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Use of Simulation Exercises for Safety Training in the U.S. Mining Industry

Department of Health and Human Services
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

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By Henry P. Cole, Ed.D., William J. Wiehagen, Charles Vaught, Ph.D., and Belinda Sue Mills

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
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USE OF SIMULATION EXERCISES FOR SAFETY TRAINING IN THE U.S. MINING INDUSTRY

By Henry P. Cole, Ed.D.,[1] William J. Wiehagen,[2] Charles Vaught, Ph.D.,[3] and Belinda Sue Mills[4]

ABSTRACT

This study reports the results of a survey of organizations that used problem-solving simulation exercises to support mine health and safety training. The exercises are designed to teach judgment and decision-making skills within two broad domains: (1) how miners respond to mine emergencies (e.g., first aid, self-rescue, and escape) and (2) how miners integrate safety concepts within the context and performance of routine production work. The simulation exercises were distributed by the Mine Safety and Health Administration's National Mine Health and Safety Academy near Beckley, WV. The present study focused on those organizations that ordered the exercises from the Academy over a 2-year period (1995-96). Researchers assessed how the materials were used and trainer perceptions of the impact of these materials on annual mine health and safety training.

A total of 147 organizations ordered the exercises over the 2-year period. Survey responses were obtained from 52 of these organizations. Sixty percent of the respondents rated the exercises as more useful than traditional instructional materials, 40% as equally useful, and 0% as less useful. Most trainers (79%) felt that the exercises help them to make better use of workers' knowledge and experience during training. Many (71%) also reported that the simulations helped to improve the effectiveness of their instruction and promoted a problem-solving approach to their training. Fifty of the fifty-two respondents reported that they would like to have new simulations developed. A large majority showed a proactive interest in helping to develop and field test new exercises. Ninety-four percent of the trainers judged the exercises as a good value; 92% planned to order more simulations in the future. Based on this study, recommendations are offered for the continuation and expansion of simulation exercises as one method for occupational health and safety training.

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BACKGROUND

From 1984 to 1990, a series of 70 simulation exercises was developed and field tested with workers in the mining industry [Cole et al. 1988a,b; 1993; 1996]. The exercises focused mainly on underground coal mining. The simulations were based on actual injury and disaster events reported in formal investigations by the Mine Safety and Health Administration (MSHA). The purpose of the simulation exercises was to teach critical problem-solving and decision-making skills to help miners prevent emergency situations and to deal effectively with such events when they arise. Exercises were developed in three broad content areas: (1) first-aid care of injured miners, (2) mining technical areas, including safe work practices, ground control, ventilation, haulage, machinery, electrical, fires and explosions, escape strategies, etc., and (3) a mix of first-aid and mine technical content. The exercises are realistic because they are developed from actual cases. Each exercise simulates key aspects of the cognitive problem solving and decision-making useful in preventing or limiting the effects of a nonroutine mine emergency situation. The exercise decision alternatives (both good and bad) and their consequences are taken directly from the real-life behavior reported in official investigations of injury and fatality events. Completing a simulation exercise provides workers with a dramatic and engaging way to comprehend lessons learned from past injury events and disasters.

Research to develop the simulation exercises was begun in 1984 by the Behavioral Research Aspects of Safety and Health (BRASH) Working Group at the University of Kentucky under a contract with the former U.S. Bureau of Mines (USBM) Pittsburgh Research Center.[5] BRASH and USBM researchers collaborated for several years to develop the simulation exercises and to field test and evaluate them. The effort was assisted through the cooperation of an extensive network that included labor organizations, coal operator associations, mining companies, Federal and State enforcement agencies, vocational and technical schools that conduct miner training, and other groups. In 1986, MSHA's National Mine Health and Safety Academy near Beckley, WV, began distributing, at the request of mine trainers, thousands of copies of the simulation exercises for use in annual refresher training classes for miners. Figure 1 shows the network of organizations and individuals involved in the development and dissemination of the exercises.

[5] The safety and health research functions of the former U.S. Bureau of Mines were transferred to the National Institute for Occupational Safety and Health in 1996.

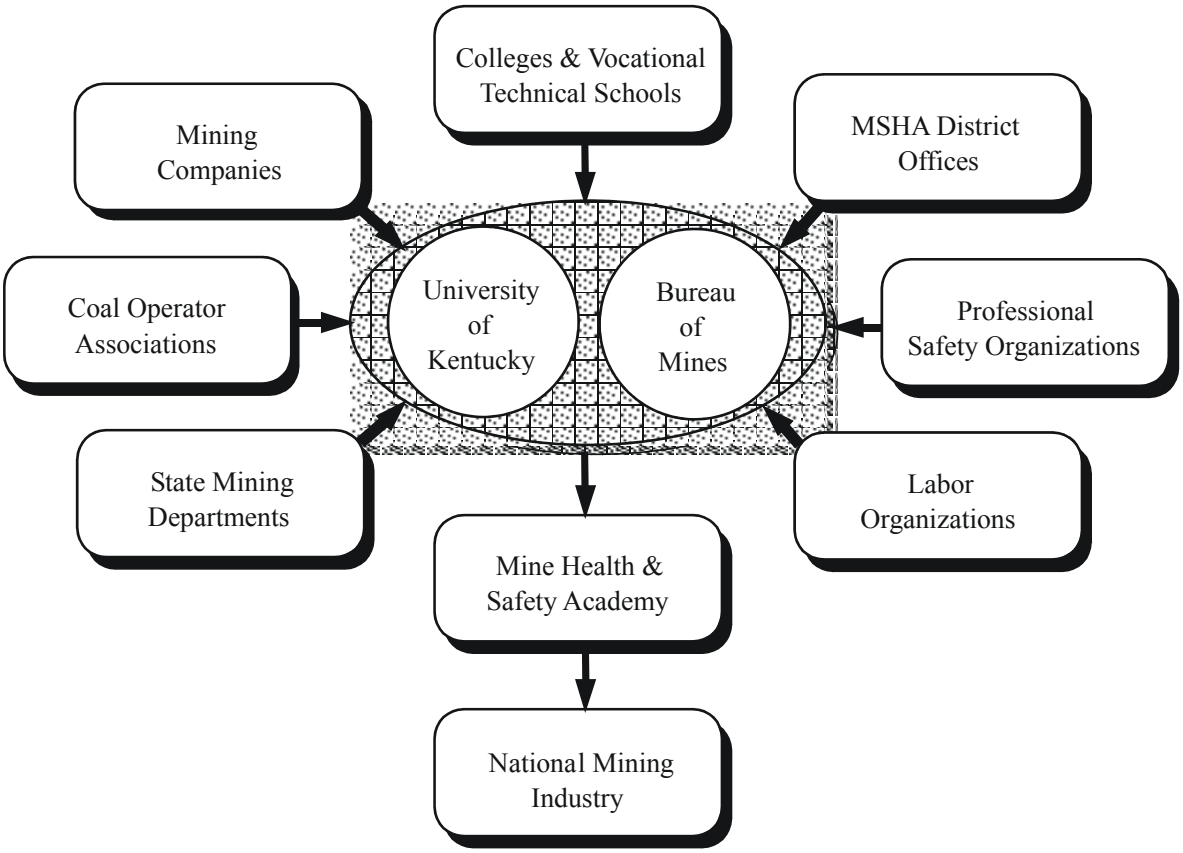

Figure 1.—Network of organizations involved in the development and dissemination of the simulation exercises for the mining industry.

