and CSM believes that one must be actively involved to promote and witness meaningful change.

Professional organizations also provide a means to meet, collaborate with, and learn from others in the industry who strive towards our same goal of protecting workers in the mining industry. Past networking opportunities have provided CSM staff contacts and collaborations with other health and safety professionals, where ideas and strategies have led to and continue to lead to successful, impactful training.

Access to current resources provided by professional organizations enables CSM staff to stay abreast of the latest news, policies, and legislation applicable to the health and safety of miners. Additionally, updates on emerging trends, issues, and technology allow CSM staff to develop training that meets the needs of the mining industry in real time.

Additionally, professional organizations provide many educational opportunities to their members through conferences, webinars, short courses, and seminars. These opportunities are key to remaining relevant and increasing knowledge and

skill level. This allows CSM staff to develop and deliver current health and safety training while being aware of and able to answer questions on topical issues current trends, and best industry processes, thereby increasing the credibility of the instructor and the training.

During this reporting period, CSM staff are members in good standing of the following organizations:

- American Exploration & Mining Association
- American Industrial Hygiene Association (National and Local)
- Mining and Metallurgical Society of America
- Society for Mining, Metallurgy & Exploration (National, Local, and Student Chapters)

During this reporting period, CSM staff attended the following conferences associated with professional associations:

- 2020 AIHA-RMS/ASSP-CO Fall Technical Conference held virtually September 15-16, 2020.
- 2020 SME Mid-Year Meeting, held virtually and in-person, Sept. 21-25, 2020.
- 2020 SME Thrive Technology Conference, held virtually on Oct. 20-21, 2020.
- 2020 AEMA Annual Meeting, held virtually on Nov. 30-Dec. 3, 2020.
- 2021 SME Annual Conference and Expo held virtually on March 1-5, 2021.
- 2021 NSC Safety Congress and Expo held virtually on March 3-5, 2021.
- 2021 AIHA-RMS/ASSP-CO Fall Technical Conference held in Arvada, CO on September 8-9, 2021.
- 2021 MINExpo held in Las Vegas, NV on September 13-15, 2021.
- 2021 Mine Safety and Health Conference held in Reno, LV on October 26-27, 2021
- 2021 SME Arizona Section Meeting held in Tucson, AZ on December 6-7, 2021.
- 2021 AEMA Annual Meeting held in Reno, NV, December 7-10, 2021.
- 2022 SME Annual Conference and Expo held in Salt Lake City on February 27- March 2, 2022.
- 2022 AIHA-RMS Fall Technical Conference held in Arvada, CO on September 13-14, 2022
- 2022 Colorado Mining Association Annual Meeting, Grand Junction, CO, June 9-10, 2022
- 2022 MSHA TRAM Conference held in Beaver, WV on October 10-13, 2022
- 2022 Mine Safety and Health Conference held in Scottsdale, AZ on October 25-26, 2022
- 2022 SME Arizona Conference held in Tucson, AZ on Dec. 4-6, 2022
- 2022 AEMA Annual Meeting held in Reno, NV on Dec. 6-9, 2022
- 2023 SME Annual Conference and Expo held in Denver, CO on February 27-March 1, 2023
- 2023 SME Minnesota Conference, Virginia, MN, April 16-18, 2023
- 2023 SME RETC Conference, Boston, MA, June 11-13, 2023
- 2023 SME Hydro-Metallurgical Conference, Phoenix, AZ, August 27-29, 2023
- 2023 AIHA-RMS Fall Technical Conference held in Wheat Ridge, CO on September 19-20, 2023

Other Educational Opportunities:

Educational opportunities, such as short courses, webinars, and seminars, are also available to the mining health and safety communities without the requirement of a membership to a professional organization. Most of these opportunities are offered by training or educational institutes with the objective of increasing the knowledge of those who attend their courses.

During this reporting period, CSM staff attended webinars and short courses provided by the following organizations:

- 3M
- CDC NIOSH Mining
- Cority
- Husch-Blackwell
- iSpring
- LeaderFactor
- National Institute for Occupational Safety and Health
- National Safety Council
- Raeco Rents
- Safety Function
- SKC
- Turning Technologies

The CSM staff is dedicated to providing world-class health and safety training to mine workers in the Western United States. CSM believes that this starts with ensuring the staff continues to increase their knowledge and involvement in the mining industry. Ultimately, investing in the EMCIS staff benefits the mine workers who attend our training as they are provided the most current information available to keep themselves safe and healthy.

*Please complete the additional information requested after section I.

