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ALPHA FOUNDATION FOR THE IMPROVEMENT OF MINE SAFETY AND HEALTH

Final Technical Report

1.0 Cover Page

Project Title: Effective Mining Safety Training: Design, Implementation, and Evaluation

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2.0 Executive Summary

Research suggests that making changes to how mandated mine safety training is conducted may result in increased knowledge acquisition and transfer. The main objective of this study is to change how mandated training is conducted in the mining industry within the boundaries of MSHA-approved training plans and corporate training policies.

With our partners, we:

- Created and disseminated The Mine Safety Training Handbook: active Training Tools for Mine Safety Trainers for use in MSHA-mandated safety training;
- Designed and implemented a 4-hour train-the-trainer course, Effective Mine Safety Training, that teaches how to use adult and active learning methodologies and emphasizes transfer of training;
- Helped trainers re-design existing mandated training courses using adult and active learning methodologies with the New Miner and Annual Refresher Training Handbook with facilitator and student guides;
- Assessed the utility of the Louisiana State University Andragogy in Process Inventory (API) instrument for the inclusion of adult learning elements in safety training.
- Conduct an empirical study (with treatment and control groups) comparing the outcomes of the re-designed training courses with traditional, lecture-based training courses.

We surveyed trainees completing annual refresher courses using traditional, passive instruction methods (control group). We then trained trainers to use more adult learning methods and helped them revise their courses. We surveyed the trainees taking the revised courses (treatment group) using more adult learning methods. These revised courses included new miner as well as annual refresher content. We used the Andragogy in Process Inventory (API) for the treatment group and an in-house survey for the control group. The API was also used on a subset of the control group. A total of 868 mine workers were surveyed . A total of 85 trainers from 11 organizations were trained to use adult learning methods.

We analyzed 573 surveys from the control group with the in-house survey and 62 API surveys. We collected 295 API surveys from the treatment group. The results of the control group surveys indicated that the courses were not challenging, there were few elements of active learning, trainees did not set goals, but they were satisfied with the topics covered and felt they could transfer the knowledge to their jobsites. The API indicated the most important factor to improve safety learning in the course was the evaluation component.

The treatment group results indicated that trainees were motived to learn to improve safety but felt they had little influence on the planning or design of the training. More active learning methods were present but there was still a large focus on lecture content. Evaluation continued to be viewed as highly useful.

Trainers have asked for a longer train-the-trainer program to incorporate more theories of adult learning, including goal setting and incorporating input from trainees in course design. We have created a 3-day High-Level Training Clinic course to accommodate the findings of this project.

3.0 Problem Statement and Objectives

Focus Area 4: Training

According to the American Society for Training & Development (ASTD) more than $100B is spent by U.S. companies each year on training. Mining companies are no different- they spend millions of dollars each year on training, much of it on MSHA-required courses such as the Annual Refresher. Some mining researchers suggest that making changes to how training is conducted may result in more positive outcomes (Peters et al, 2010); and research in industries outside of mining suggests that some training methodologies, such as active learning, can result in increased knowledge acquisition and reduction in illness, injury, and accidents (Burke et al, 2006; Robson et al, 2010). However, little research is available on using these training methodologies in the mining industry, specifically in mandated training.

The main objective of this study is to change how mandated training is conducted in the mining industry. The project was designed to provide guidance to mine trainers on how to modify existing training courses to include more active and engaging learning experiences and how to implement these revised courses in a manner that meets MSHA requirements. We also assessed the Andragogy in Process Inventory (API) instrument for use in evaluating the amount of adult learning content in training courses. Our objective was accomplished through four Specific Aims:

- Specific Aim #1- Re-design mandated training courses
    - Create and disseminate a handbook of active learning exercises based on the re-designed courses;
    - Re-design existing mandated training courses using adult and active learning methodologies;
- Specific Aim #2- Train-the-trainers
    - Design and implement a train-the-trainer course that highlights using adult and active learning methodologies and emphasizes transfer of training;
- Specific Aim #3- Implement and evaluate re-designed mandated courses
    - Disseminate the train-the-trainer curriculum for use by the mining community;
    - Conduct an empirical study (with treatment and control groups) comparing the outcomes of the re-designed training courses with traditional, lecture-based training courses.
- Specific Aim #4- Evaluate the Andragogy in Process Inventory (API) instrument
    - Evaluate the usefulness of the Andragogical Process Inventory (API) instrument for assessing the adult learning content of mine safety training courses

4.0 Research Approach

Our research objective was accomplished through the completion of four specific aims, as outlined below.

Specific Aim #1 – Re-design mandated training courses

When researchers such as Kowalski & Vaught, 2002; Kowalski-Trakofler et al, 2004, call for mine safety training to be more "adult learning oriented" or to "include adult learning principles", they are typically referring to the idea of andragogy or "the art and science of helping adults learn" put forth by Knowles (1990). Andragogy differs from pedagogy in that the focus is on the adult learner, and the teacher or instructors becomes an equal in the learning, i.e. a facilitator, not a director. Knowles built on the work of many early adult education researchers proposing the andragogical framework, which identified the following:

- The need to know – the learner needs to know what they will be learning and why they need to learn it before beginning to learn.
- The concept of the learner – the learner takes responsibility for their lives and hence want control or responsibility for their learning; increasing self-directedness.
- The role of learners' experiences – adult learners come to the classroom with rich experiences that can help them and others learn.
- Readiness to learn – the learner will more readily accept the learning when they are experiencing real-life situations that necessitate it.
- Orientation to learning – adults are problem-, task-, or life-centered on their orientation to learning – not subject-centered.
- Motivation – strongest motivator for adult learners is internal pressure, not external.

These principles were core tenets in the development of a process model to develop educational or training programs for adults. The andragogical process model differs from a typical content-driven model in that the focus lies in procedures that involve the learners, helping them gain the knowledge and skills needed, not merely in delivering content. The eight elements of the andragogical process model, as designed by Knowles, Holton and Swanson (2011), include:

- Preparing learners;
- Setting climate;
- Mutual planning;
- Diagnosing of needs;
- Setting of objectives;
- Designing learning plans;
- Learning activities; and
- Evaluation.

Our process to re-design the mandated training was to focus on the learner. There are

several recurring themes in the literature for active learning (e.g. Prince, 2004):

- **Discussion/questioning** – requires the instructor to understand to understand techniques of questioning and strategies and styles for involving discussion. This is an important consideration for our train-the-trainer program since many mine trainers use discussion to engage learners but have limited training on techniques of questioning and strategies for involving participants.

- **Modified lecture** – active lectures involve problem solving, critical thinking, attitude change and motivation for further learning. Both McKeachie et al and Bonwell & Eison (1991) identified active lecturing methods that go beyond discussions and questioning including pausing, immediate tests and quizzes, demonstrations, and alternative formats (mini lectures, guided lectures, and responsive lecture). The modified or active lecture may be a comfortable technique for many trainers and has the potential for greater transfer of learning, something identified as crucial in the ever changing mining environment

- **Peer learning/collaborative learning** - McKeachie et al (1986) found that when immediate knowledge is the measure of effectiveness, lecture is equal to other instructional methods. However, more active and engaging methods are proven to be more effective when the measures are "transfer of knowledge to new situations, or problem solving, thinking attitude change or motivation for further learning" (p. 70). Collaborative learning may hold great potential for formal mine training courses because some literature suggests it is occurring informally on the job (Kowalski-Trakofler et al, 2004). Moreover, some mine trainers report they already use some aspects of this approach by pairing native English speakers with an English language learner, or older experienced miners with younger inexperienced miners.

- **Cooperative learning** - Cooperative learning is different than collaborative learning in that learners are typically assessed (and rewarded) for their work as a group rather than individually. McKeachie et al (1986) note that cooperative learning has affective impacts, as well as cognitive; and suggest the goals are to develop skills in group membership, leadership, and interpersonal relations. In the research reviewed by McKeachie et al, they note that final exam scores were not affected by student centered teaching, however the studies showed significant impacts to "student adjustment", specifically greater empathy and reductions in prejudice. Johnson, Johnson, and Smith (1991) state for something to be considered "cooperative" learning it must include: positive interdependence, face to face interaction, personal accountability, collaborative skills, and group processing. The researchers found that cooperative learning activities increased productivity, social support, and self-esteem, as well as development of positive relationships. Similarly, Prince's (2004) review of the literature noted "results are consistently positive" and additionally, he found that "cooperation promotes interpersonal relationships, improves social support, and fosters self-esteem" (p. 5). While cooperative learning may hold great potential for mine training, especially in

emergency response situations where research suggests miners act as a group with a leader rising up (Alexander et al, 2010), initial conversations with mine trainers suggest this approach may be hardest to implement because of learner resistance.

- **Simulations/Cases/Games/Problem-based learning** - McKeachie et al (1986) believe the primary goal of the case method is to "develop student ability to solve problems using knowledge concepts and skills relevant to the course" (p. 68) and their review of the literature found that the use of the case method results in the ability to apply knowledge, especially outside the classroom. Bonwell and Eison (1991) found that the use of the case method increased "higher-order thinking" and learner motivation. Additionally, some studies indicated changes in learner attitudes and increased enthusiasm. Prince (2004) identified positive learner attitudes as the most significant (and consistent) outcome of what he calls problem-based learning. His review also found support for long-term knowledge retention, increase of class attendance, use of learning resources and studying for understanding (not short-term recall). Many trainers are already using this approach in their trainings when they present fatalgrams. However, because the case is presented to the learner instead of engaging the learner, the outcome falls far short of its potential. As such, we believe this active learning approach may hold great potential for mine safety and health training.

Ultimately the goal of safety training is to transfer the knowledge, skills, attitudes, and other attributes to the job site. Burke and Hutchins (2007) suggest three primary factors influence transfer of training - learner characteristics, intervention design and delivery, and work environment. Within these factors we further narrowed our search to include those elements that are well-developed constructs with significant empirical research and significant impacts on transfer. These include 1) learner self-efficacy, 2) motivation, and 3) perceived utility/value, as well as 4) learning goals.

1) Several studies suggest that self-efficacy can be increased through training interventions, such as: mastery experiences, supportive feedback, goal setting, and self-management strategies (Gist, 1989; Gist, Stevens & Bavetta, 1991). We believe that learner self-efficacy may be a crucial part of mandated safety and health training success, especially for the new miner being inundated with hours (and days) of new information and vocabulary. Both our active learning methods and our trainers must accommodate this important element.

2) Learner motivation is positively related to learning outcomes including skill acquisition, declarative knowledge, and reactions to and transfer of training (Colquitt et al, 2000). Stevens and Gist (1997) found that "mastery-oriented trainees would engage in more interim skill-maintenance activities, plan to use more effort, and show more positive affective responses than performance-oriented trainees" (p. 974). Moreover, their study found that a training intervention can affect participants' goal orientations (or motivational dispositions). This research suggests that the structure of our mandatory training should steer participants to mastery of the knowledge, not just to perform well to pass the exam or receive

kudos from the instructor.

3) Human resource development research suggests that learners' perceived value of the training can impact whether they will apply the new knowledge they acquired (Baumgartel, Reynolds, & Pathan, 1984; Axtell et al, 1997; Lim & Morris, 2009). Burke & Hutchins (2007) state "Put simply, for maximal transfer, learners should perceive that the new knowledge and skills will improve a relevant aspect of their work performance" (p. 269). We consider this significant since many mandated trainings are framed as an "hour" requirement (I need my 8 hour refresher) rather than being viewed as relevant or important to completing the job.

4) Burke & Hutchins (2007) note that to maximize transfer to the job, trainees must explicitly communicate objectives to the learners. Moreover, some researchers note that goal setting (both directed and participatory) has been found to help participants regulate their behavior, mobilize their effort, and extend their effort over time (Locke & Latham, 2006). We consider this approach to be cost effective and simple measures to increase the likelihood of transfer. It can be included as part of the re-designed course, but trainers must also see the value it can bring post-training.

A summary of the key adult learning design elements is shown in Table 1.