An earlier study [Cole et al. 1996] contributed to the present study in two ways. First, a review of the Academy printing records from December 30, 1986, to December 30, 1994, revealed that more than 400,000 copies of answer sheets for simulation exercises had been printed and disseminated. The number of answer sheets used is a better indication of the numbers of workers reached than the number of problem booklets printed. Unlike the problem booklets, the latent-image answer sheets are consumable. When a worker selects and marks with a special pen his or her decision alternatives on a latent-image answer sheet, a previously invisible (latent-image) message appears on the answer sheet that tells the respondent the consequences of that decision. The sheet, therefore, can be used only once.

Second, interviews with 40 key mining industry health and safety specialists suggested that the exercises had changed the way mine safety trainers thought about and conducted annual refresher instruction [Cole et al. 1996]. Specifically, many instructors reported that the simulation exercises influenced them to adopt a less didactic and a more participatory learning and problem-solving approach to their instruction. The interviews also found that safety trainers had begun to adapt existing exercises to new content areas and formats. Some trainers reported adapting the exercises for use with workers in industries other than mining. This was confirmed in the present study when Academy records of who had ordered copies of the exercises were examined.

GOALS

The goal of the present study was to determine how mine safety and health instructors were using the simulation exercises. Specifically, we wanted to learn which exercises were being used, with what types of workers, how the materials may have influenced instructor and company training practices, instructors' perceptions of the value of the simulations, and what new simulation exercises instructors wished to have developed. This goal was achieved by three activities:

1. Examining National Mine Health and Safety Academy records for simulation exercises ordered over a 2-year period (January 1, 1995, to December 30, 1996). This endeavor identified each instance in which a simulation exercise or its component parts had been ordered and who had ordered the exercise.

2. Constructing a followup survey questionnaire to collect more information from trainers about the exercises that they ordered, how they were used, and their influence on training practices.

3. Administering the survey form, collecting and compiling the data received from respondents, reporting the findings, and making recommendations for the development and use of new exercises.

METHODS

This section describes how the Academy records were examined to obtain a sample of companies and organizations that had purchased simulation exercises. The sampling procedures, the questionnaire structure, and data analysis procedures are also described.

PURCHASE ORDER RECORDS

On two occasions, members of the project team visited the National Mine Health and Safety Academy to record simulation exercise purchase order information. Assisted by the Academy staff, a complete list of all the simulation exercise orders for the 2-year (1995-96) period was compiled. A total of 187 organizations and individuals were included on this master list.

SAMPLE

From the Academy records, the master list was reviewed and checked for accuracy. Many addresses were incomplete. Some purchase orders were duplicates for the same company with different addresses. After extensive checking of company addresses and telephone numbers by phone calls and internet searches, we found that some companies no longer existed, while others had consolidated their multiple locations to one site. An updated list of 147 companies and organizations was then created. Two address labels were generated for each of these organizations, and each was assigned a confidential (individual) identification number.

An explanatory cover letter and a 27-item, 3-page questionnaire were mailed to each of 147 organizations (see appendix A). A $1 bill was included with each questionnaire with a note explaining that the money was a token of our appreciation for completing the questionnaire and that it might be used to "treat yourself to a cup of coffee or donate the dollar to some good cause." A second $1 bill was promised upon our receipt of the completed questionnaire within a 2-week period. A private individual donated the dollar bills. As questionnaires were returned to the University of Kentucky, the data were logged into a computer file.

RESPONSE RATE

Twelve of the questionnaires were returned by the U.S. Postal Service as "undeliverable." Thirteen incomplete questionnaires were returned. Of these, three included notes that said the individual had purchased the simulation exercises in

order to examine them with the expectation of either adapting or constructing new exercises for workers other than miners. The 10 remaining incomplete questionnaires usually bore notes that the person who had ordered the materials was no longer with the company, and the person responding did not know if, when, or how the exercises had been used. These 25 cases were removed from the sample of 147 organizations, which resulted in a revised sample of 122.

Two followup requests (letter and phone calls) were made to organizations that did not reply to the first survey. These requests were made at 3- and 6-week intervals. In some cases, the follow-up requests determined that exercises were ordered by purchasing agents, not by employees who had used the exercises. Thus, the contact person was not able to tell how an exercise was used or who had used it. In other cases, it was found that trainers who had used the exercises were no longer with the organization that had ordered the material. These followups not only shed light on nonrespondents, but also resulted in the return of a few more questionnaires, for a total response of 52 (43%).

QUESTIONNAIRE DESIGN AND CONTENT

The questionnaire (see appendix A) was designed to make it fairly easy for participants to complete. Only two items (1 and 27) required a constructed response. All other items could be answered by checking alternatives, although eight items provided opportunities for comment outside of the alternatives listed. Table 1 shows the question groupings in relation to questionnaire items.

DATA ANALYSIS

The questionnaire data were entered into a spreadsheet and analyzed using a commercial data analysis program. Participants' verbatim responses to open-ended items were identified by item and organization ID number. Descriptive statistics were completed for questionnaire items described in table 1.

Table 1.—Question groupings and questionnaire items

Question groupings	Questionnaire items
Respondent and organization demographics	1, 2.
How trainers learned about and first used the exercises	3, 4.
Number and types of workers trained	6, 7, 8.
Numbers and types of exercises ordered	Academy records.
How the exercises were used	5, 9, 10, 11, 12, 13.
Methods by which instructors evaluated the exercises	14.
Judgments about the value of the exercises	15, 16, 17, 18, 19, 20.
Impact of the exercises on worker training	21.
Instructors' interest in new exercises	22, 23, 24, 25, 26.

RESULTS

The results are reported in the following sections. Each section corresponds to a grouping of the questionnaire, as described in table 1.

RESPONDENT AND ORGANIZATION DEMOGRAPHICS

A total of 52 persons from different organizations returned completed survey forms. Table 2 shows the demographics of these organizations, including their location and type of organization. Table 2 reveals that 38 (73%) were located in the East, 10 (19%) in the West, and the rest in the Midwest and South. Mining firms, training suppliers, and State and Federal agencies accounted for 91% of the organizations that used the exercises.

Thirty-six of the respondents listed the word "safety" in their titles (safety directors, managers, coordinators, specialists, or engineers). Seven persons included the word "trainer/training" in their job title (safety trainer, training coordinator, training manager, associate dean, and training specialist). Four listed technical and production-related jobs (production supervisor, geologist, publications manager, and loadout crew leader). Two listed personnel and employee development in their job titles; two others loss control and risk management.

Table 2.—Characteristics of respondents' organizations

Region	No. of respondents	Mining company	Training supplier	State and Federal offices
East	38	28	5	4
Midwest	3	1	1	0
West	10	7	0	0
South	1	1	0	0
Total	[1]52	37	6	4

[1]5 organizations did not report the specific type of organization.

NUMBER AND TYPES OF WORKERS TRAINED

For the 3-year period (1994-96), 48 of the organizations reported training a total of 31,785 workers with simulation exercises. Four organizations did not report the numbers of workers trained. The median number of workers trained was 280.