C. PRODUCTS

C.1. Publications, conference papers, and presentations

Publications

- Bourgeois, J. P., 2020, "Characterizing the Dynamics Associated with the Hydro-Excavation of Reinforced Shotcrete and Concrete Lines in Underground Mines and Tunnels", Ph.D. Thesis, Colorado School of Mines, Mining Engineering Department, Golden, CO.
- Guasta, L., Miller, H., & Reiher, M. (2020). Regulatory training needs assessment: Survey highlights industry trends and best practices. *Mining Engineering*, 72(10), 32-36.
- Powers, J. (2020). Safety Share: COVID-19 PPE. *Mining Engineering*, 72(12), 6.
- Vault, K. (2021). Safety Share: Sleep Deprivation. *Mining Engineering*, 73(2), 6.
- Lauriski, D. (2021). Total Worker Health. Mining industry stands to benefit from NIOSH's initiative. *Mining Engineering*, 74(3), 56.
- Reiher, M. (2021). Surviving Shiftwork. *Mining Engineering*, 74(5), 6.

Conference Presentations

Mine Safety and Health Conference

- 2021 Surviving Shiftwork
- 2022 Total Exposure Health
- 2022 Management of Change
- 2022 Incorporating Games in Part 48 Training
- 2022 Cognitive Biases and Blind Spots

Society for Mining, Metallurgy, and Exploration Conference

- 2021 Best Practices from BBS: Motivating Miners to "Do the Right Thing"
- 2021 NORA Working Group Outcomes: Automation and Autonomy
- 2021 Safe Alternatives in Shotcrete Liner Removal

Safety Fest

- 2022 Hazard Recognition Challenge/EXAMiner

MSHA Training Resources Applied to Miners

- 2022 Incorporating Games in Part 48 Training (2)
- 2022 Showing Your Hand: Card-based and Tabletop Games for Part 48 Training (2)
- 2022 Cognitive Biases and Blind Spots (2)

C.2. Website(s) or other Internet site(s) – include URL(s)

<https://www.emcis.mines.edu>

C.3. Technologies or techniques

Nothing to report

C.4. Inventions, patent applications, and/or licenses

Nothing to report

C.5. Other products and resource sharing

Training games and activity templates -- <https://emcis.mines.edu/templates/>

- Card Sharks
- Dress the Miner
- Hierarchy of Controls
- Jeopardy
- Mine-opoly
- Wheel of Hazards

Recorded Presentations and Training Modules -- https://emcis.mines.edu/training-2/online_modules/

- Cognitive Biases and Blind Spots
- Diesel Particulate Matter
- Fitness for Duty in Mining
- Incorporating Games in Part 48 Training
- Management of Change
- Surviving Shiftwork

D. PARTICIPANTS

D.1. What individuals have worked on the project? Please include calendar, academic, and summer months.

Commons ID	S/K	Name	Degrees(s)	Role	Cal	Aca	Sum	Foreign	Country	SS
HUGHBMILLER	Y	Miller, Hugh	BS,MS,PHD	PD/PI	3.0	0.0	0.0			
MICHELLEREIHER	Y	Reiher, Michelle	BS,MS,MBA	PD/PI	27.0	0.0	0.0			
	N	Derber, Whitney	BA	Faculty	12.0	0.0	0.0			
	N	Guasta, Lori	BA,MA,PHD	Faculty	11.0	0.0	0.0			
	N	Lauriski, David	BA,MA	Faculty	24.0	0.0	0.0			
	N	McDaniel, Kirk	BS,ME,MBA,PHD	Faculty	6.0	0.0	0.0			
	N	Powers, Jerry	BS,MS	Faculty	5.0	0.0	0.0			
	N	Vault, Koretta	BS,MBA	Faculty	18.0	0.0	0.0			
	N	Bourgeois, Josef	BS	RA	1.0	0.0	0.0			
	N	Moore, Jillian	BS,MS	RA	2.00	0.0	0.0			
	N	Fellows, Elizabeth		UGrad	9.0	0.0	0.0			
	N	Manley, Gregory		UGrad	4.0	0.0	0.0			

D.2 Personnel updates

- a. Level of Effort:** Nothing to report
- b. New Senior/Key Personnel:** Nothing to report
- c. Changes in Other Support:** Nothing to report
- d. New Other Significant Contributors:** Nothing to report

E. IMPACT**E.1 - What is the impact on the development of human resources, if applicable?**

Not applicable

E.2 - What is the Public Health Relevance and Impact? The investigator should address how the findings of the project relate beyond the immediate study to improve practices, prevention or intervention techniques, legislation, policy, or use of technology in public health.