Table 1. Key design elements to improve mine safety training

Elements of adult learning	**Andragogical Process Model**	**Elements of Active Learning**	**Requirements for transfer**
Why they need to know	Prepare the learner	Discussion/questioning	Self-efficacy (mastery)
Learner takes responsibility	Set the climate	Modified lecture	Motivation – competencies and capabilities
Share experiences	Mutual planning	Peer learning	Perceived value – relevance to job, not seat time
Real-life experiences	Diagnose needs	Cooperative learning	Learning goals – for use on the job
Task or life-centered approach	Set objectives	Problem-based learning	
Internal pressure is best motivator	Design learning plans		
	Learn activities		
	Evaluation		

The elements from Table 1 were included in our Effective Mine Safety Training Course (i.e.

active learning for trainers) and our Mine Safety Training Handbook: Active Training Tools for Mine Safety Trainers.

For the past five years, the UA team has worked closely with mine trainers throughout the Western U.S., researching mine safety and health training. When studying the use of adult learning principles or active learning methodologies, mine trainers consistently noted barriers to implementation, such as:

- Lack of training/class time
- Lack of time to revise training materials
- Lack of money to hire consultants or buy curriculum
- Large class sizes
- Hesitance to remove lecture slides/content
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Moreover, several trainers have noted in the past that active learning took up "valuable" lecture time/content/slides and that if you weren't lecturing you were being "lazy" or "slacking".

Based on this experience, we have designed a project to show trainers these barriers can be overcome.

Using our knowledge of adult learning principles, active learning methodologies and transfer of training research, we proposed to re-design three regulatory-required courses:

- New miner;
- Newly hired experienced miner; and
- Annual refresher

The New Miner and Newly Hired Experienced Miner used the same content and were essentially the same course so we re-focused on two courses: New Miner and Annual Refresher for surface and underground, coal, and metal/nonmetal. 30CFR Parts 46 and 48 specify the required topics for each type of training course. Using these requirements as a guide, we worked closely with each partner to identify active and engaging learning exercises that were applicable to each topic.

We visited five of our seven industry partners' training courses to observe and evaluate annual refresher training and to collect their training materials to help us re-design their courses. Companies reviewed were: Arizona State Mine Inspector, BHP Billiton, Vulcan Materials, Freeport McMoRan, and McCraren Compliance. These companies represent coal, construction materials, and metal mining companies and contract trainers (state mine inspector and McCraren Compliance).

The first step in re-designing courses was to create a catalog of active learning strategies that could be used in any training course.

The active learning handbook was compiled from activities suggested by safety trainers who are members of our Health and Safety Technical Partnership (HSTP) in the University of Arizona Lowell Institute for Mineral Resources. The members of the HSTP assisting with the handbook represent the following companies:

Resolution Copper Project
Barrick Gold of North America
Coeur Mining
Freeport McMoRan
Salt River Materials Group
Asarco LLC
Vulcan Materials
BHP Billiton
Luminant Mining
Hecla Limited

Activities were modified to apply to multiple commodity sectors and training courses. In addition the project team created new activities. The handbook was reviewed by trainers from BHP Billiton, Freeport McMoRan, Resolution Copper, Salt River Materials Group, Vulcan Materials, and McCraren Safety Compliance.

The goal of this aim was to provide guidance and materials to trainers to use the best practices in Table 1 in their training. To help trainers see how to use these best practices with our active learning handbook we re-wrote the annual refresher and surface and underground new miner training course, including content for coal and metal/non-metal. The instructor and student guides serve as an example for trainers to show them they can incorporate adult learning and best practices for transfer and still meet their MSHA training plan requirements.

Specific Aim #2 – Train-the-trainers

Much like the evidence surrounding active and engaging learning environments, there is significant research suggesting that the classroom behaviors of the instructor can also impact learning (Leach, 1996; Perry, 1997; McKeachie, 1986; Murray, 2007). This is an important consideration because many health and safety trainers have risen to their current positions due to their technical expertise, and not because of formal education or background in effective training strategies. Therefore, we considered it imperative to design and implement a program focused on the characteristics and competencies for highly effective teaching and training that also incorporated foundational knowledge on the use and implementation of active and engaging learning exercises; and how to encourage participants to transfer their training back to their job.

We created and delivered the Effective Mining Safety Training Course for trainers. The course included topics such as principles of adult learning, leading discussions, directing activities and exercises, doing debriefs, assessing learning, designing activities, encouraging transfer, goal setting, and evaluating the course. Like the mandated courses we re-designed (Specific Aim #1), the train-the-trainer course was highly active and engaging to allow the participants to observe many of the most common active learning methods in action.

The syllabus for the Effective Mining Safety Training Course includes the following topics based on the best practices in Table 1. This course is a half-day and introduces the elements of active learning in mine safety training.

1. **Introduction**
   - Emergency procedures
   - Activity: Icebreaker (used to engage the class and get them acquainted and more comfortable with speaking in their group)
2. **Course Preparation**
   - Setting up your classroom to meet your goals
3. **Basics of Active Training**
   - Key characteristics of the adult learners
   - Types of motivation
   - Adding experiences to training
   - Orientation to learning
   - Collaboration
4. **Active vs. Passive Training**
   - Activity: On the Fence (can be used as an informal assessment of information retention)
5. **Application of Active vs. Passive Training**
   - Activity: Create a Quiz (each student is responsible for creating a quiz on the information they just learned in the module. Once done they will switch quizzes and answer questions)

- Activity: Word Wall (mining specific terms are sometimes not easy to remember when you hear one write it down and place it on the word wall. On a break the instructor will write down the meaning of all new words and clarify.)
- Activity: Debate (When a really great conversation is taking place ask the class to take sides and defend their place)
- Activity: Video Fill in the Blank (script the text in a video leave some key blanks and instruct students to fill in the missing words as they watch the video)
- Activity: What's Your Experience? (Ask for people to share a specific time when they made a good or bad decision. Pose the questions was it preventable? What happened? And what can happen if you don't report an injury right away? How could you have changed the outcome of a bad situation?)
- Activity: Stations (works well after lunch when people are at a low energy level this gets them up and moving. Breaking them into small groups' stations can be used in a plethora of ways. We specifically used it to define the Hierarchy of Controls)
- Activity: Plain Language (Using MSHA Fatalgrams create a story to depict how the mood of the workers might have been. Use language that the audience will understand and paint a picture. The idea behind this is that the employees will relate and pull more information out of the fatalgram that just reading it to them or having them read it themselves.)

6. **Implementing Activities**
   - When should I be using activities?
   - Are they meeting my training objective?
   - Will they enhance the training and engagement in my classroom?
7. **Closure**
   - Review of the activities and handbook
   - Provide contact information for any further questions

The course is 4 hours in duration and trainers re-design a component of their training courses within the class. Figures 1 and 2 show trainers engaging in activities in the training course.

Figure 1. Active learning training with trainers at Coeur Mining's Kensington Mine near Juneau, Alaska.

Figure 2. Active learning training using Legos at the Western Mining Safety and Health Conference in Reno, NV.

Specific Aim #3 – Implement and evaluate re-designed mandated courses

For this aim we evaluated training courses at our partner organizations in order to make any necessary revisions or modifications before publishing the handbook of active learning exercises. The evaluation included assessing the content and design of each course and looking specifically at program content, logistics/administration, materials, delivery methods, instructor, activities, length, training environment, transfer expectation, overall evaluation, and recommendations for improvement. The Mine Safety Training Handbook: Active Training Tools for Mine Safety Training reflects the feedback from the trainers who participated.

After trainers completed the Effective Mine Safety Training Course they agreed to modify their training courses and allow us to survey the trainees who received the modified training (the treatment group). We were able to review all or part of the training materials for 6 of our partner organizations (Vulcan Materials, Luminant, McCraren Compliance, UA San Xavier Mine, Freeport McMoRan, Resolution Copper, and BHP Billiton). We did, however, help deliver the annual refresher training for Bridger Coal using our active learning methods. All organizations had to comply with existing MSHA training plans and corporate requirements for their training. All organizations included elements of adult learning from Table 1, including PowerPoint slides and lecture content.

The second part of this aim involved evaluating the control group which received passive training and the treatment group which received training from trainers who had received active learning training under Aim #2. The treatment group use of the API survey is discussed in detail under Aim #4.

Because we were unable to randomize participants, we proposed a quasi-experimental research approach when implementing the re-designed courses. We had a control group and a treatment group but were not able to have them matched at each training site due to constraints within the companies regarding their training needs. The control groups received traditional, lecture-based training as it was currently implemented by each training partner. The treatment groups received the Effective Mine Safety Training course to teach them about active learning and how to revise their courses.

We intended for each participant (both treatment and control) to fill out an anonymous pre- and post-course survey. The control group survey was developed for this project and is included in Appendix B. The survey includes 21 questions using a 5 point Likert scale with 1=strongly disagree and 5=strongly agree. Questions 1-8 were related to the learning environment. The mapping of questions to the key design elements for adult learning from Table 1 are shown in Table 2 below.

Table 2: Mapping the control group in-house survey to elements of adult learning from Table 1. The mapping to the API questions is not one-to-one.

Control Group Question	**Elements of adult learning, active learning, transfer**	**Design Element**
Q1-8	*Set the climate*	Andragogical Process Model (API)
Q9	*Prepare the learner*	API
Q10-12	Why they need to know *Design of Learning Activities*	Elements of Adult Learning, API
Q18,27-29	Discussion/questioning, modified lecture, peer learning, cooperative learning, problem-based learning *Evaluation*	Elements of Active Learning, API
Q13,21,24	*Diagnosis of Learning Needs,* *Design of Learning Experience*	Elements of adult learning and API
Q19	Mastery, competencies, perceived value, goals (transference questions) *Mutual Planning*	Requirements for transfer, API
Q26	*Setting objectives*	API
Q17	*Design of the Learning Experience*	Requirements for transfer, API

Using the results from these surveys we intended to statistically test the following hypotheses:

H1: Treatment group participants report increased levels of self-efficacy post-training.

H2: Treatment group participants have higher post-course quiz scores.

H3: Treatment group participants have higher affective responses.

H4: Treatment group participants report higher levels of intent to transfer.

H5: Treatment group participants report higher levels of perceived utility/value.

The treatment and control groups were also to receive the API survey. We found out into the project that trainers and trainees were highly resistant to filling out pre-and post-course surveys so we could only use post-course surveys. The trainers and trainees would only fill out 1 of the 2 surveys and the control group preferentially filled out the shorter survey. The control group survey had 29 questions and was designed to focus on elements of transfer as some elements of active learning in Table xx.. The API is a validated instrument with 59 questions and was designed to test for the presence of adult learning methods in the training. We made the decision to only use the API with the treatment group since testing this instrument was a requirement of Aim 4 and its focus was on measuring the amount of adult learning elements in the training course. We found that trainees had difficulty filling out the API survey. We experimented with a shortened version of the API and will investigate alternative assessments to surveys in future work. We were unable to test the hypotheses identified above for these reasons.

Trainers would not allow us to pre- or post-test their trainees so we were unable to test the hypothesis that treatment group trainees had better understanding of the subject matter. We have, however, written sample quizzes into the training handbook for trainers to use or modify if their organization allows.

Specific Aim #4 – Evaluate the Andragogy in Process Instrument

Adult learning principles are foundational to the design and delivery of highly effective training and many researchers and scholars in the mining community have suggested they be incorporated into mine safety and health training courses and teaching practices (Kowalski & Vaught, 2002; Kowalski-Trakofler et al, 2004). To date, there is only one instrument validated to measure these andragogical (adult learning) principles and their associated process design elements – the Andragogy in Process Inventory (API). The instrument was created and validated by our collaborators at Louisiana State University (LSU) (Holton, Wilson and Bates, 2009). The instrument was distributed to some participants in the control group and all participants in the treatment group in order to test its use in evaluating mine safety training for inclusion of adult learning methods. The completed surveys were sent to Dr. Reid Bates at LSU for analysis and interpretation. The survey is proprietary to Dr. Bates and his colleagues. The instrument can be rented from Dr. Bates on a per copy basis and his team conducts the analysis of the results.