The fewest number of workers trained by an organization was five. The maximum number of workers trained by 1 organization was 8,000.

Of the workers trained with the simulation exercises, 79% were hourly workers, 14% were supervisors, and 3% were managers (figure 2). Other job categories accounted for 4% of those trained (figure 2). Overall, more than 92% of those trained were workers at the mine site. Of these, 67% were involved in coal mining, 15% in nonmetal mining, and 10% in metal mining. The remaining 8% were not listed as miners. Some of these workers were involved in the construction industry. Others had no commodity area listed.

Of the 52 organizations, 33 used the exercises to train underground miners, 31 to train surface miners, and 25 to train other mine workers. Only four of the organizations used the exercises to train nonmining workers. One group trained vocational-technical students with the exercises.

HOW TRAINERS LEARNED ABOUT AND FIRST USED THE EXERCISES

MSHA first distributed the mining simulation exercises to the mining industry in December 1986. Two of the survey questions asked respondents (1) how they first learned about the exercises and (2) in what year they first used the simulation exercises.

Five sources from which the respondents could have learned about the exercises were listed on the questionnaire. Because any given individual could have learned about the exercises from more than one source, respondents were asked to check all the sources that apply. Figure 3 is the frequency of these five information sources as reported by the respondents. Most respondents learned about the exercises from MSHA's *Catalog of Training Products for the Mining Industry*. Attending a conference or workshop (most likely a mine trainers or mine health and safety conference) was another frequent choice for this item. About one-half of the respondents indicated that they first used the exercises before 1994.

NUMBERS AND TYPES OF EXERCISES ORDERED

Table B-1 in appendix B is a frequency listing of the exercises ordered by the 52 questionnaire respondents. The 52 organizations placed a total of 249 orders for 55 different simulation exercises. The 55 exercises ordered were distributed across the 7 content areas listed in table 3.

Table 3.—Exercise content areas ordered by 52 organizations

Primary content of exercise	No. of exercises ordered
First aid care of injured miner(s)	[1]31
Underground mine fires	6
Electrical safety	5
Rescue and/or mine recovery	5
Roof control and/or roof fall	5
Mine ventilation	3
Safety and health management	3

[1]Exercise content overlaps with other areas (electrical, fire, ventilation, etc.). Total exceeds 55 because of overlapping nature of exercise content.

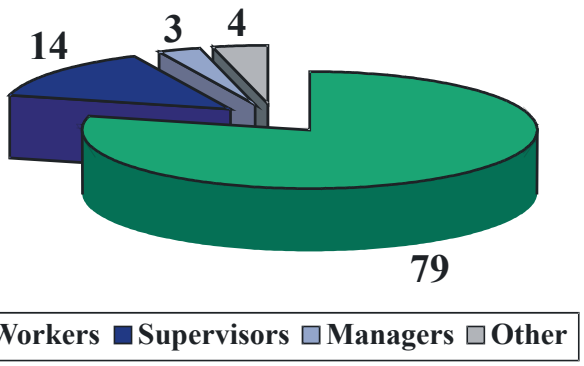

Figure 2.—Trainees' distribution across job categories (n = 31,785).

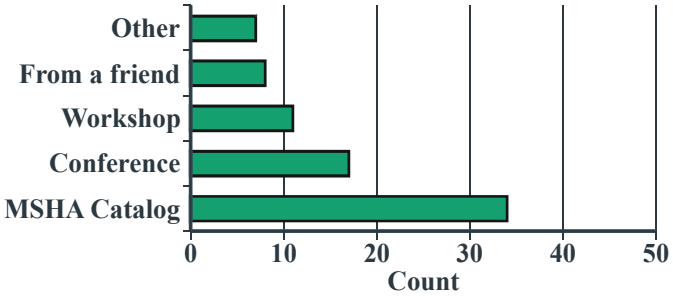

Figure 3.—Source from which the respondents learned about the exercises.

The simulation exercises ordered include four different formats. Most of the exercises were developed in latent-image format. This method uses a reusable problem booklet to present the simulation exercise narrative and a separate consumable answer sheet. Trainees select from decision alternatives in the simulation exercise and use a special pen to mark their choices on the latent-image answer sheet. The pen develops a previously invisible (latent-image) response for each answer selected. The latent image provides immediate feedback about whether the alternative is a good or bad decision, as well as the immediate consequences of that decision.

The paper-and-pencil format is similar to the latent-image format in that the same type of problem booklet is used to present the exercise scenario. However, the participants record their choices on a one-page (non-latent-image) answer sheet. Feedback is provided through a master answer sheet that explains which alternative actions are correct and incorrect, why this is so, and offers additional information about the potential consequences of each action.

The four role-play simulations are first-aid exercises. These require the participants to first diagnose and then to care for a simulated injury victim. The injuries generally are hidden and require the first-aiders to conduct a thorough hands-on primary and secondary survey. Injury labels and cues are hidden on the person playing the part of the injured miner. When found, these labels and other cues simulate the feedback provided by an actual primary and secondary survey. An observation checklist scores the performance of the participants. When the exercise is completed, the performance data are used to provide feedback to the trainee.

The fourth format is a latent-image, three-dimensional (3-D) color slide-reel exercise. This format is identical to the latent- image format with one addition. The illustrations that would normally be included as drawings in the exercise problem booklet are presented as 3-D color slides mounted on a circular slide reel and viewed with a handheld 3-D viewer.

Table 4 lists the frequency with which each of these four types of exercises was ordered by the 52 organizations. The large number of latent-image exercises and the smaller numbers of the other formats that were ordered during this period is related mainly to the availability and not to a preference for any given format.

Table 4.—Frequency with which four types of exercise formats were ordered by 52 organizations

Type of exercise	No. ordered
Latent-image	43
Paper-and-pencil	6
Role play	4
Latent-image and 3-D slide reel	2
Total	55

HOW THE EXERCISES WERE USED

A series of four questions asked how instructors administered the exercises, in what ways they may have tailored or modified the exercises, and if they made use of the supplemental materials in the instructor's copy that is provided for each exercise.

Administration

Five methods of administration were listed on the survey form. The first method called "individual" involves giving one exercise problem booklet, one answer sheet, and one latent-image pen (for latent-image exercises) to each participant. The second method called "group AS" involves placing the trainees in groups of four to five persons, giving each person his or her own problem booklet, but giving only one answer sheet and marking pen to each small group. The third method called "group PB/AS" involves giving each small group (normally two to five trainees) only one problem booklet, answer sheet, and marking pen. The fourth method called "whole class" involves the instructor using one problem booklet to lead the members of the class through the exercise step by step without the trainees having either a problem booklet or an answer sheet. The fifth method called "story" involves the instructor telling the exercise story and discussing each major decision point and its alternatives with the class members. The last method was "other." The first five categories were included on the questionnaire because each of these methods of exercise administration had been observed in miner training classes [Cole et al. 1988a,b; 1993; 1996]. The "other" category was added to gather information about administration methods that had not been observed before.