Please see below Research Outcomes/Impacts

F. CHANGES**F.1 – Changes in approach and reasons for change, including changes that have a significant impact on expenditures**

Not applicable

F.2 - Actual or anticipated challenges or delays and actions or plans to resolve them

The COVID-19 pandemic provided many challenges to CSM, especially related to the delivery of training courses and the number of trainees in each course. 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 the Annual Refresher course 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 such as interactive games, breakout rooms and discussion sessions which resulted in the desired result – engaging training. Unfortunately, New Miner courses are not conducive to remote delivery and, given the pandemic constraints, resulted in the cancellation of four (4) Surface and Underground New Miner courses and one (1) Underground New Miner course during this 3-year project period. July 27, 2020, was the first day CSM successfully offered limited (10 trainee maximum) in-person training again with strict COVID-19 preparation protocols and training day requirements. As the pandemic moved towards an endemic, CSM began reducing the number of remote courses and increasing the number of in-person courses offered. In-person training has returned as the normal course of training. However, CSM remains aware of some industry constraints and routinely evaluates the need to add remote classes based on feedback and demand.

F.3 - Significant changes to human subjects, vertebrate animals, biohazards, and/or select agents

No change

G. Special Reporting Requirements**G.1 Special Notice of Award Terms and Funding Opportunities Announcement Reporting Requirements**

Nothing to report

G.2 Responsible Conduct of Research

Not applicable

G.3 Mentor's Research Report or Sponsor Comments

Not applicable

<p>G.4 Human Subjects</p> <p>G.4.a Does the project involve human subjects? No</p> <p>G.4.b Inclusion Enrollment Data Nothing to report</p> <p>G.4.c ClinicalTrials.gov Does this project include one or more applicable clinical trials that must be registered in ClinicalTrials.gov under FDAAA? Not applicable</p>
<p>G.5 Human Subject Education Requirement Are there personnel on this project who are newly involved in the design or conduct of human subject's research? Not applicable</p>
<p>G.6 Human Embryonic Stem Cells (HESCS) Does this project involve human embryonic stem cells (only hESC lines listed as approved in the NIH Registry may be used in NIH funded research)? No</p>
<p>G.7 Vertebrate Animals Does this project involve vertebrate animals? No</p>
<p>G.8 Project/Performance Sites Organization Name – Colorado School of Mines DUNS – 010628170 Address – 1500 Illinois St, Golden, CO 80401</p>
<p>G.9 Foreign Component No foreign component</p>
<p>G.10 Estimated Unobligated Balance G.10.a Is it anticipated that an estimated unobligated balance (including prior year carryover) will be greater than 25% of the current year's total approved budget? No</p>
<p>G.11 Program Income Is program income anticipated during the next budget period? The reporting and budget period for this award ended August 31, 2023.</p>
<p>G.12 F&A Costs Is there a change in performance sites that will affect F&A costs? No</p>

I. OUTCOMES

I. Provide a concise summary of the outcomes or findings of the award, written for the general public in clear and comprehensible language, without including any proprietary, confidential information or trade secrets.

Note: project outcome information will be made public in NIH RePORTER

Please see below.

*** Additional information is required:**

- **Abstract** (*for the full study; 500 words or less*)
- **Significant or Key Findings** (*identify by specific aim or in parentheses after related findings/statements for each specific aim*)
- **Translation of Findings**
- **Research Outcomes/Impact** (*some contents may also be reported in E. Impact and I. Outcomes.*)

Abstract

The Energy, Mining and Construction Industry Safety Program 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 and others 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, 2020, to August 31, 2023, CSM conducted 81 courses designed to support MSHA training requirements as defined under 30 CFR Part 48 for New Miner, Annual Refresher, and MSHA Instructor training. This training was developed to meet the specific needs of underserved populations working on mine sites, including contractors, suppliers, consultants, equipment manufacturers, educators, and 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 continues to build for the future. During this reporting period, CSM posted six online training courses, delivered twenty conference presentations and three short courses, conducted fourteen webinars, and published six articles in Mining Engineering.

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 (Specific Aim 3). As such, during the reporting period, CSM presented twenty-two guest lectures at five western universities.

CSM believes that the safety training provided to underserved populations has contributed to reducing the number of accidents and illnesses in the mining industry. One of the main objectives of safety training is not only to comply with federal regulations but also to avoid accidents and help prevent workplace injuries. This is accomplished by providing miners with the necessary knowledge on how to work safely. Training puts miners in the best possible position to avoid hazards and reduce the incidence of accidents and illnesses. 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.

Section 1

Significant or Key Findings

With the support and collaboration of NIOSH and other mining stakeholder groups, CSM had developed and delivered highly effective training since 1999. Based on the data gathered for this reporting period, the following are the significant or key findings of the training program.