The API does not measure whether training yields a safer miner. It measures whether elements of andragogical learning are present in the training. Active learning for adults has been shown by many researchers to be more effective than passive learning. The API is a powerful tool to assess whether adult learning methods are used in training and contains a measure of Motivation to Improve Safety Through Learning (MTISL). The MTISL is designed to assess an individual's attitude toward safety training, expectations about the value of the training, and for teaching adults during the past 40 years. Defined as the "art and science of helping adults learn" (Knowles, 1990, p. 54), and "an intentional and professionally guided activity that aims at change in an adult person" (Knowles et al., 1998. p. 60), andragogy has become synonymous with the education and

training of adult learners. It has been described as "the preeminent and persistent practice-based, instructional method" (Rachal, 2002, p. 211); a "guiding principle on how best to educate adults" (Beder & Carrea, 1998, p. 75); a "set of guidelines for effective instruction of adults" (Feuer & Gerber, 1988, p. 35); and "a way of thinking about working with adult learners" (Merriam & Brockett, 1997, p. 135). their belief in their own capacity to apply the learning on the job.

Andragogical theory suggests a number of design elements that foster adult learning, adult motivation to learn, and outcomes from adult learning. The design elements encompass a range of activities which can occur before, during, and after the learning experience. The API is designed to assess the extent to which the design elements are present in a training program. The scales measuring the design elements are listed and defined in Table 3. The survey instrument reported on in this analysis contained 36 items measuring the eight different design elements.

In the social sciences a scale is a type of composite measure that is composed of several items (in this case survey items) that have a logical or empirical structure among them. Because they are a composite measure scales take advantage of differences in intensity among the indicators of a variable. Scales represent the operationalization of "constructs". The most commonly used scale is the Likert scale which was used here (a 5-point Likert type scale with responses from "strongly agree," to "strongly disagree."

Constructs are approximated units of phenomenon that cannot be observed directly. Put somewhat differently, they are linguistic devices used to specify or describe phenomenon or elements of a phenomenon in which we are interested. For example, the idea of "motivation" is a construct. Constructs are important tools in the social sciences because, for one reason, they are a central element of theory: Theory describes constructs and the relationships between constructs. To be useful beyond theory we have to be able to measure these unobservable elements. We make constructs observable and measureable through their operationalization as variables (i.e., scales). A scale is an observable entity capable of taking on two or more values. In the present case, our "constructs" of interest (e.g., design of learning activities) represents a component of adult learning theory. We have made these measureable through the creation of a set of survey items represented in the scales by the same name. This measurement process is intended to provide an operational referent for a phenomenon (construct) at a higher level of abstraction. A multidimensional construct is simply one with more than one dimension. These are often useful when it is useful to try to obtain a more complete picture or measurement of a particular phenomenon. We have made these measureable through the creation of a set of survey items represented in the scales by the same name. This measurement process is intended to provide an operational referent for a phenomenon (construct) at a higher level of abstraction.

Table 3: Learning Process Design Scales for Adult Learners

Scale	Definition
Prepare the Learner	The degree to which the learner was prepared for the learning experience through the provision of information or activities and exercises that clarified objectives and responsibilities.
Climate Setting	The degree to which the learning climate is perceived to be supportive and fully collaborative.
Mutual Planning	The degree to which the learners perceived themselves to be full partners with other learners and the instructor In planning the learning experience.
Diagnosis of Learning Needs	The degree to which the learner perceived the learning experience provided assistance or opportunities for the learner to diagnose her/his developmental needs.
Setting of Objectives	The degree to which learners had meaningful input and could set or collaborate in the setting of objectives for the learning experience.
Design of the Learning Experience	The degree to which the learning activities were collaboratively designed and adapted to meet individual needs and capabilities.
Design of Learning Activities	The degree to which the learning experience utilized a variety of active learning methods that encouraged learners to engage the task domain and to discover task solutions on
Evaluation	The extent to which the evaluation methods used in the learning experience were appropriate and met the learner's needs.

Andragogical theory suggests that integration of these design elements in adult learning settings enhances the learning experience for adults and fosters improved learning-related motivation and outcomes. Therefore, in addition to the design elements associated with adult learning theory (andragogy), the API also included a measure of Motivation to Improve Safety Through Learning (MTISL). MTISL is defined as the motivation to improve work-related safety outcomes by engaging in training or learning activities and using what is learned to perform job functions more safely. It is a multidimensional construct designed to assess an individual's attitudes toward safety training, expectations about the value of that training for improving safe work, beliefs about the his/her capacity to apply learning from safety training, and his/her motivation to learn and apply that learning on the job. The MTISL measure for this project included 17 items on the survey. The MTISL measure was included in the data collection to examine the extent to which andragogical design element present in the safety training courses were associated with the motivation to improve safety through learning of the training participants.

Evaluation is a design element scale that, as defined in Table 3, refers to the extent to which the evaluation methods used in the learning experience were appropriate and met the learner's needs. It is one of the constructs that adult learning theory suggests is important in adult learning contexts and which we have operationalized as a scale here.

The 17 items that measure the Motivation to Improve Safety Through Learning (MTISL) are shown in Figure 3 and include the following on a 6 point Likert scale where 1=strongly disagree and 6=strongly agree. The respondent scores on each of the 17 items in MITSL are summed to yield a single scale score.

1.	I always learn new and important things in safety training. ATT TRNG	1 2 3 4 5 6
2.	My performance improves when I apply at work what I learn in safety training. TEPE	1 2 3 4 5 6
3.	I have no trouble learning new ways to work more safely. SLSE	1 2 3 4 5 6
4.	Safety training programs are a critical part of my work. ATT TRNG	1 2 3 4 5 6
6.	I work hard to learn the material covered in safety training programs. MOT LEARN	1 2 3 4 5 6
7.	I am able to improve safety at work by learning new things. SLSE	1 2 3 4 5 6
8.	I am committed to learning as much as I can in the safety courses I attend. MOT LEARN	1 2 3 4 5 6
9.	Even when it is difficult to learn what is taught in safety training, I keep trying. MOT LEARN	1 2 3 4 5 6
10.	I plan to apply as much of the safety training as possible to my work. MOT TRANSFER	1 2 3 4 5 6
11.	If I want to work more safely I can learn new skills to do so. SLSE	1 2 3 4 5 6
12.	I devote a great deal of time and energy to using on my job what I learn in safety training. MOT TRANSFER	1 2 3 4 5 6
5.	Safety training programs are important for my work-related development. ATT TRNG	1 2 3 4 5 6
13.	I am determined to put into daily practice what I learn in safety training. MOT TRANSFER	1 2 3 4 5 6
14.	My goal is always to use as much of the learning from safety training as I can at work. MOT TRANSFER	1 2 3 4 5 6
15.	The harder I work in safety training the better I do my job. TEPE	1 2 3 4 5 6
16.	When I am confronted with safety problems at work I am confident I can learn what is needed to solve them. SLSE	1 2 3 4 5 6
17.	The more safety training I apply to my job the better my work performance will be. TEPE	1 2 3 4 5 6

Figure 3. MTISL items on the API.

5.0 Summary of Accomplishments

We created a program to increase the use of adult learning strategies in MSHA-mandated training courses by: 1) creating the "Mine Safety Training Handbook: Active Learning Tools for Mine Safety Trainers; 2) teaching adult learning principles to safety trainers through the "Effective Mine Safety Training Course"; 3) we helped trainers revise their training courses using more adult learning techniques; 4) we evaluated a control group (receiving traditional passive training) and a treatment group (receiving active learning) and assessed whether the Andragogy in Process Inventory survey was applicable to measure the amount of adult learning content in mining training courses.

Specific Aim #1 – Re-design training with active learning to be used in mandated safety courses.

Using our knowledge of adult learning principles, active learning methodologies and transfer of training research, we worked closely with our partner organizations to create a handbook that teaches the principles of adult learning, effective transfer of knowledge from classroom to jobsite, and active learning methods. The Mine Safety Training Handbook: Active Training Tools for Mine Safety Trainers helps trainers understand how to revise their MSHA-mandated safety training courses.

Our primary output for this aim was the " Mine Safety Training Handbook: Active Training Tools for Mine Safety Trainers" . The cover of the handbook is shown in Figure 4 and the table of contents is shown in Figure 5. The handbook covers the adult learning design elements from Table 1. We have distributed 175 hardcopies of the book to trainers during this contract. The handbook was made available at on-site training courses, through trainers, at multiple mining industry conferences that were attended by our research group, and through a MSHA train-the-trainer course.

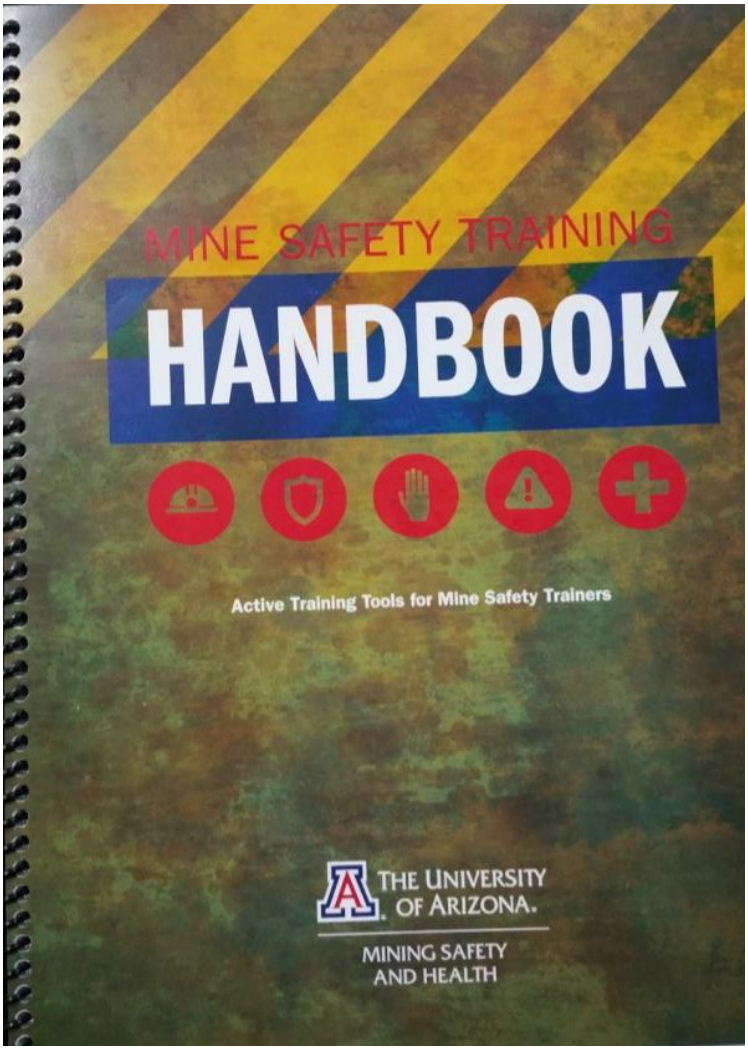

Figure 4. Cover of the Mine Safety Training Handbook

TABLE OF CONTENTS

Figure 5. Table of Contents of "Mine Safety Training Handbook: Active Training for Mine Safety Training".

Two categories of training and materials were created in this project: 1) active learning strategies captured in the "Mine Safety Training Handbook" and translated to practice through the "Effective Mine Safety Training" course; 2) implementation of the previous items in MSHA-mandated training courses (new miner and annual refresher) with our New Miner and Annual Refresher Training Facilitator Guide as an example of how to overcome barriers to implementing changes to training.

The Mine Safety Training Handbook: Active Training Tools for Mine Safety was created with input from industry trainers and we observed implementation of active learning in mandated safety courses at 9 locations in Table 4. We revised the handbook and Effective Mine Safety Training course based on feedback we received from trainers and our observations. Specific items that trainers and ort project personnel included in observations of training included the content and design of each course, logistics/administration, materials, delivery methods, instructor qualities, use of activities, length of activities, training environment, transfer expectation, overall evaluation, and recommendations for improvement from trainers and trainees. The final version of the "Mine Safety Training Handbook" reflects the best practices of trainers across coal, metal/nonmetal, and construction materials.

To help address barriers to implementing adult learning strategies in required training courses we created the "New Miner and Annual Refresher Training Facilitator Guide" and accompanying student guide. These materials are not intended to wholly replace a company's training materials but provide a template to show that adult learning practices can be used and still meet the required MSHA training plan in the time allowed. Trainers can use any of the materials from the training handbook they want. There are still powerpoint slides, lecture content, but also suggested activities, pre- and post quizzes. The handbook is best understood after trainers have completed the Effective Mine Training course. The facilitator guide is 450 pages and the student guide is 202 pages.