Figure 4 shows the frequency with which these six methods were used to administer the exercises. The most frequently used method was the "group AS." Use of this method was motivated by two factors. First, instructors prefer this method because it fosters dialog and group decision-making. Collaboration is required because members of the small groups have to agree on the selection of their decision alternatives and mark these on one answer sheet. The second reason was the desire to conserve latent-image answer sheets. During visits to miner training classrooms as part of earlier studies [Cole et al. 1988a,b; 1993; 1996], instructors reported that cost savings was one additional reason for using the group answer sheet method. For example, the cost of answer sheets for the individual administration of an exercise to a class of 30 trainees is $15. However, by placing the 30 trainees into 6 groups of 5 people with each group having only 1 latent-image answer sheet and 1 pen, the cost per class for answer sheets is only $3.

The "group PB/AS" was the next most frequent method. With this method, each group is given only one problem booklet, one answer sheet, and one pen. This method is similar to the group AS method and was used for the same reasons.

Instructor Modification of the Exercises

One item on the questionnaire asked the respondents if they used the exercises as they were designed, if they modified the exercises in some way, or if they used the exercises as resources from which to construct their own training activities. Figure 5 shows the responses: 44 (85%) of the organizations reported using the exercises "as is." Ten organizations (19%) reported adapting or modifying the exercises, and 10 (19%) also reported using some of the exercises as resources for developing their own training materials. Some organizations used the exercises in more than one way; thus, the sum of the values reported exceeds the number of organizations.

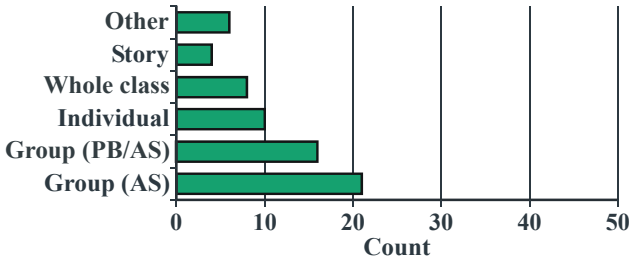

Figure 4.—Frequency of exercise administration methods.

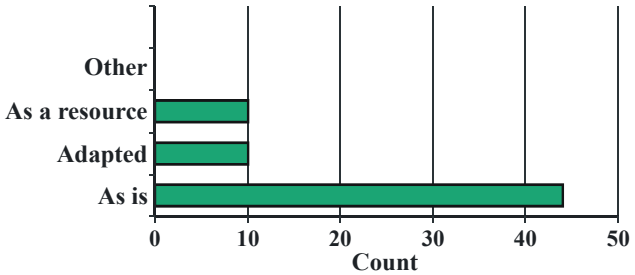

Figure 5.—Frequency of how organizations used the exercises.

Among the 52 organizations, a number of respondents reported making some changes to one or more of the exercises to customize the training for their workers. Figure 6 displays the ways in which these trainers modified exercises.

Use of the Instructor Copy and Notes

Each exercise comes with an instructor's copy. The instructor's copy lists the performance objectives for the exercise, provides tips about how to use the exercise, includes a master answer sheet, and includes a set of followup notes that provide supplemental information about each decision alternative in the exercise scenario. One item on the questionnaire asked the respondents if they used these supplemental materials. Another item asked if they found the information in the instructor's copy to be useful. Figure 7 shows these responses. Forty-seven persons (90%) reported using these resources; only three persons reported not using the notes or master answer sheets. Fifty (96%) of the respondents reported that the notes in the instructor's copy were useful.

METHODS BY WHICH INSTRUCTORS EVALUATED THE EXERCISES

Each simulation has two features that can be used to evaluate the exercise.

1. *Scoring instructions*. These are used by the individual trainee (or group) to calculate their exercise performance score. A maximum possible score is provided for each exercise, thus providing a reference for comparison.
2. *A one-page questionnaire.* The questionnaire has two parts. The first part records the trainee's demographic information, including job specialties, special training, and experience. The second part asks the trainee to judge the authenticity of the exercise scenario, the degree to which the exercise taught the trainee something new, and the likelihood that what was learned from the exercise will be of use.

These two built-in properties of the exercise allow an instructor to assess the effectiveness of the exercise in several different ways. First, the instructor can look at the performance scores and determine areas of strength and difficulty. Second, the instructor can look at the exercise questionnaire and at the performance scores of persons with different types and levels of training to determine for which groups the exercise was most effective and which groups and individuals need more instruction in specific areas. Third, the instructor can examine the portion of the questionnaire that reports the miners' evaluation of the authenticity, worth, and utility of the exercise. This information can be used to help validate the exercise, make decisions about the selection of other exercises to be used in the future, and make changes or updates to the original exercise.

The survey of the 52 respondents included items to elicit the frequency with which instructors used these and other methods to evaluate the effectiveness of the exercises. The results are presented in figure 8. The evaluation method used by 42 (81%) of the 52 organizations was the instructor observing, talking to, and listening to the trainees. Twenty-one (40%) of the respondents reported using the exercise performance score to evaluate the exercise. Only 11 (21%) reported that they used the exercise evaluation questionnaire to judge the effectiveness of the simulations. Nine (17%) of the respondents reported that they used other methods to assess the effectiveness of exercises. In the comment portion of this item, some of the other methods included—

(1) Conducting an oral quiz on contested answers;
(2) Asking the workers how the principles presented in the exercise apply to their jobs;
(3) Judging how effectively the members of the small groups worked together in solving the exercise problem;
(4) Holding a class discussion by which to evaluate the accuracy and usefulness of the exercise; and
(5) Seeking feedback from the workers' managers, supervisors, and other staff about the effectiveness of the exercises as revealed in worker comments, attitudes, and behavior.

Interestingly, only one organization (1.9%) reported that it did not try to evaluate the effectiveness of the exercises.

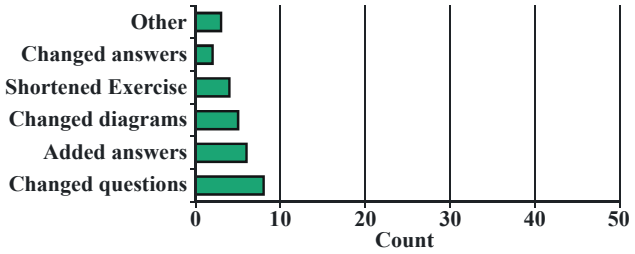

Figure 6.—Frequency and type of exercise modifications.

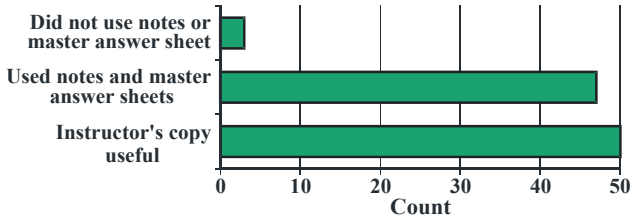

Figure 7.—Instructors' judgment about usefulness and utility of the instructor's copy.

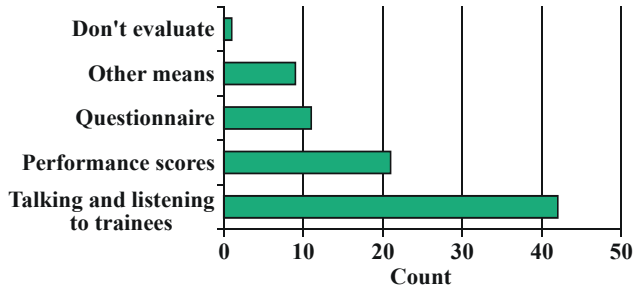

Figure 8.—Frequency of method by which instructors evaluate exercise effectiveness.