- Utilizing instructors with mining experience, who are technical experts in the topics they teach, provides credibility to the courses. (Specific Aim 1, 2, and 3)
- Incorporating multiple instructors during training courses, either as team instructors or sequentially changing throughout the training, increased the attention span of trainees. (Specific Aim 1, 2, and 3)
- Integrating personal safety and hazard recognition through stories provided real-life, relatable examples for trainees. (Specific Aim 1, 2, and 3)
- 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. (Specific Aim 1 and 3)
- 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. (Specific Aim 1)
- Thinking outside the box with respect to routine training systematically enhanced the quality of the training. (Specific Aim 1)
- Capitalizing on the widespread use of the Edgar Experimental Underground Mine increased training retention (Specific Aim 1 and 2)

Translation of Findings

The key findings of this research are useful to organizations that provide safety and health training and are committed to 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" (NIOSH, 2023a). The r2p approach includes six core elements: Partnerships, Intramural Science, Extramural Science, Technology Transfer, Communication and Evaluation (NIOSH, 2023b). 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 agencies, 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 a wide range of 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 and Impacts

In 2021 MSHA reported 37 miner fatalities. This ended a run of six straight years in which fewer than 30 miners died on the job. MSHA noticed the upward trend in fatalities early in the year, and at the June 9, 2021, MSHA stakeholder conference call, Sam Pierce, Acting Administrator for Enforcement at MSHA discussed "doing something different" to stop the increasing number of fatalities (National Safety Council, 2021). MSHA's focus during this call was on improving training as described by Tim Watkins, Deputy Administrator for Enforcement at MSHA.

"As we look at these fatalities, what sticks out to me is decisions. The decisions that were made to do what they were doing at the time the accident happened. The best way to make good decisions is through training. If you've had the proper training, then you're going to make proper decisions, recognize the hazards. Sometimes, we have people who lack the experience and training to recognize what is a hazard. Some people may look at things and say it's not a hazard until it's too late. We do recognize that we have lots of people out there working that they have training, but do they really have the in-depth training they need?" (National Safety Council, 2021).

With a renewed focus on training and invigorating initiatives such as the powered haulage initiative, MSHA reported a moderate improvement in fatalities for 2022. This was a positive trend MSHA hoped to see continue, but there is still significant improvement to be made. Unfortunately, as of the MSHA stakeholder conference call on July 26, 2023, MSHA had recorded 25 fatalities. This upward trend in fatalities prompted Brian Goepfert of MSHA's metal/nonmetal mining safety division to declare "We just need to put an end" to the rise in mining deaths (National Safety Council, 2023). Some of the guidance offered revolved around instruction on best practices, training on following the manufacturer's recommendations, and completing workplace examinations. This focus on training is reinforced through research that determined "safety training increases the reporting of injuries and illnesses but also has real safety effects on days-away-from-work incidents" (Waeher, 2009). This is because one of the main objectives of safety training is not only to comply with federal regulations but also to avoid accidents and help prevent workplace injuries. This is done by providing miners with the necessary knowledge on how to work safely. Training will not guarantee complete workplace safety, but it will put miners in the best position to avoid hazards and reduce the number of accidents and illnesses to the lowest possible levels. 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. As such, this program fills an important regional need by providing occupational health and safety training and needs-based education to students, individuals and companies engaged in mining and exploration activities throughout the Western United States. The program is particularly critical for underserved populations working on mine sites, including contractors, suppliers, consultants, equipment manufacturers, and small mine operators.

References for Section 1

Kirkpatrick, D. L. (1994). *Evaluating Training Programs: The Four Levels*. San Francisco: Berrett-Koehler.

National Institute for Occupational Safety and Health. (2023a, October 10). *Research to Practice Overview*. Retrieved from Centers for Disease Control and Prevention: <https://www.cdc.gov/niosh/mining/aboutus/aboutus.html>

National Institute for Occupational Safety and Health. (2023b, October 10). *Research to Practice Overview*. Retrieved from Centers for Disease Control and Prevention: <https://www.cdc.gov/niosh/r2p/default.html>

National Safety Council (2021). 'We need to do something different': MSHA stakeholder call focuses on improved training. *Safety and Health Magazine*. Retrieved from <https://www.safetyandhealthmagazine.com/articles/21339-we-need-to-do-something-different-msha-stakeholder-call-focuses-on-improved-training>

National Safety Council (2023). MSHA: 'We just need to put an end' to the rise in mining deaths. *Safety and Health Magazine*. Retrieved from https://www.safetyandhealthmagazine.com/articles/24336-msha-we-just-need-to-put-an-end-to-the-rise-in-mining-deaths?utm_source=sfmc&utm_medium=email&utm_campaign=daily&utm_content=

Waehrer, G. (2009). Does Safety Training Reduce Work Injury in the United States? *The Ergonomics Open Journal*, 2, 26-39. Retrieved from <https://benthamopen.com/ABSTRACT/TOERGJ-2-26>.