Specific Aim #2 - Train the trainers to use active learning.

We trained 85 trainers from 10 organizations (see Table 4) during the contract performance period and introduced an additional 104 trainers to the active learning methods at the Western Mining Safety and Health Conference, October 27-28, 2015 in Reno, NV.

Table 4. Trainers trained to use adult learning principles in mine safety training.

Company	Location	Date	Mining Sector	Trainers
Vulcan Materials	Burbank, CA	12/5/13 pilot 9/22/14 final	Construction Materials	7
Luminant	Dallas, TX	8/18/14	Coal Surface	7
McCraren Compliance	Tucson, AZ	8/29/14	All	4
AZ State Mine Inspector	Phoenix, AZ	8/8/14	All	4
UA San Xavier Mine	Sahuarita, AZ	8/9/14	All (Students & Contractors)	1
Freeport-McMoRan	Green Valley, AZ	12/13 (multiple days) pilot trainers have had additional training for active learning	Copper Surface	4
Rio Tinto/Resolution Copper Project	Superior, AZ	2/14 (multiple days) pilot, trainers have had additional training for active learning	Copper Underground	2
BHP Billiton	Farmington, NM	3/11/15	Coal Underground	18
Bridger and Bowie Skyline (note these are two separate companies)	Rock Springs, WY	6/15/15	Coal Underground	8

Coeur Mining	Rapid City, SD	9/24/15	Gold, Silver by-product Surface	6
Coeur Mining	Juneau, AK	10/1/15	Gold Underground	18
Coeur Mining	Lovelock, NV	10/14/15	Silver, Gold Surface	6
				85 trainers

The feeback on the Active Learning Handbook and re-designed training was universally positive. Some of the comments received from the training course include:

From Deb Hutchison, Vulcan Materials:
“In starting to compile our training for next year, several of the training items from your Mine Safety Training Handbook have been considered and included for use. In the past we have used the following activities with much success:
"On the Fence"
"Video Bingo"
"Icebreaker Interview"
"Fatalgram Review"
"Pair Share"
"Sit and Stand"

These simple activities provide a break in the lecture type training. It gets the employees engaged in their own training. We have had comments like, "best training I've ever had," "great interaction," I believe that these activities have really enhanced the learning experience for our miners.
The classroom set-up information has also been helpful. It sets the stage for the entire day of interactive learning.

Thank you for your efforts and allowing us to participate in the "train the trainer" course. It has definitely helped us all become better trainers.
Deb

P.S. - How can I get additional copies of the "Mine Safety Training Handbook"?”

From Sean McCraren,
”Good afternoon Aly,
Your train the trainer session was very informative and educational. The training with the workbook has allowed a different dimension into the classroom for interactive learning. People have responded well to the material in the workbook. You have done a tremendous job working on this to enhance the training for trainers.

At BHP Billiton some of the verbal feedback we received was that the time they were in class went by quickly. The trainers didn't feel like they were actually in the class for 4 hours and never had a feeling of wanting it to be over. After the class we had the opportunity to meet with all of the trainers and they shared different ideas for activities and how they can make them work in their classes.

Specific Aim #3 – Implement and evaluate re-designed mandated courses.

Our research plan was to use pre- and post-course surveys for control and treatment groups. We developed our own survey to use with control groups that was discussed under Aim #2. The control group survey is appended. The API survey was tested with the control group but used primarily with the treatment group. Since we encountered resistance to filling out surveys across the spectrum of mining organizations and trainees, we were unable to test the hypotheses discussed under the Research Plan section for Aim #3.

We will discuss the control group surveys in this section and the treatment group API results under Aim #4.

Our control group received annual refresher training using non-active learning methods. A total of 573 post-course surveys were received (see Table 5) using an in-house survey and 62 surveys were collected using the API survey. The 62 trainees who filled out the API survey also filled out the in-house survey. Annual refresher training courses were the only courses available from our partners during the time period allocated for the control group study. Data from these surveys were entered into a database, the results of which are described below.

The trainees surveyed included workers from construction materials, coal, and metal/non metal for both surface and underground operations. The construction materials sector includes workers in stone, sand, gravel, cement. Contractors are also included in our training. Contractors work on mine sites and have the same safety requirements as "miners". They are performing skilled operations such as high-voltage power systems, heavy lift crane operations, confined space repairs, etc. Safety applies to everyone on the mine site and we cannot exclude contractors from our safety training. We do not suspect that the inclusion of contractors biases the sample as the purpose of our study is to test the use of adult learning strategies in mine safety training and contractors are adults receiving the same training as those employees working directly for the mining company.

The fact that we could not use both annual refresher and new miner training in the control group may introduce some bias into the results. The resistance to filling out surveys prevents clear-cut conclusions. Surveys that were not completely filled out or contained the same answer for all questions were removed from the analysis.

Table 5: Control Group. Annual refresher training courses surveyed to collect baseline data on standard format for training.

Company	Location	Date	Mining Sector	*Course Type (NM, AR)	Trainees
Salt River Materials Group	Clarkdale	Multiple dates (8/5/14 – 8/14/14)	Construction materials	AR	125
Sundt Construction conducted by AZ SMI	Tucson	5/22/14	Construction contractor	AR	29
Naumann Hobbs, conducted by AZ SMI	Tucson	5/27/14	Materials Handling	AR	14
Western Technologies, conducted by AZ SMI	Phoenix	5/28/14	Contractors	AR	26
SSI, conducted by AZ SMI	Phoenix	5/29/14	Electrical	AR	26
Kaman Ind, conducted by	Phoenix	5/29/14	Contractors	AR	16

SMI					
McCraren Compliance	Tucson	Multiple dates (4/17/14 – 7/24/14)	All sectors	AR	47 (API)
Weir Wales conducted by McCraren	Tucson	6/19/14	Contractors	AR	14 (API)
Westland Resources conducted by McCraren	Tucson	6/20/14	Consultants	AR	12 (API)
AZ State Mine Inspector	Phoenix, Tucson, Flagstaff, Camp Verde	Multiple dates (5/20/14 – 7/29/14)	All sectors	AR	174
Caterpillar Proving Ground conducted by AZ SMI	Green Valley	Multiple dates (6/4/14 – 6/12/14)	Equipment Operators/Mechanics	AR	51
Cemex, conducted by AZ SMI	Phoenix	6/16/14	Construction materials	AR	9
Ninyo & Moore conducted by AZ SMI	Phoenix	6/17/14	Contractors	AR	13
ADEQ conducted by AZ SMI	Phoenix	6/18/14	Regulators	AR	17
				Total	**573 Total collected 73 API surveys distributed, 62 collected**

Analysis of Traditional Lecture-Based Training Survey (Control Group)

We used an in-house survey for the majority of the control group. The survey was intended to gage basic information on adult learning content in traditional safety training and was not intended to match the API instrument. The control group survey is appended.

Data were entered from surveys administered to trainees at the conclusion of mining training programs. Table 6 provides the descriptive statistics for the 573 respondents who completed the survey. Table 7 compares the survey question responses to the adult learning elements from Table 1. Some surveys were removed due to zero-variance in response or failure to answer the question. The survey used a 5 point Likert scale.

The questions analyzed include:

Q9: Topics covered met the purpose of the course

Q10: Materials (handouts, Powerpoint, student guides, etc) worked for the purpose of the course

Q11: Course exercises/activities were meaningful to the purpose of the course

Q12: Group discussions were helpful

Q13: The topics were easy to understand

Q17: The length of the program was appropriate for the purpose of the course

Q18: There was enough time to practice what I learned in the course

Q19: Training topics were meaningful/important for my job

Q21: I was challenged in this course

Q24: The training met my needs

Q26: I set written goals for using what I learned in this course on the job (Yes/No). If yes, how confident are you in your ability to meet your goals (on a scale of 0-100%)

Q27: For the following topics, please mark yes or no if you will be capable of applying (0%, 25%, 50%, 75%, 1005):

Health and safety standards
Transportation controls and safety standards
Escape and emergency evacuation plans; firewarning and firefighting
Ground control
First aid
Electrical hazards
Prevention of
accidents Health
Explosives
Hearing protection
Self-rescue and respiratory devices

Q28: What will help you apply what you learned from this class?

Q29: What will prevent you from using what you learned in this course?

Table 6: Descriptive statistics from control-group survey data.

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Q9	561	4.0	1.0	5.0	4.60	0.65	0.43
Q10	562	4.0	1.0	5.0	4.52	0.68	0.47
Q11	558	4.0	1.0	5.0	4.51	0.70	0.49
Q12	558	4.0	1.0	5.0	4.43	0.75	0.57
Q13	559	4.0	1.0	5.0	4.60	0.61	0.38
Q17	560	4.0	1.0	5.0	4.48	0.80	0.64
Q18	551	4.0	1.0	5.0	4.37	0.80	0.64
Q19	561	4.0	1.0	5.0	4.47	0.73	0.53
Q21	559	4.0	1.0	5.0	3.86	1.04	1.07
Q24	516	4.0	1.0	5.0	4.55	0.68	0.47

Table 7. Mapping the control group survey to elements of adult learning from Table 1 along with the means of the responses from the in-house survey and the API results from Table 12. The API elements are shown in italics in column 2. The API elements were evaluated on a 6-point Likert scale.

Control Group Question	**Elements of adult learning, active learning, transfer**	**Design Element**	**In-house Survey Means (5-pt Likert Scale)**	***API Means (6-pt Likert Scale)***
Q1-8	*Set the climate*	Andragogical Process Model (API)	4.4 (range 4.6-3.8)	*4.9*
Q9	*Prepare the learner*	API	4.6	*4.7*
Q10-12	Why they need to know *Design of Learning Activities*	Elements of Adult Learning, API	4.5,4.5,4.4	*4.8*
Q18,27-29	Discussion/questioning, modified lecture, peer learning, cooperative learning, problem-based learning *Evaluation*	Elements of Active Learning, API	4.4,Tables 8-10	*4.7*
Q13,21,24	*Diagnosis of Learning Needs,* *Design of Learning Experience*	Elements of adult learning and API	4.60, 3.9,4.6	*4.3*
Q19	Mastery, competencies, perceived value, goals (transference questions) *Mutual Planning*	Requirements for transfer, API	4.5	*4.2*

Q26	*Setting objectives*	API	See paragraph below	*4.2*
Q17	*Design of the Learning Experience*	Requirements for transfer, API	4.5	*4.1*

The lowest mean for the in-house survey in questions 1-8 was question 7 "food was good".

The strongest mean scores for the in-house survey were for questions 9, 13, 24 which map to prepare the learner and diagnose needs: the course covered the required topics, the topics were easy to understand, and the course met my needs. Questions pertaining to elements of active learning in the course received scores in between the highs and lows (questions 10,11). The lowest mean scores related to questions about transfer from the classroom to the jobsite and design of the learning experience (questions 18-21). The scores suggest that the respondents did not get enough time to practice the content covered in the training. This might be explained by the lack of active learning components in the training or the inclusion of too much material in the time allotted for the training. The question that received the lowest mean score, 3.86, asked the respondent if they felt challenged in the course.

Question 26 asked the respondents if they had set written goals for what they learned in the course and how confident they felt in meeting those goals. The input for this question is different from the rest of the survey. It requires a two-level response in which the first response indicates whether they have written set goals or not, and if they have, then the second response indicates the confidence in their ability to meet those goals. The response rate for the question was close to 60%. Of those, a majority (60%) did not set written goals ("No" responses) to be used on the job. Of those who did set written goals ("Yes" responses), over 90% were completely confident in applying them on the job. The large number of negative responses for this question indicates that either respondents failed to set written goals for themselves or there was not a formal request from the instructor or employer to write down goals. The percentage of "Yes" responses may be increased by including an activity in the training that requires the trainees to reflect on what they learned in the course, and write down their goals for applying them on the job.