JUDGMENTS ABOUT THE RELATIVE USEFULNESS AND VALUE OF THE EXERCISES

Respondents were asked to compare the relative usefulness of the simulation exercises to other common health and safety training materials like videotapes, slides, overhead projector transparencies, printed materials, and lecture notes. Three response categories were listed for comparing the simulation exercises to these types of traditional training materials. The categories were "not as useful," "as useful," and "more useful." The results are illustrated in figure 9. Thirty-one (60%) of the respondents judged the simulation exercises as more useful than the array of traditional materials. Twenty-one (40%) believed that the simulation exercises were as useful as the traditional materials. No one judged the materials as less useful than the traditional materials.

During the study period, the simulation exercises were available from the National Mine Health and Safety Academy at a cost of 50 cents each for one problem booklet, one latent-image answer sheet, and one marking pen. The cost of the instructor's copy was $1.00. Problem booklets could be ordered in quantity from the Academy or duplicated locally. Because the booklets are reusable, most organizations ordered only enough problem booklets (25-35) to provide each member of a training class with a copy and ordered only 1 copy of the instructor's copy. Latent-image answer sheets are consumable and cannot be duplicated locally. The marking pens are also consumable, but can be used by many people before they are depleted of developing fluid.

The survey form asked respondents to comment on the economic value of the exercises. Forty-nine (94%) of the respondents agreed that the simulation exercises were a good value (see figure 10). In addition, 48 (92%) stated that they would order and use more latent-image exercises in the future, and 29 (56%) reported that as of October-November 1996 they had already ordered more simulation exercises to be used in 1997. Twenty-five (48%) of the respondents also reported that they would purchase CD-ROM versions of the exercise in the future if the exercises were available in this format.

IMPACT OF THE EXERCISES ON WORKER TRAINING

The survey presented a series of six choices about how the simulation exercises had influenced the organization's training program. Respondents were asked to check each statement that applied to their situation (see item 21 of the survey in appendix A). Figure 11 presents the results for this portion of the survey.

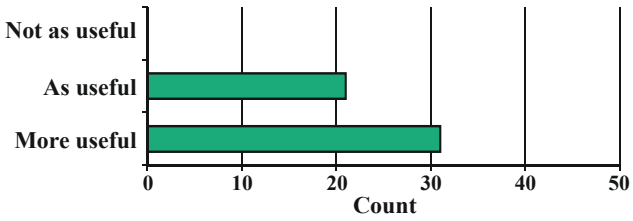

Figure 9.—Instructors' judgment of simulation exercise usefulness compared to other teaching materials.

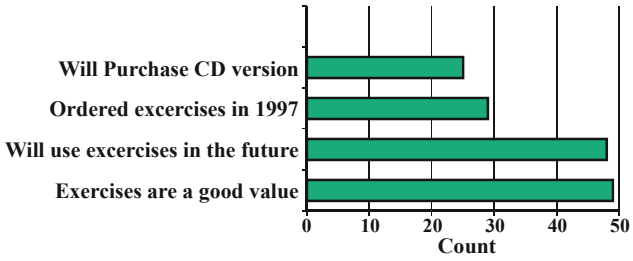

Figure 10.—Instructors' perceived value of the exercises.

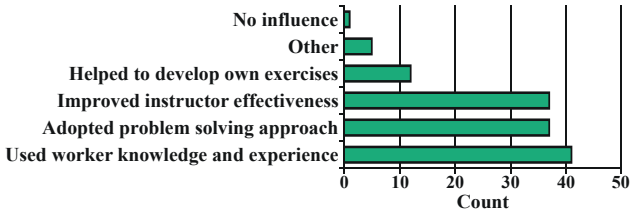

Figure 11.—Influences of the exercises on organization's training program.

Forty-one (79%) of the respondents reported that the simulation exercises helped them to make better use of worker knowledge during training classes. Thirty-seven (71%) reported that the exercises helped them to adopt a more problem-solving approach to training. An equal number reported that the exercises helped to improve instructor effectiveness. Twelve (23%) of the respondents indicated that the simulation exercises helped them to develop their own new simulation exercises. Five (10%) reported that the exercises had influenced their training in other ways. The comment section for this item included statements like "generated creativity in creating programs," "helped get participants involved that otherwise would not be," "helped promote team work in problem solving," "promotes employee discussion," and "improves [instructor] facilitation skills and trainee involvement."

These results independently replicate the findings from another study that involved interviews with 40 mine health and

safety leaders [Cole et al. 1996]. These leaders were asked about the impact and effectiveness of the simulation exercises on miner health and safety training in the United States. Only 1 of the 40 persons included in the earlier study was a respondent in the present study.

INSTRUCTORS' INTEREST IN NEW EXERCISES

The survey included a few items that asked the respondents to indicate their interest in new simulation exercises and what format they preferred for these exercises. Respondents were asked to select as many formats as they wished. Fifty (96%) individuals reported that they would like to have new simulation exercises developed. When asked about what exercise formats they preferred, 41 (79%) selected latent-image, 19 (37%) selected computer-administered, 18 (35%) selected role-play, 15 (29%) selected paper-and-pencil (a format that requires no latent-image answer sheet), and 2 (4%) indicated "other." These results are presented in figure 12.

Respondents were then asked in what ways they would be willing to help develop new simulation exercises. Three options were provided, and respondents were asked to select all that applied to their situation. Forty-one (79%) reported that they would help by reviewing new exercises, 40 (77%) said that they would assist by field testing the exercises, and 22 (42%) said that they would assist by attending exercise development workshops. These data are presented in figure 13.

Item 27 of the survey asked the respondents to list new topics for which they would like simulation exercises developed. A total of 38 persons (73%) responded with an extensive list of topics. Table 5 is a summary of the number of respondents who wanted new exercises, by mining sector. The table shows that the respondents want new exercises developed for all sectors, especially surface and underground mining.

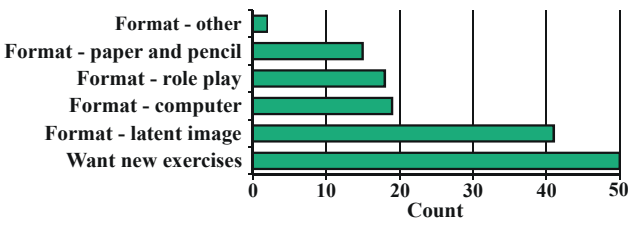

Figure 12.—Instructors' interest in new simulation exercises and preferred format.

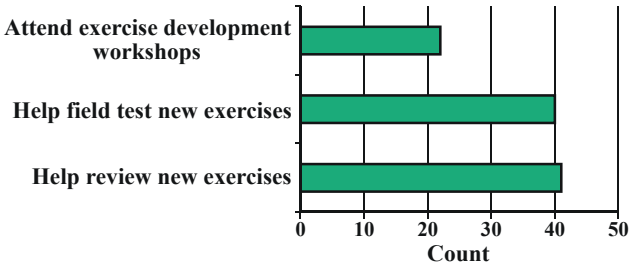

Figure 13.—Ways in which instructors are willing to help develop new exercises.