Question 27 asks the respondent to indicate whether they will be capable of applying a number of topics learned in class. The input for this question is similar to Question 26 in which it requires a two-level response from the student. They are first asked whether they can apply the topic or not, and if they can, to what extent they can apply it. The average response rate for this question was 82.1% and of those who responded, the percentage of 'Yes' responses was nearly 95%. This indicates that the respondents felt they were capable of applying the concepts taught during the training. A majority (70%) of those were 100% confident in using these skills on the job. These surveys were for annual refresher so the trainees were experienced in mining and had prior safety training.

The most positive response was for topic vii, Prevention of Accidents, and the least positive was for topic ix, Explosives. Explosives are handled by specialty contractors so this group

of trainees would have little experience with this topic.

Question 28 is a subjective question which gauges the factors that will help the respondents apply the skills learned during the training. There were a total of 191 written responses out of the 572 surveys collected. The text responses were collected and analyzed by creating keywords, the percentages for which are shown in Table 8.

The list of topics and data for questions 27 on how capable the trainees feel in applying specific knowledge from the course are summarized in Table 9.

Table 8: Response rate for question regarding "what will help respondent apply what they learned from the class" (question 28, control group).

KEYWORD	PERCENTAGE
Safety/Awareness	38.74%
Experience	12.04%
Practice	10.99%
Application	10.47%
Opportunity	8.38%
Attitude	6.28%
Refreshers	4.71%
Reviews	3.66%
Planning	2.62%
Support	2.09%

The majority (39%) thought that better safety/awareness standards in mines are key, in order to correctly apply the concepts learned on the job. This was followed by gaining more experience on the job, practicing the skills learned during training, and applying the concepts taught. On the other end of the scale, support from management was cited the least number of times as a factor that would help them successfully apply their new skills on the job.

S.No	Topic	Blanks	Responses	Y	N	Y			
						100	75	50	25
i	Health and safety standards	17.5%	82.5%	99.2%	0.8%	66.8%	29.1%	3.6%	0.6%
ii	Transportation controls and safety standards	17.7%	82.3%	97.0%	3.0%	67.9%	26.7%	4.5%	0.9%
iii	Escape and emergency evacuation plans; firewarning and firefighting	18.4%	81.6%	95.9%	4.1%	66.5%	24.1%	6.3%	3.1%
iv	Ground control; working in areas of highwalls, water hazards, pits, and spoil banks; illumination and night work	17.7%	82.3%	91.9%	8.1%	67.9%	22.0%	7.2%	3.0%
v	First aid	17.31%	82.69%	97.89%	2.11%	63.72%	24.7%	9.5%	2.1%
vi	Electrical hazards	17.8%	82.2%	94.7%	5.3%	68.3%	20.8%	7.7%	3.2%
vii	Prevention of accidents	17.7%	82.3%	99.4%	0.6%	73.9%	21.0%	4.0%	1.2%
viii	Health	17.7%	82.3%	97.0%	3.0%	74.1%	20.0%	5.0%	0.9%
ix	Explosives	18.9%	81.1%	79.1%	20.9%	63.7%	20.7%	11.3%	4.3%
x	Hearing protection	17.7%	82.3%	98.5%	1.5%	78.8%	17.0%	3.3%	0.9%
xi	Self-rescue and respiratory devices	18.7%	81.3%	91.4%	8.6%	68.4%	23.5%	6.5%	1.7%
	Averages	**17.9%**	**82.1%**	**94.7%**	**5.3%**	**69.1%**	**22.7%**	**6.3%**	**2.0%**

Table 9: Summary of responses for questions 27 regarding how confident the respondents are in applying the topics

For question 29, the respondents were asked to list factors that would prevent them from applying the concepts taught in the course. There were far fewer responses to this question compared to any other question in the survey. A total of 92 responses were collected out of a possible 572, which is a response rate of 16%. The same methodology was followed for the text analysis. The responses were collected and analyzed based on keyword selection (Table 10).

Table 10: Response rate for question "what will prevent you from using what you learned in the course?" (question 29, control group)

KEYWORD	PERCENTAGE
Complacency	39.13%
Lack of practice	19.57%
Lack of Safety	14.13%
Nothing	8.70%
Management	7.61%
Bad Attitude	5.43%
Lack of experience	3.26%
Lack of equipment	1.09%
Lack of refreshers	1.09%

Nearly 40% of the respondents felt that complacency on the job was the major obstacle that would prevent them from successfully applying the skills learned during the training. This was followed by lack of practice and lack of safety on the job. Only one respondent noted that a lack of a refresher course would prevent them from using what was learned in the course.

Specific Aim #4 – Andragogy in Process Inventory Instrument.

In this section we will discuss the control and treatment group results using the Andragogy in Process Inventory (API) developed by researchers at Louisiana State University.

We pilot tested the API with the control group and received 62 surveys from this group and describe those results in this section.

After training the trainers described in Table 4 in under Aim 2 we requested that trainers revise their training approach to use the principles of adult learning and use the API survey at the end of their training course. A total of 295 surveys were returned using the API instrument from the companies shown in Table 11. Annual refresher training accounted for 68% of the responses and new miner accounted for 23%; other training accounted for 9%. Of the new miner training, 20% was for underground metal/nonmetal. We received surveys from surface and underground coal, sand and gravel, and metal/nonmetal. We analyzed data by training type but not commodity type.

Table 11: T reatment group survey collection using the API survey. AR is annual refresher, NM is new miner, other training includes mine gasses, first aid, and fire boss training.

Company	Location	Mining Sector	Training	Surveys Collected
Vulcan Materials	Burbank, CA	Construction Materials	AR	12
Luminant	Dallas, TX	Coal Surface	AR	51
McCraren Compliance	Tucson, AZ	Surface	AR and NM (9) surface, m/nm, other (25)	141
UA San Xavier Mine	Sahuarita, AZ	Underground Metal/nonmetal	NM	59
BHP Billiton	Farmington, NM	Coal Underground	AR	32
				295 Surveys Collected

A significant finding was that both trainers and trainees were resistant to completing any surveys at the end of the training – simple or complex surveys. The API survey is long and some questions were difficult for miners to understand. We tried a shortened version of the API with a small population (n=12) but ultimately decided to stay with the full version. The API surveys were analyzed by Dr. Reid Bates at Louisiana State University.

API Results for Control Group

The data originally contained responses from 62 participants. After careful examination of the data it was necessary to remove 8 participants from the data base. Seven of these deletions were done because the responses from these participants showed zero variance (i.e., the same rating was applied to every survey items) and one was deleted because over 80% of the survey items showed no response (the data were missing). In total, this amounted to about 13% of the data. A summary of the remaining data is presented below.

The descriptive statistics for the respondents who provided this data indicate that all participated in the annual refresher MSHA training; the large majority were male (87% versus 13% female) and were evenly divided between those 45 years of age or less (51%) and those older than 45 (49%). Slightly more than 82% of the respondents had participated in at least 4 safety training courses in the 12 months preceding the current training. Forty percent reported they were mandated to attend this MSHA training by their employer and about 47% attended for the purpose of upgrading or gaining new skills.

Table 12 shows the descending mean scores for the eight API scales and the Motivation to Improve Safety Through Learning (MTISL) scale. The MTISL scale emerged with the highest mean (5.26) suggesting that training participants were motivated to use learning to improve safety behavior at work. Although this factor could be stronger the result is encouraging.

Some general explanations and cautions about interpreting the API results follow. Evaluation is a design element scale that, as defined in Table 3, refers to the extent to which the evaluation methods used in the learning experience were appropriate and met the learner's needs. It is one of the constructs that adult learning theory suggests is important in adult learning contexts and which we have operationalized as a scale here.

Beta coefficients are standardizations of the regression coefficients: that is, they convert the regression coefficients to a mean of 0 and a standard deviation of 1.0. They therefore eliminate the problem of dealing with different units of measurement (they allow direct comparisons) and reflect the relative impact on the dependent variable of a change in one standard deviation in either variable while holding all other variables constant. The common unit of measurement allows us to determine which variable has the most impact. In the present case, the beta values allow us to interpret the impact of evaluation, for example, in relation to the other variables. It does not allow us to determine the

importance of evaluation or learning activities, in any absolute sense. So all we can say is that evaluation is most important and learning activities is least important, the other factors fall somewhere in between but, since they were not statistically significant, there is not much that can be said about them. If the beta coefficient is not statistically significant, no statistical significance can be interpreted from that predictor. The best we would be willing to say is more research is needed to obtain a more accurate picture of the role of these factors. More generally, and as noted earlier, the beta value is a measure of how strongly each predictor variable influences the criterion (dependent) variable. Since the beta is measured in units of standard deviation if the beta coefficient is .74 and is statistically significant, then for each unit increase in the predictor variable (evaluation), the outcome variable (MTSIL) will increase by .74 units. Thus, the higher the beta value the greater the impact of the predictor variable on the criterion variable.

The API design scales can be grouped into 2 general categories: those equal to or greater than 4.72 suggesting generally positive design elements in the training. These include four scales: Climate Setting, Design of Learning Activities, Preparing the Learner, and Evaluation. These scores indicated participants perceived the training to provide a supportive climate for training, included some activities that encouraged trainees to be active (as opposed to passive) learners in the training program, provided moderate preparation for the learning event, and used evaluation methods that were seen as meaningful and valid to a certain degree. The second general category, with mean scores between 4.10 and 4.27, include Diagnosis of Learning Needs, Mutual Planning, Setting Learning Objectives, and Design of the Learning Experience. In general, mean scores at this level on a six-point scale are positive. This suggests these other dimensions of adult-oriented learning including the collaborative diagnosis of learning needs assessment, collaborative planning for learning, the design of learning activities oriented around sound readiness for learning and using learning contracts and projects to foster more effective learning and learning transfer were less in evidence. These data combined with the MTISL results suggested that an improvement in motivation to improve safety through learning could be realized if some of these andragogical design elements could find greater expression in the training.

Table 12: Descriptive Statistics for API survey of control group

	N	Alpha	Minimum	Maximum	Mean	Std. Deviation	Variance
MTISL	52	.95	3.94	6.00	5.2590	.57709	.333
Climate Setting	54	.86	3.17	6.00	4.8951	.73637	.542
Design of Learning Activities	51	.85	3.00	6.00	4.7712	.79858	.638
Prepare the Learner	54	.81	3.40	6.00	4.7481	.73118	.535
Evaluation	50	.82	3.00	6.00	4.7200	.82578	.682
Diagnosis of Learning Needs	53	.89	1.50	6.00	4.2689	1.02710	1.055
Mutual Planning	54	.91	1.25	6.00	4.2407	1.20823	1.460
Setting of Objectives	53	.95	1.80	6.00	4.2038	1.16123	1.348
Design of the Learning Experience	52	.95	1.25	6.00	4.1010	1.20585	1.454
Valid N (listwise)	49						

Although it could be argued that the restricted sample size is only marginally appropriate for subjecting the data to a hierarchical regression equation, such a test does provide some insight into the factors that explain the greatest variance in MTISL. The results of a hierarchical regression are presented in Table 13. The API variables were entered into the regression equation based on the order in which they would be encountered in the training process. Thus climate setting and preparing the learner were entered first; diagnosis of learning needs, and mutual planning second; setting objectives, learning activities and design of the learning experience third; and evaluation last. Entry of the variables in this order allows a partitioning of variance so that the amount of variance in MTISL explained by each set of factors can be examined in isolation and the amount explained by all factors together can be assessed. Results indicate that the first set of variables (climate setting and preparing the learner) explained 27.4% of the variance in MTISL, significant at the alpha error level of .001. The next two sets of factors added marginally (5.2%) to the explained variance. The final variable, evaluation, increased the explained variance by 15% a significant increase ($p < .002$). In total all the variables together explained nearly 48% of the variance in MTISL, a significant figure ($p < .001$).

In the full model with all variables entered the evaluation scale was the only one to emerge with a significant Beta value ($\beta = .74$, $p < .002$) (Beta values for the API variables included in the full regression model are displayed in Table 14). The Beta value is a measure of how strongly each predictor variable in the regression equation influences the criterion (in this case MTISL). The positive Beta for evaluation suggests the stronger the perceived evaluation component in this training the stronger the motivation to improve safety through learning for these trainees. In short, evaluation emerged as the single most important predictor in this sample. Again, however, the small sample analyzed here strongly indicates these results should only be considered preliminary. A correlation table with all the variables is provided in Table 14.