Table 5.—Mining sectors for which respondents wanted new simulation exercises developed

Sector	Frequency[1]	Percent[1]
Surface	35	67
Underground	30	58
Coal	17	33
Nonmetal	16	31
Metal	15	29
Preparation plant	6	12
Other	15	29

[1]Because respondents could list as many topics as they wished, the totals add up to more than 52 organizations and more than 100%.

DISCUSSION AND RECOMMENDATIONS

Based on the present study and earlier studies [Cole et al. 1988a,b; 1993; 1996], it is clear that the simulation exercises have favorably impacted mandatory miner refresher training in the United States. It is also clear that the development and dissemination of the simulation exercises could not have been done without the collaboration of the many agencies and organizations shown in figure 1. This section addresses two broad issues. These include lessons learned from this 12-year effort and problems and prospects involved in the continued development and dissemination of the simulations.

LESSONS LEARNED

The response to the simulation exercises from workers and trainers in the mining industry has been overwhelmingly positive. The widespread use and impact of the exercises is related to their origin in real-world cases, the interactive narrative way in which the cases are presented, and the collaborative learning and problem solving promoted by the exercises. Pooled data from miners' performance scores on the exercises also are useful for identifying and correcting misconception, work organization, and engineering problems that could contribute to injury events and disasters.

MINERS' RESPONSES TO THE EXERCISES

In earlier studies [Cole et al. 1988a,b; 1993; 1996], miners reported that the exercises are interesting, relevant, help them learn to work together more effectively with each other and their supervisors, and help them to better recognize and prevent workplace hazards and injuries. Miners also reported that they liked being involved in the development, field testing, and

improvement of the simulation exercises. Miners appreciate that when the simulation exercises are used, their personal knowledge and experience becomes an integral and legitimate part of the classroom problem-solving activity that is central to each exercise. When the exercises are used in annual refresher training classes, miners become active contributors to the instructional process rather than more passive recipients of didactic information presented by the instructor.

INSTRUCTORS' RESPONSE TO THE EXERCISES

Instructors confirm the reports of miners about the impact and effectiveness of the simulation exercises for engaging workers in meaningful learning that has a positive impact on safety knowledge and attitudes in daily work activities [Cole et al. 1996]. Another indicator of trainers' appreciation of the exercises is the widespread use of the simulations over a 13-year period. More than 400,000 copies of answer sheets for simulation exercises were used from December 1986, when the exercises were first released by the National Mine Health and Safety Academy, to December 1994 [Cole et al. 1996]. The Academy reported that rarely has the industry shown such a great interest in any one type of mine health and safety instructional materials.

During the 2-year period (1995-96), the 52 trainers in the present study reported using an array of 55 exercises with about 32,000 workers. The trainers surveyed also valued the exercises and their continued use. For example, 96% wanted new exercises developed, 79% wanted new latent-image format exercises, and 48% expressed an interest in CD-ROM or Web-based delivery formats. About 77% said that they would help develop new simulations by field testing new materials, and 42% said that they would participate in exercise development workshops. More than 94% of the trainers rated the exercises as a good value. About 60% of the trainers rated the exercises as "more useful" than other available instructional materials, 40% judged the simulations to be "as useful" as other materials, and no one rated the simulations as "less useful" than other instructional materials.

About 79% of the trainers reported that the exercises helped them to better incorporate miners' knowledge and experience into a collaborative learning approach to training, and 71% reported that the exercises helped them to adopt a more problem-solving approach to their instruction generally. Slightly more than 71% of the trainers said that using the simulations improved their effectiveness as instructors, and 23% said that the exercises helped them to develop their own new simulation problems and exercises.

THE EXERCISE NARRATIVES AS REAL-WORLD MODELS

Traditional safety and health training is often rule-bound. A simple set of procedures is often specified for how to prevent or deal with some specific problem, whether it is a first-aid procedure involving a spinal injury or a protocol about how to escape from a mine fire. Such protocols are appropriate because they provide a logical framework for how to respond to classes of events. But the protocols alone are not enough. For example, studies of miners who escaped from mine fires found that the standard protocols almost always break down [Cole et al. 1998; Vaught et al. 1996; Bower and Morrow 1990].

Many researchers have noted that real-world decision-making is guided by internalized stories that direct our goals, judgments, and actions [Bruner 1986; Sarbin 1986; Crites 1986; Cole 1997]. The use of internalized stories that we have heard, lived, and told to others provides a way of thinking about the meaning of past events, projecting goals, and striving for the future, as well as understanding the meaning of the current circumstances in which we find ourselves [Cole 1997]. It is largely through internalized stories (sometimes called culture tales) that we understand our own and others' conduct in response to predicaments and problems [Crites 1986]. The universal use of narrative by humans to guide and direct goals and conduct has been referred to as “stories to live by” [Cole 1997]. Narratives have traditionally been used in miner training and in other classroom settings. For example, trainers often tell "war stories" as they describe events related to the points that they are trying to teach. Stories of injury or disaster events are often presented as case studies. Presenting the case is mainly telling the story of an event followed by a post hoc analysis of what happened, why it happened, and who was responsible for the errors made. The emphasis is on hindsight and the analysis of a past event. Fixing blame about who was at fault often diverts attention from coming to a better understanding of underlying factors and issues that contributed to the problem in the first place. The presentation of a case study in this manner does little to simulate the foresight that is required for dealing effectively with an unfolding emergency situation where decisions must be made with incomplete and often conflicting information.

For these reasons, each simulation exercise is designed as an unfolding story of an actual event that either had the potential to or actually evolved into a serious injury event or disaster. Each simulation exercise story has a plot, characters who have goals and who encounter obstacles to those goals, and predicaments that cause well-rehearsed protocols to break down. As in the real-world events depicted, the simulations include conflicting information about what is happening and what course of action is necessary to remedy the situation. The simulation exercises purposefully avoid fixing blame. Rather, they focus on the proactive and constructive use of foresight to prevent or limit the effects of a developing problem situation that threatens health and life. Therefore, the case-based unfolding simulation narratives help workers and managers to focus more on proactive prevention than on retroactive fault-finding. The simulations help to bring to the forefront the use of stories within a carefully planned teaching method, rather than using off-the-cuff stories as casual addenda to lesson plans.

The simulation exercise narratives are interactive in two ways. First, the individuals working the exercise interact with

the characters, events, and predicaments in the unfolding story, selecting from among alternative actions at each decision point and learning the consequences of each of those decisions. Second, as they work through the exercises in small groups of three to five persons, the participants also interact with each other, debating and discussing which actions to take at key points in the unfolding scenario. As in real life, there is often too little, too much, or conflicting information. Standard protocols fail, and workers must draw on their own prior knowledge and experience to solve the problem.

Miners and trainers report that the problem-solving nature of the exercises helps foster a spirit of collaboration for solving other problems at the mine site. Many interesting problems must be solved each day in all workplaces; most of these solutions require teamwork. The design of the simulation exercises exemplifies that "good solutions" are not often "predefined." As in real life, solutions to the problems in the simulation exercises are not always as simple as traditional, prescriptive safety training approaches might suggest. Rules are useful to help guide actions, to help understand risk, and to visualize plausible outcomes from errors in judgment. But rules alone cannot formulate creative and effective solutions to most problems.