Table 13: Regression Model Summary for Control Group

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.523[a]	.274	.242	.500	.274	8.487	2	45	.001
2	.561[b]	.314	.250	.497	.040	1.265	2	43	.293
3	.571[c]	.326	.208	.511	.012	.235	3	40	.872
4	.691[d]	.477	.370	.456	.151	11.286	1	39	.002

a. Predictors: (Constant), Climate Setting, Prepare the Learner

b. Predictors: (Constant), Climate Setting, Prepare the Learner, Diagnose Learning Needs, Mutual Planning c. Predictors: (Constant), Climate Setting, Prepare the Learner, Diagnose Learning Needs, Mutual Planning, Setting of Objectives, Learning Activities, Design of the Learning Experience

d. Predictors: (Constant), Climate Setting, Prepare the Learner, Diagnose Learning Needs, Mutual Planning, Setting of Objectives, Learning Activities, Design of the Learning Experience, Evaluation

Dependent Variable: Motivation To Improve Safety Through Learning

Table 14: Correlation Table for Control Group

	MTISL	PL	CS	MP	DLN	SO	DLE	LA	Eval	#	Age
Motivation to Improve Safety Through Learning (MTISL)	--										
Prepare the Learner (PL)	.46*	*.27*									
Climate Setting (CS)	.54*	.87*	*.39*								
Mutual Planning (MP)	.30*	.72*	.70*	*-.48*							
Diagnose Learning Needs (DLN)	.33*	.72*	.71*	.87*	*-.30*						
Setting Objectives (SO)	.25	.61*	.59*	.81*	.87*	*.40*					
Design of the Learning Experience (DLE)	.01	.66*	.56*	.79*	.83*	.94*	*-.38*				
Learning Activities (LA)	.46*	.70*	.74*	.64*	.75*	.65*	.65*	*-.18*			
Evaluation (Eval)	.55*	.67*	.70*	.71*	.77*	.62*	.60*	.88*	*.74**		
# of Safety Training/last 12 months (#)	.17	-.11	-.03	-.27*	-.25	-.37*	-.41*	-.06	-.17	--	
Age	-.16	-.43*	-.23	-.33*	-.30*	-.36*	-.38*	-.30*	-.28	.11	--

*p < .05

Beta values for the API variables included the full regression model are shown in italics on the diagonal

API Results for Treatment Group

The data from the treatment group originally contained responses from 295 participants. After careful examination the data it was necessary to remove 14 participants from the data base. Each of these deletions was done because the responses from these participants showed zero variance (i.e., the same rating was applied to every survey item). In total, this amounted to about 5% of the data and yielded a sample size for this analysis of 281.

The type of training received by the treatment group and the commodity sector are shown in Table 11. The respondents who provided the data for this project were asked on the API survey to indicate in writing the title of the training program in which they were participating. Of the 281 respondents 42 (14.9%) did not provide an answer to this question. The remaining responses indicated 39 respondents (13.9%) participated in the new miner 40 hour training, 174 (61.9%) in the MSHA refresher training, and 26 (.09%) in a variety of other training programs including awareness, fire boss, first aid, geophysical logging engineer, mine gases, and move smart. The large majority were male (85% versus 15% female). The sample was fairly evenly divided between those 45 years of age or less (60.6.2%) and those older than 45 (37%). Nearly 82% of the respondents had participated in at least 4 safety training courses in the 12 months preceding the current training. Forty-two percent reported they were mandated to attend the training by their employer and about a similar percentage attended for the purpose of upgrading or gaining new skills.

Table 15: Descriptive Statistics- Treatment Group All Training

	N	Alpha	Mean	Std. Deviation	Variance
MTSIL	265	.97	5.14	.85	.73
Climate Setting	267	.89	4.65	1.04	1.08
Prepare the Learner	265	.86	4.42	1.09	1.19
Evaluation	265	.84	4.31	1.20	1.43
Learning Activities	266	.57	4.10	.90	.81
Mutual Planning	265	.90	3.97	1.37	1.88
Diagnosis of Learning Needs	258	.92	3.94	1.39	1.93
Set Learning Objectives	266	.95	3.88	1.44	2.07
Design of the Learning Experience	264	.92	3.84	1.41	1.99

Table 15 shows the descending mean scores for all respondents in all training programs for the treatment group for the eight API scales and the Motivation to Improve Safety Through Learning (MTISL) scale. Tables 16, 17, and 18 break down the results across the types of training program being assessed. This includes 39 respondents in the New Miner 40-hour training, 174 in the MSHA refresher training, and 26 in a variety of 'other' training programs. Looking at the descriptive statistics for each of these categories of training program reveals a similar pattern of results.

In general, a relatively consistent pattern reflected in a three-tiered pattern of results can be seen in the full data set as well as in the data sets for each category of training (although with some variation in the relative level of the ratings across training categories). The data reveal a first tier of relatively high mean scores for motivation to improve safety through learning and for climate setting. This indicates the training environment (i.e., climate), often established through the trainers' interaction with trainees, was perceived as respectful and supportive. The MTISL mean score indicates that training participants were energized and motivated to use learning to improve safe work behavior.

At the second tier, evaluation and preparing the learner formed a consistent mid group of factors. These findings indicate the evaluation procedures used during training were perceived as appropriate given the learning experience and the content of training. It further suggests that activities took place prior to or during the training program (e.g., provision of advance information about the program) that help to clarify training goals and prepared learners for the program.

The third tier of factors, those with the lowest mean scores, include mutual planning, diagnosis of learning needs, setting learning objectives, design of the learning

experience, and learning activities. Three of these factors (mutual planning, setting learning objectives, and design of the learning experience) indicate a relatively inconsistent collaborative component in the training programs. That is, it suggests the learning objectives, learning activities, and the learning experience as a whole were developed with only moderate input from or collaboration with the trainees. It further indicates only mild agreement among trainees that assistance and opportunities for the diagnosis of trainees' learning needs vis-à-vis safety were provided. Finally, the mean for learning activities suggests limitations on the extent to which the training included active learning methods which engage adult learners. Put differently, it suggests there is still too much reliance on 'passive' (e.g., lecture) instructional methods.

Table 16: Descriptive Statistics for the New Miner 40-hour Training

	N	Mean	Std. Deviation	Variance
Climate Setting	32	5.17	.58	.34
MTISL	32	5.14	.76	.57
Evaluation	31	4.66	.99	.99
Prepare the Learner	32	4.65	.98	.97
Learning Activities	31	4.21	.65	.43
Diagnosis of Learning Needs	32	4.20	1.18	1.40
Mutual Planning	31	4.10	1.31	1.72
Set Learning Objectives	31	4.03	1.22	1.49
Design of the Learning Experience	31	4.02	1.12	1.25
Valid N (listwise)	27			

Table 17: Descriptive Statistics for the MSHA Refresher Training

	N	Mean	Std. Deviation	Variance
MTISL	175	5.10	.86	.74
Climate Setting	171	4.50	1.10	1.20
Prepare the Learner	170	4.35	1.15	1.31
Evaluation	171	4.15	1.27	1.61
Learning Activities	173	3.80	.73	.53
Mutual Planning	169	3.77	1.45	2.10
Diagnosis of Learning Needs	162	3.74	1.47	2.17
Set Learning Objectives	173	3.66	1.55	2.39
Design of the Learning Experience	170	3.66	1.51	2.27
Valid N (listwise)	148			

Table 18: Descriptive Statistics for the Other Training

	N	Mean	Std. Deviation	Variance
MTISL	24	5.33	.88	.78
Climate Setting	25	4.92	.89	.80
Prepare the Learner	25	4.71	.81	.66
Evaluation	25	4.71	.85	.73
Set Learning Objectives	23	4.63	.93	.86
Mutual Planning	25	4.44	1.04	1.09
Design of the Learning Experience	25	4.39	1.08	1.16
Diagnosis of Learning Needs	24	4.36	1.17	1.38
Learning Activities	24	3.93	.80	.64
Valid N (listwise)	21			

Alternative Survey

In October 2014 we communicated to Dr. Bates that there was resistance by miners to fill out the long API survey and the questions were difficult to understand. We requested a shortened survey. In order to accommodate this request and still collect comparable data, Dr. Bates created a shorter instrument that contained six scales. Three API scales were selected including diagnosis of learning needs, learning activities, and evaluation as these covered the breadth of the training process from beginning (assessment of needs) to end (evaluation) and were consistent with the data collected with the longer, original survey. Two new scales were selected for their capacity to provide information about the utility and transferability of the training. These scales assessed the job relevance of the

training and the extent to which the delivery of training facilitated its application on job (i.e. transfer). A sixth scale was included in this survey, safety self-efficacy, which provides a measure of an individual's confidence in managing and solving safety-related problems. The scales contained in this alternative survey are shown with their definitions in Table 19.

Table 19: Scales and Scale Definitions for the Alternative Survey

Scale	Definition
Diagnosis of Learning Needs	The degree to which the learner perceived the learning experience provided assistance or opportunities for the learner to diagnose her/his developmental needs.
Learning Activities	The degree to which the learning experience utilized a variety of active learning methods that encouraged learners to engage the task domain and to discover task solutions on their own.
Evaluation	The extent to which the evaluation methods used in the learning experience were appropriate and met the learner's needs.
Content Validity	The extent to which the trainees judge the training content to accurately reflect job requirements.
Transfer Design	The extent to which training has been designed to give trainees the ability to transfer learning to job application.
Safety Self Efficacy	The extent to which individuals feel confident and self-assured in their ability to solve safety-related problems and deal with unexpected safety events.

Alternative Survey Results

The respondents who provided the data for this alternative survey all participated in the one-day MSHA refresher training (n = 12). The large majority were male (91.7%, n = 11). Most of the respondents (67%) were 45 years or younger and 67% of the respondents had participated in at least 3 safety training courses in the 12 months preceding the current training. Thirty-three percent reported they were mandated to attend the training by their employer and 67% attended for the purpose of upgrading or gaining new skills.

Table 20: Descriptive Statistics for the Alternative Survey

	N	Alpha	Mean	Std. Deviation	Variance
Evaluation	11	.78	4.66	1.04	1.09
Content Validity	12	.51	4.63	1.40	1.96
Transfer Design	12	.80	4.50	1.24	1.53
Learning Activities	12	.71	4.46	.82	.67
Safety Self Efficacy*	12	.85	4.40	.58	.34
Diagnosis of Learning Needs	12	.90	3.94	1.45	2.09
Valid N (listwise)	11				

**Safety self-efficacy assessed using a 5-point scale. All other factors used a 6-point scale.*

Table 20 shows the descending mean scores for the scales in the alternative survey. It is important to note that the safety self-efficacy scale was assessed using a 5-point Likert-type scale while the other variables were assessed using a 6-point Likert-type scale. Thus the 4.40 mean for safety self-efficacy suggests training participants were clearly confident in their ability to manage and resolve safety-related issues.

The mean scores for the remaining scales suggest, first, that the presence of meaningful evaluation and active learning methods were moderately present. An even more moderate presence is seen for activities that encourage and help trainees diagnose their own learning needs. The data also suggest training that is perceived as moderately relevant to the trainees' jobs (content validity). Finally, the mean for transfer design suggests the manner in which the training was delivered only moderately supported the transfer of that learning to the workplace.

Supplemental Analysis for Treatment Group

A hierarchical regression analysis was applied to the data from the API survey to provide some insight into the factors that explain the greatest variance in MTISL. The results of a hierarchical regression are presented in Table 21. The API variables were entered into the regression equation based on the order in which they would be encountered in the training process. Thus climate setting and preparing the learner were entered first; diagnosis of learning needs, and mutual planning second; setting objectives, learning activities and design of the learning experience third; and evaluation last. Entry of the variables in this order allows a partitioning of variance so that the amount of variance in MTISL explained by each set of factors can be examined in isolation and the amount explained by all factors together can be assessed. Results indicate that the first set of variables (climate setting and preparing the learner) explained 32% of the variance in MTISL, significant at the alpha error level of .001. The next three sets of factors added marginally (.04%) to the explained variance. In total, all the variables together explained nearly approximately 35% of the variance in MTISL, a significant figure ($p < .001$).

In the full model with all variables entered three factors emerged with significant Beta values: climate setting ($\beta = .33$, $p < .05$) and mutual planning ($\beta = -.16$, $p < .05$) evaluation scale was the only one to emerge with a significant Beta value ($\beta = .74$, $p < .002$) (Beta values for the API variables included in the full regression model are displayed in Table 19). The beta value is a measure of how strongly each predictor variable in the regression equation influences the criterion (in this case MTISL). The positive Beta value for climate setting indicates that when employees perceive a positive, supportive relationship with the instructor/trainer their motivation to apply safety training at work increases. On the other hand, the negative Beta value for mutual planning suggests limiting employee participation in planning safety training will enhance motivation to improve safety through learning. This runs counter to the expectation that adult learners prefer to be engaged in planning their learning experiences. These data suggest this may not be the case for mine safety training. Perhaps due to the nature of the mining environment and attendant safety protocols, employees may not feel qualified to contribute in a meaningful way to the planning and design of safety training.

A correlation table with all the variables is provided in Table 22.

Table 21: Regression Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.58[a]	.33	.32	.72	.33	53.78	2	218	.00
2	.60[b]	.36	.35	.71	.03	3.51	3	215	.02
3	.62[c]	.37	.35	.71	.01	1.58	2	213	.21
4	.62[d]	.37	.35	.71	.00	.51	1	212	.48

a. Predictors: (Constant), Climate Setting, Prepare the Learner

b. Predictors: (Constant), Climate Setting, Prepare the Learner, Diagnose Learning Needs, Mutual Planning, Setting Objectives

c. Predictors: (Constant), Climate Setting, Prepare the Learner, Diagnose Learning Needs, Mutual Planning, Setting Objectives, Learning Activities, Design of the Learning Experience

d. Predictors: (Constant), Climate Setting, Prepare the Learner, Diagnose Learning Needs, Mutual Planning, Setting Objectives, Learning Activities, Design of the Learning Experience, Evaluation

Table 22: Correlation table.

	MTISL	PL	CS	MP	DLN	SO	DLE	LA	Eval	#	Age
Motivation to Improve Safety Through Learning (MTISL)	--										
Prepare the Learner (PL)	.53*	*.09*									
Climate Setting (CS)	.55*	.85*	*.33**								
Mutual Planning (MP)	.34*	.73*	.74*	*-.16**							
Diagnose Learning Needs (DLN)	.37*	.71*	.72*	.82*	*.09*						
Setting Objectives (SO)	.39*	.67*	.71*	.84*	.90*	*.09*					
Design of the Learning Experience (DLE)	.40*	.70*	.69*	.79*	.88*	.89*	*.09*				
Learning Activities (LA)	.50*	.63*	.67*	.51*	.59*	.58*	.66*	*.08*			
Evaluation (Eval)	.49*	.73*	.77*	.67*	.77*	.75*	.78*	.69*	*.08*		
# of Safety Training/last 12 months (#)	.05	.00	-.08	.05	.01	.07	.05	-.11	-.01	--	
Age	-.06	-.11	-.12	-.13*	-.22*	-.21*	-.16*	-.06	-.20*	.11	--

*p < .05

Beta values for the API variables included the full regression model are shown in italics on the diagonal

6.0 Dissemination Efforts and Highlights

We have implemented and will continue to implement the following dissemination activities from this project:

Specific Aim #1 – Re-design training with active learning to be used in mandated safety courses – We are distributing the "Mine Safety Training Handbook: Active Training for Mine Safety Trainers" to trainers who complete the Effective Mine Safety Training course. Additional copies are available on our website as a pdf file. Each exercise includes the appropriate 30 CFR Parts 46 and 48 training topics, purpose, objective, time, trainer activities, learner activities, techniques or equipment needed, the process, group success/assessment, accountability, debrief and summary. Additionally, each activity includes a personal review by a trainer who has implemented the activity. We will continue to work with MSHA trainers to incorporate the handbook and active learning into their train-the-trainer courses.

We have distributed 175 hardcopies of the book to trainers during this contract. The handbook was made available at on-site training courses, through trainers, at multiple mining industry conferences that were attended by our research group, and through a MSHA train-the-trainer course.

Specific Aim #2 - Train the trainers to use active learning – We created the "Effective Mine Safety Training" course. Trainers can receive this training by signing up on a website that is being established.

Specific Aim #3 – Implement and evaluate re-designed mandated courses.
We created a facilitator and student version of our "New Miner and Annual Refresher Training Handbook". This handbook contains the content for new miner and annual refresher training for surface and underground miners in coal, metal/nonmetal, and construction materials. The handbook contains relevant powerpoint slides, background information, activities, recommendation for using adult learning methods, and pre- and post-quizzes. These materials are distributed through the MSHA blue-card training we provide as well as a High-Level Training clinic we offer.

Specific Aim #4 – Adult learning (andragogical) instrument– Will publish our results and experience with the API.

7.0 Conclusions and Impact Assessment

For the past five years, the UA team has worked closely with mine operators and mine trainers throughout the U.S. to improve mine safety and health training. When discussing the use of adult learning principles or active learning methodologies in our previous course "Teaching Strategies for Mine Safety Trainers", funded by NIOSH, mine

trainers consistently noted barriers to implementation, such as:

- Lack of training/class time
- Lack of time to revise training materials
- Lack of money to hire consultants or buy curriculum
- Large class sizes
- Hesitance to remove lecture slides/content

Moreover, several trainers noted that active learning took up "valuable" lecture time/content/slides and that if you weren't lecturing; you were being "lazy" or "slacking".

Based on this experience, we designed a project that would attempt to overcome these barriers and will be a substantial benefit to the mining and research communities.

- We created a handbook for active learning in mine safety training and distributed 175 copies to trainers. The handbook has received universal praise from trainers.
- We designed and conducted a four-hour train-the-trainer course to help trainers understand active learning and how to use it in their courses. We delivered the full course to 85 trainers from 11 organizations at 10 sites. We delivered training to surface and underground coal sites and surface and underground metal/nonmetal mines as well as contractors. The training courses received high praise from trainers.
- We reached 868 mine workers with either control or treatment group training.
- We re-designed the new underground miner and annual refresher courses for metal/nonmetal and coal. The courses contain all the content, suggested active learning methods, and assessments needed for the trainer and trainee. Trainers can modify this material rather than re-writing their courses. The material incorporates a pre- and pos- test that trainers can use to diagnose the level of understanding prior to training and after.
- We used the API survey for the first time in mine safety training. This is a powerful tool to assess the degree to which active learning methods are used in safety training. While the survey is hard to fill out it demonstrates important changes that can be made to improve the efficacy of safety training.

Specific Aim #1 Re-design mandated training courses

The Mine Safety Training Handbook: Active Training for Mine Safety Training has clear directions for implementing a revised MSHA training course to include adult learning methods. Each activity identifies where it fits best in the training course, what type of course, and how long it takes. The cost of reproducing the handbook is approximately $50 per book.

Revising entire training courses can be daunting for busy trainers. To facilitate the use of

more adult learning in training we have written new miner and annual refresher courses as a guide to show trainers explicitly how they can use adult learning within their approved training plans. The Annual Refresher and New Miner Training Guide comes with a facilitator and student version. Trainers can use the guide as a template or use any of the materials they want.

Specific Aim #2 Train-the-Trainers

The Effective Mine Safety Training Course was very well received by the 85 trainers who took the course during this project. Because of the positive results, we are now providing training to MSHA "blue card" trainees using our active learning handbook, course curriculum and teaching methods. With support from NIOSH we teach an advanced course called the High-Level Training Clinic which takes three days and includes the Effective Training for Mine Safety course along with other adult learning content. Trainers have time in the course to practice revising their courses. The clinic courses are available for registration via a website. We offer clinic courses every month and have six courses filled.

Specific Aim #3 Implement and evaluate re-designed mandated training courses

The control group was all annual refresher trainees and largely contractors. More than 80% had been through substantial training in the previous year. We do not believe the inclusion of contractors biased the results because the goal was to modify training to include adult learning methods and to use the API to measure the extent to which adult learning methods were present in the training. Contractors are required to take the same training as workers directly employed by the mining companies. There could be a bias between annual refresher and new miner trainees. There may be a possibility that respondents over report socially desirable characteristics, i.e. they may feel they need to report positively about required safety training.

Based on the in-house survey of the control group:

- The trainees were satisfied with the topics covered in the course and were confident in their ability to apply knowledge to their jobsite yet some questions related to transfer of knowledge received low scores
- The design of the learning experience was not challenging and exercises were only moderately meaningful
- There were few elements of active learning
- There was no goal setting by the trainees

The API MTISL analysis indicated that the most important factor in motivating learning to improve safety was evaluation within the course – in other words trainees wanted to demonstrate the ability to use a safety practice and get feedback. We conclude that there was, in fact, minimal use of adult learning strategies in the control group training and in particular the use of goal setting and involvement of the trainees in the design of the

experience was lacking.

Specific Aim #4 Adragogical in Process Inventory

Data were collected to characterize the extent to which mine safety training programs were consistent with adult learning theory and the adult learning practices that are seen as fostering the adult learning. The courses were taught by trainers who had received instruction in how to use adult learning methods in our four-hour course and who then revised at least portions of their courses.

In general, the data from the API paint the following picture of mine safety training as it relates to adult learning:

- Trainees are well-motivated to use learning to improve safety and confident in their ability to manage and resolve safety-related issues.
- Training takes place in a supportive, respectful climate.
- Trainees perceived they had a somewhat limited influence on the planning of safety training, the learning objectives addressed by training, or the design of the learning activities.
- Modest efforts are undertaken as a part of the safety training to diagnose or help trainees diagnose their learning needs vis-à-vis safety.
- Active learning techniques are moderately present in the training with perhaps a larger focus on the use of lecture.
- The evaluation activities used in training are perceived as useful and appropriate by trainees.

These findings suggest that improvements in safety training could continue to be made that would improve its alignment with adult learning theory and practice. The nature of the approved MSHA training plan and difficulty in understanding the degree of flexibility allowed in changing training methods and still complying with the approved plan complicates the ability to move to a training approach that more fully involves the trainees in design of training.

We believe some steps can be taken to improve training and still comply with approved training plans. For example, steps could be taken to:

Diagnose the safety-related learning needs of trainees prior to training. Up- front needs analysis could improve the efficiency of training by identifying high priority learning needs on which learning could be focused. It would also enhance trainee's perception of job relevance and utility of the training. This is particularly relevant to annual refresher training.

Enhance the interactive nature of the assessment, planning, and design phases of

training. For adults, the best learning is that which occurs interactively. Adults prefer to be engaged in and collaborative partners in the learning process. This is perhaps even truer when the learning addresses a topic such as safety that is an inherently applied topic and one that is quite important in the mining workplace. In the context of safety training, this could mean the introduction of strategies for engaging trainees in assessing their learning needs, setting learning objectives, and planning for and assisting in the design of training.

Increase the active learning strategies in the training. There is ample evidence in the training literature that active training is superior to passive training (e.g., lecture or video presentations). There is also evidence that as workplace training methods become more engaging (i.e., requiring trainees' active participation), employees learn more and negative outcomes such as safety-related accidents are decreased (Burke et al., 2006). There are a wide range of active learning strategies to foster trainee engagement. For example, some of the most engaging safety training programs emphasize behavioral modeling which involves behavioral simulations in which trainees observe a model's behavior (demonstration), reflect on and practice the behaviors that were observed, and feedback is provided to the trainee to help him/her further refine the target behaviors.

We had difficulties with using a survey-based approach to evaluate training changes, particularly the use of the API survey. This has raised the question whether the mining community is substantially different in training approach and needs to other groups who have successfully used the API.

Based on research at LSU (Bates, personal communication), adult learners like to have input into the planning of their learning experiences. On the other hand, we also know that adults who may not have a lot of expertise in an area may prefer to have less engagement and more leadership. Take, for example, adults returning for graduate degrees: they typically don't prefer a lot of engagement in planning instruction in a course. They prefer leaving it up to the professor (the expert). It is possible if the trainees are new miners, for example, who know little about safety this might well be their attitude.