HOW INSTRUCTORS EVALUATE THE SIMULATION EXERCISES

Although two evaluation features are built into the simulation problems, 80% of the organizations relied on other means to assess the utility of the instruction. These other methods included instructor observations and interaction with trainees as the main way to assess exercise effectiveness. Forty percent of the respondents also used the trainees' exercise performance scores to evaluate training effectiveness. Only 21% reported using the trainee's evaluation questionnaire that accompanies each simulation exercise.

There are several reasons why instructors do not consistently use the built-in evaluation tools.

1. Time is important, and a formal evaluation (either through assessing scores or the trainee evaluation questionnaire) takes time. There are many topics to address in annual mine safety refresher classes. It is hard to assess every instructional component. In addition, many mine safety trainers ask the trainees to evaluate the entire refresher training at the end of the 8-hr session, rather than each of the individual instructional components.
2. Using the exercise to check performance scores of trainees is especially difficult because most instructors use the exercises in small group settings. Assessing individual scores is thus impossible and, one can argue, not even desirable. The exercises are designed to be teaching tools, not tests. Therefore, trainers' observations and interactions with trainees carry significant weight as they are making informed decisions about learning, not scoring. If the exercises were (wrongly) administered as tests, it would be possible to fail the test, but perhaps learn enough to apply the lessons in the real world. Good training simulations should allow for mistakes. It is even desirable to make mistakes; this allows one to see the consequence of inappropriate decisions. The notion of having "good or likely wrong answers" is a key feature of the simulations. Without plausible wrong answers, the simulations would have considerable less value as teaching instruments. Making decision errors during a simulation can help prevent a decision error in a similar real-world event.
3. Trainers may rely heavily on the fact that the exercises are already field tested and validated. The instructors copies present the data from the field tests. Perhaps mine trainers conclude that the materials are valid teaching tools and there is no need for further formal evaluations within their classes. Thus, they use the exercises as prescribed and rely on their own observations to refute or verify the findings and results presented in the instructor's copy.

One important implication from this finding is the need to make sure that the exercises are researched, authenticated with experts, and field tested with individual and small groups of miners. This process produces educationally sound materials and must be completed before dissemination. The fact that mine trainers do not have the time to formally collect evaluative data on individual exercises heightens the importance of conducting thorough research. An important component of educational research is field testing and revisions of the exercises based on field trials.

UTILITY OF POOLED EXERCISE PERFORMANCE SCORES

The exercise performance scores are appreciated by both miners and their instructors because these scores and the exercise feedback communicate immediately in a powerful, personal way what miners know and do not know about preventing or coping with a real-world emergency event [Cole et al. 1988a,b; Cole 1994; Cole et al. 1998; Wala and Cole 1987; Passaro et al. 1989; Barrett and Kowalski 1995]. The performance results for a given exercise pooled across many miners also provide valuable information for researchers and policy makers. For example, when simulation exercises are developed based on actual mine events, the decision-making of miners about particular aspects of the problem can reveal dangerous misconceptions. These include—

1. Mine ventilation principles that can lead to methane ignitions [Cole et al. 1987; Wala and Cole 1987; Passaro et al. 1989; Barrett and Kowalski 1995];
2. Entrapment in bins and hoppers [Cole 1994];
3. Beliefs and behavior that compromise escapes from underground mine fires [Cole et al. 1998];
4. Failure to recognize and avoid dangerous mine roof conditions [Passaro et al. 1994]; and

5. Misconceptions and errors that compromise the health of an injured colleague during first-aid procedures [Cole et al. 1988a].

Properly constructed simulations based on actual hazardous mine situations and emergency events provide decision-making tasks that can be used to assess workers' proficiency in preventing or coping with these nonroutine situations. The simulations are tools that both teach and test proficiency in critical skills [Cole 1994].

When pooled across many miners, performance data from a simulation exercise can also be used to identify and correct engineering and work organization factors that contribute to injury events and disasters. For example, in hands-on simulation exercises using emergency breathing apparatus to escape from underground mine fires, a series of studies identified problems in the training protocols for self-contained self-rescuer (SCSR) donning and use. The studies used miners' performance data from simulated escape situations to improve SCSR training. These studies subsequently resulted in empirically based changes to (1) the training protocols for existing SCSRs, (2) the improved design of new generation SCSRs, and (3) changes in the Code of Federal Regulations that direct how SCSR training shall be conducted [Vaught et al. 1996].

ISSUES AND PROSPECTS

The development and widespread use of simulation exercises in the U.S. mining industry was made possible by cooperation among the network of organizations shown in figure 1. The National Mine Health and Safety Academy played a key role by printing, advertising, and disseminating the exercises.

To print the necessary quantities of latent-image answer sheets, the Academy contracted with a vendor (from 1986 to 1998) that used an offset printing process. This process required a significant order of answer sheets. This worked well for some exercises, but not for others; the supply simply exceeded the demand. Thus, during 1998, the Academy decided to discontinue the printing, marketing, and distribution of the latent-image simulations. As a result, MSHA provided its inventory of simulation exercises to NIOSH. NIOSH has accepted the function of distributing these materials to the mining community.

Within the last several years, the latent-image simulation exercise method has been generalized to several settings outside of mining. These include hazardous waste storage, removal, and disposal; agriculture; carpentry and construction; health care; disability awareness and prevention; high school social studies instruction about the economics of safe work practices; and violence prevention and conflict resolution among adolescents. There seems to be a growing interest in the use of the simulation exercise method as a way to teach and assess occupational health and safety skills to a wide range of workers. Demand for the simulation exercises in the mining industry also remains high.

Three prospects for the continued development and dissemination of simulation exercises arise from three circumstances. These are (1) the growing interest in simulation exercises as intervention tools by which to promote occupational health and safety, (2) the rapid growth of Web-based software and technology by which to develop and deliver interactive narrative simulation exercises, and (3) the use of answer sheet formats that do not use latent-image ink.

The development of a Web site that could include all of the simulation exercises developed to date may be an effective way to disseminate the materials. Exercise orders from Academy records indicate that many trainers first ordered one instructor's copy for a few exercises and then later ordered problem booklets and answer sheets for specific exercises. Presumably, the trainers wanted to examine the instructor's copy to learn more about the exercises and the supporting materials that accompany each exercise. Internet access to exercise materials would make this process much more efficient and rapid. Trainers could search for topics of interest, examine all parts of any exercises, determine what they wanted to use, and immediately download and print the appropriate materials. This method would also make distribution of the materials easy, efficient, and inexpensive because there is no need to inventory and ship the materials from a distribution center.

Web-site distribution of the materials could also facilitate record-keeping about the types of organizations using the exercises. Web-based delivery also would permit ongoing communication between the developers of the simulation materials and those who use them. Evaluation of existing materials, suggestions for their improvement, customizing existing exercises by industry sector, and developing new exercises could all be enhanced. The communication network could enable many health and safety professionals to become involved in the analysis of training needs for diverse groups of workers and in the development and field testing of new exercises. Communication among health and safety professionals who used the Web site could also facilitate sharing information and ideas about training needs and resources.

A Web-based delivery system could involve more stakeholders in the entire process, not only in the early stages where exercises are conceptualized, but also in the field testing and marketing of the materials. Additional delivery and exercise formats might be explored to engage trainees in discussion, debate, and problem solving as a means to teach important lessons about workplace health and safety.