On the other hand, the LSU experience (Bates, personal communication) with industrial training suggests that it is often viewed with some disdain ("We have to go to another one of these safety training programs. They are mostly a waste of my time"). To the extent this attitude may be prevalent in mine safety training, particularly among more veteran workers in this setting perhaps the trainees don't want to be engaged in planning learning because they see it as a waste of their time – or think it won't make any difference in the final product – or just want to get it over with.

8.0 Recommendations for Future Work

Our future work includes the following recommendations and action items:

1. Trainers often need more extensive training in how to use adult learning strategies effectively in their mandated courses. We are implementing the following action items to address this:
    a. We are using adult learning strategies in training MSHA "blue card" trainees. These are safety professionals taking the course to obtain their training authorization to teach MSHA safety courses.
    b. We offer an advanced training program called the High-Level Training Clinic which covers the theory of adult learning and then puts the theory into practice during a three-day course.

2. Evaluating training effectiveness with surveys does not seem to work in mine safety training. We will be examine the use of pre- and post-testing as an alternative to surveys as well as incorporating survey questions into the training in small parts.

3. The Andragogy in Practice Inventory (API) and its Motivation to Improve Safety Through Learning (MTISL) component are powerful assessments for training. Investigation of modifications to the API or alternative methods of assessment should be explored.

4. Trainees need to be more explicitly engaged in assessing their learning needs, setting goals, and planning and assisting in the design of their training. This approach will require modification even to our approach to training.

9.0 References

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10.0 Appendices

Appendix A - Mine Safety Training Handbook: Active Training Tools for Mine Safety Training: http://miningsh.arizona.edu/train-the-trainer

Appendix B – New Miner and Annual Refresher Training Handbook – Facilitator Guide: http://miningsh.arizona.edu/train-the-trainer

Appendix C - New Miner and Annual Refresher Training Handbook – Student Guide: see website
http://miningsh.arizona.edu/train-the-trainer

Appendix D – Control group survey – attached to this document

Appendix E – API survey – attached to this document

Annual MSHA Refresher Course Completion Survey

Course Date:	7/24/14
Course Name:	MSHA 48
Instructor Name:	Derek Lisec
Course location:	McCraren Compliance

For each survey item below, use the rating scale to the right and circle the number that matches your judgment.

	Survey Item	Scale 1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree				
1	Registering for the course was easy	1	2	3	(4)	5
2	Communications (phone calls, emails, etc.) about the course were clear and direct	1	2	3	(4)	5
3	Course schedule was well planned (restroom breaks, lunch, etc.)	1	2	3	(4)	5
4	Training room was good for learning	1	2	3	(4)	5
5	Environmental conditions – comfort, heating, noise, visibility – were good for learning	1	2	3	(4)	5
6	There was enough space for class activities	1	2	(3)	4	5
7	Food was good (variety, type, etc)	1	(2)	3	4	5
8	I would recommend we use this space for future trainings	1	2	3	(4)	5
9	Topics covered met the purpose of the course	1	2	3	(4)	5
10	Materials (handouts, powerpoints, students guides, etc) worked for the purpose of the course	1	2	3	(4)	5
11	Course exercises/activities were meaningful to the purpose of the course	1	2	3	(4)	5
12	Group discussions were helpful	1	2	3	(4)	5
13	The topics were easy to understand	1	2	3	(4)	5
14	Technology (Internet, projectors, clickers etc.) was used effectively in the course	1	2	3	(4)	5
15	Instructor(s) were easy to understand	1	2	3	4	(5)
16	Instructors were well-prepared	1	2	3	4	(5)
17	Length of the program was appropriate for the purpose of the course	1	2	3	(4)	5
18	There was enough time to practice what I learned in the course	1	2	3	(4)	5
19	Training topics were meaningful/important for my job	1	2	3	(4)	5
20	My company will support me in using what I learned in this course	1	2	3	(4)	5
21	I was challenged in this course	1	(2)	3	4	5

22	Overall environment was good for learning	1	2	(3)	4	5
23	There was enough time to complete the course	1	2	3	(4)	5
24	The training met my needs	1	2	3	(4)	5
25	I would recommend this training program to other people	1	2	3	(4)	5
26	I set written goals for using what I learned in this course on the job: Yes / (No) If yes, how confidant are you in your ability to meet your goals (on a scale of 0-100%)? 100%					

27	For the following topics, please mark yes or no if you will be capable of applying....	**Yes**	**No**	**If yes, confidence in doing so: 0%, 25%, 50%, 75% or 100%**
	Health and safety standards	100		
	Transportation controls and safety standards	75		
	Escape and emergency evacuation plans; firewarning and firefighting	75		
	Ground control; working in areas of highwalls, water hazards, pits, and spoil banks; illumination and night work	100		
	First aid	75		
	Electrical hazards	75		
	Prevention of accidents	75		
	Health	100		
	Explosives	50		
	Hearing protection	100		
	Self-rescue and respiratory devices	75		

28	What will help you apply what you learned from this class? practice
29	What will prevent you from using what you learned in this course? not paying attention

MINE SAFETY TRAINING SURVEY

Please read each of the following statements and circle the number (1, 2, 3, 4, 5 or 6) that most closely reflects your opinion of the learning experience you have just completed. There is no right or wrong answer. Your first impression or reaction is usually the most accurate.

For the following items, please think about
THE SPECIFIC SAFETY TRAINING PROGRAM YOU HAVE JUST COMPLETED

1 - Strongly disagree 2 - Disagree 3 - Somewhat disagree
4 – Somewhat agree 5 - Agree 6 – Strongly agree

1.	Sufficient steps were taken to prepare me for the learning process.	1	2	3	4	**5**	6
2.	I had the opportunity to work with others to plan our learning.	1	2	3	4	**5**	6
3.	The way I was prepared for this learning experience gave me confidence I needed.	1	2	3	**4**	5	6
4.	The instructor developed strong rapport with the learners.	1	2	3	4	5	**6**
5.	Before this learning experience, I was given exercises or activities that prepared me to learn.	1	2	3	4	**5**	6
6.	There was an adequate amount of dialogue with my instructor regarding my learning needs.	1	2	3	4	**5**	6
7.	We shared responsibility for planning the learning process.	1	2	3	4	**5**	6
8.	The learning expectations were clear to me before this learning experience began.	1	2	3	4	**5**	6
9.	Learners were full partners with the instructor in this learning experience.	1	2	3	**4**	5	6
10.	I was helped to diagnose my learning needs.	1	2	3	4	**5**	6
11.	The instructor and I worked together to prepare me for this learning experience.	1	2	3	4	**5**	6
12.	The way learner responsibilities were clarified was appropriate for this learning experience.	1	2	3	4	**5**	6

Please turn to the next page

1 - Strongly disagree 2 - Disagree 3 - Somewhat disagree
4 – Somewhat agree 5 - Agree 6 – Strongly agree

13.	Learners and instructors cooperated in planning the learning.	1	2	3	4	**5**	6
14.	The instructor acted as a rich resource for my learning during this learning experience.	1	2	3	4	**5**	6
15.	We collaborated in planning the learning/instruction.	1	2	3	4	**5**	6
16.	The climate in this learning experience was collaborative.	1	2	3	4	**5**	6
17.	I was helped to assess my weaknesses and identify my developmental needs.	1	2	3	**4**	5	6
18.	I completed activities that helped me identify my learning needs.	1	2	3	4	**5**	6
19.	The instructor and the learners negotiated the learning objectives.	1	2	3	4	**5**	6
20.	Learners were encouraged to set their own individual learning objectives.	1	2	3	**4**	5	6
21.	Learners and the instructor became partners in setting learning objectives.	1	2	3	4	**5**	6
22.	There were mechanisms in place to collaboratively design which learning activities would be used.	1	2	3	4	**5**	6
23.	The learners determined what learning objectives to pursue.	1	2	3	4	**5**	6
24.	Many different kinds of activities were used to help learners explore and apply new knowledge or skills.	1	2	3	4	**5**	6
25.	As a part of this learning experience, I did some analysis to figure out the best direction for my learning and development.	1	2	3	4	**5**	6
26.	The instructor and I worked together to design learning activities that work for me.	1	2	3	4	**5**	6
27.	Steps were taken to adapt the learning experience to my capabilities.	1	2	3	4	**5**	6
28.	An effort was made to adjust the design of the learning to fit this situation.	1	2	3	4	**5**	6
29.	The instructor relied heavily on lecture.	1	2	3	4	**5**	6
30.	The methods used to evaluate my learning in this learning experience were appropriate.	1	2	3	4	**5**	6
31.	The learning methods kept me actively involved in the learning process.	1	2	3	4	**5**	6
32.	Learners were encouraged to work together to make decisions about how learning would occur.	1	2	3	**4**	5	6

Please turn to the next page

1 - Strongly disagree 2 - Disagree 3 - Somewhat disagree
4 – Somewhat agree 5 - Agree 6 – Strongly agree

33.	All of the learning activities required my full and active participation.	1	2	3	4	(5)	6
34.	Evaluation methods used during this learning experience met my needs.	1	2	3	4	(5)	6
35.	The learning activities required little action on my part.	1	(2)	3	4	5	6
36.	Evaluation methods helped me diagnose my needs for further learning.	1	2	3	4	(5)	6

The following statements address your views of safety training programs in general. Please read each statement carefully. Using the scale below and rate the extent to which you agree or disagree with each statement.

1 - Strongly disagree 2 - Disagree 3 - Somewhat disagree
4 – Somewhat agree 5 - Agree 6 – Strongly agree

37.	I always learn new and important things in safety training.	1	2	3	4	(5)	6
38.	My performance improves when I apply at work what I learn in safety training.	1	2	3	4	(5)	6
39.	I have no trouble learning new ways to work more safely.	1	2	3	4	(5)	6
40.	Safety training programs are a critical part of my work.	1	2	3	4	(5)	6
41.	I work hard to learn the material covered in safety training programs.	1	2	3	4	(5)	6
42.	I am able to improve safety at work by learning new things.	1	2	3	4	(5)	6
43.	I am committed to learning as much as I can in the safety courses I attend.	1	2	3	4	(5)	6
44.	Even when it is difficult to learn what is taught in safety training, I keep trying.	1	2	3	(4)	5	6
45.	I plan to apply as much of the safety training as possible to my work.	1	2	3	4	(5)	6
46.	If I want to work more safely I can learn new skills to do so.	1	2	3	4	(5)	6
47.	I devote a great deal of time and energy to using on my job what I learn in safety training.	1	2	3	4	(5)	6
48.	Safety training programs are important for my work-related development.	1	2	3	4	(5)	6

Please turn to the last page

1 - Strongly disagree 2 - Disagree 3 - Somewhat disagree
4 – Somewhat agree 5 - Agree 6 – Strongly agree

49.	I am determined to put into daily practice what I learn in safety training. MOT	1	2	3	4	(5)	6
50.	My goal is always to use as much of the learning from safety training as I can at work.	1	2	3	4	(5)	6
51.	The harder I work in safety training the better I do my job.	1	2	3	4	(5)	6
52.	When I am confronted with safety problems at work I am confident I can learn what is needed to solve them.	1	2	3	4	(5)	6
53	The more safety training I apply to my job the better my work performance will be.	1	2	3	(4)	5	6

54. What was the TITLE of the education or training program you have just attended? Annual / Refresher

55. What was the LENGTH of the program you have just attended? (tick the correct circle)

- O Less than 1 day
- ✓ 1 day
- O 2 days
- O 3 days
- O 4 days
- O 5 days
- O 6 days
- O 7 days
- O More than 7 days

56. What is your gender?

- O Female
- ✓ Male

57. Including this program, how many safety training programs have you attended in the last 12 months?

- O 1 program
- ✓ 2
- O 3
- O 4
- O 5
- O 6
- O 7
- O 8
- O 9
- O 10 or more programs

58. Which of the following best reflects your main goal for engaging in this learning experience? (check the one that best fits)

- ✓ Upgrade skills for current job
- O Acquire new skills for current job
- O Preparation for a new job
- O Required to attend by employer

59. What is your age?

- O Less than 26 years of age
- O 26-35
- O 36-45
- O 46-55
- ✓ 56-65
- O 66 years or older