If such a Web-based development, marketing, and delivery system is developed, it should probably include simulation exercises from multiple industry sectors, not just mining. The materials could be presented in print formats nearly identical to their existing paper versions and used as source files that could be downloaded and printed out. A more effective presentation of the materials could make good use of the interactive audio

and visual features of Web-based instruction. Audio and visual feedback could be provided immediately as a person selects each decision alternative. The extensive supplemental material included in the exercise discussion notes could be accessed by topic anytime the individual needed or wanted more information. Researchers at NIOSH and the University of Kentucky have developed prototype simulation exercises in multimedia interactive computer format.

Finally, researchers are exploring the use of other types of formats and printing methods. These options include using small printing businesses to better match supply with demand and alternative formats for the narrative-based learning models that do not use invisible, latent-image ink. Several non-latent-image simulations have been developed by NIOSH for mining and by the University of Kentucky for agriculture and construction.[6]

ACKNOWLEDGMENTS

The authors gratefully acknowledge the personnel from MSHA's National Mine Health and Safety Academy near Beckley, WV, for their dedication and help in gathering the information that was critical to complete this study. We are especially grateful to Mary Lord, Order Specialist at the Academy. We also recognize the assistance of Roberta Calhoun, Safety and Occupational Health Specialist, NIOSH Pittsburgh Research Laboratory, for her objective review and comment on earlier drafts of this report.

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[6] Refer to the following University of Kentucky Web sites: www.kiprc.uky.edu/materials.html and www.mc.uky.edu/scahip/products.html

APPENDIX A.—COVER LETTER AND SIMULATION EXERCISE SURVEY QUESTIONS

October 15, 1997

MEMORANDUM

TO:

FROM: Henry P. (Hank) Cole
Project Director
Telephone (606)257-7873
e-mail <hcole@pop.uky.edu>

RE: An important request

I am directing a study about the use of the mine emergency simulation exercises that are distributed by the National Mine Health and Safety Academy in Beckley, West Virginia.

Academy records show that your organization ordered some of these exercises during 1994-96. It would be helpful if you or some other appropriate person in your organization would read and complete the enclosed questionnaire.

Your answers will be strictly confidential and neither individuals nor organizations will be identified. The results from nearly 200 organizations across the country will be combined and reported as group data.

The study is important because it will tell us how to improve the simulation exercises and also what new exercises to develop to assist your organization with its health and safety training.

The survey should take only about 5 minutes to complete. It is designed so that most answers can be completed by making check marks in the appropriate spaces.

As a small token of our appreciation, a $1 bill is enclosed. Please give this to the person who completes the survey form and returns it to us in the enclosed self-addressed envelope. Upon receipt of the completed survey form in two to three weeks, we will send another $1 bill to you or to the person who completes the form.

Enclosure: Simulation exercise survey materials and questions

INTRODUCTION

From 1986 to 1995 the University of Kentucky, the Bureau of Mines, and the National Mine Health and Safety Academy developed many mine emergency simulation exercises for the annual refresher training of coal miners. The exercises teach problem-solving skills for mine emergency situations. Most of these simulation exercises consist of a problem booklet and a latent-image answer sheet. When marked with a special pen the latent or invisible answers become visible.

The National Mine Health and Safety Academy in Beckley, West Virginia lists the exercises in their Catalog of Training Materials. During the last nine years the Academy distributed more than 300,000 copies of the simulation exercise materials. Review of the Academy records revealed that your firm ordered some of these exercises during the 1994-96 period. The materials your organization ordered during this time are listed on the enclosed page.

We are trying to learn how these materials have been used, with what groups of workers, and with what success. We also want to know what new simulation exercise topics you want or need so that these might be developed in the future. We need your help.

First, we need to make sure this information and the enclosed questions get to the person or persons in your organization who actually used the simulation exercises to train workers. We have attached a single page that lists (1) the exercise materials you ordered, (2) the quantities that you ordered, (3) the date(s) that the materials were ordered, (4) the address to which the materials were shipped, and if available, (5) the name of the person who ordered the materials. If you are not knowledgeable about how the simulation exercises were used in training sessions, would you please give these materials to a person who knows how and with whom the exercises were used?

Second, would you or another knowledgeable person please answer the questions and return them to us in the enclosed self-addressed and stamped envelope within the next two weeks?

Your answers to these questions will be confidential. We will not identify individuals or organizations. The responses of persons from all organizations will be pooled and summarized in our final report. We will also send you a copy of the summary report.

If you have questions or need clarification, please call Henry Cole (606) 257-7873 or Sue Mills (606) 257-3796 at the University of Kentucky or William Wiehagen at the Pittsburgh Research Center (412) 892-6468.

Sincerely,

Henry P. Cole,
Project Director
September 15, 1997

Enclosures: List of simulation exercises ordered by your firm during 1994-1996
Survey Questions
Self-addressed and stamped envelope

Simulation Exercise Survey Questions

1. Please list your job title. _____

2. About how many people are employed in your firm? _____

3. How did you first learn about the mining simulation exercises? (check all that apply.)_____

   ___ MSHA Catalog ___ conference ___ workshop ___ friend ___ other

4. In what year did you first start training with the latent-image simulation exercises? _____

5. How did you use the exercises you ordered in 1995-96? (Check all that apply.)

   ___ used as is to train people ___ adapted and modified and then used to train people

   ___ used as a resource to construct my own training activities _____ other?_____

6. If you used the exercises to train people during the1994-96 period, about how many persons did you train? _____

7. About what percent of these people were: _____ workers _____ front-line supervisors

   ____ managers ____ others (please identify) _____

8. If you used the exercises for training, whom did you train? (check all that apply.)

   ___ underground coal miners ___ surface coal miners ___ other mining industry workers

   ___ technical/vocational school students ___ nonmining industry workers (please identify)

   _____

9. If you used the simulation exercise(s) "as is" or with slight modifications, how did you administer the materials? (check all that apply.)

   ___ gave 1 problem booklet, 1 answer sheet, and 1 pen to each person

   ___ gave 1 problem booklet, 1 answer sheet, and 1 pen to each group of 4 or 5 persons

   ___ led the whole class through the exercise step by step without the class members having their own problem booklets, answer sheets, and pens

   ___ used the problem book and answer sheet to tell the exercise story and to discuss the problem with the class members (but did not go through the exercise step by step)

   ___ other? (please describe) _____

10. Did you tailor or customize the exercise(s) in any way? (check one) ___ Yes___ No

11. If "Yes," how did you modify the exercise(s)? (check all that apply)

    ___ shortened exercise ___ changed some questions ___ changed some answers

    ___ changed some diagrams ___ added new questions ___ added new answers

    ___ other (please describe) _____

12. Did you use the exercise(s) instructor's notes and master answer sheet? ___ Yes___ No

13. Are the materials included in the instructor's copy useful? ___ Yes___ No

14. How do you evaluate a simulation after you have used it with a group? (check all that apply)

___ I observe the trainees, talk to and listen to them to judge the value of the activity.

___ I have the trainees complete the one-page exercise questionnaire and examine the results.

___ I examine the trainees' exercise scores to see what areas they know well and in which areas they need more instruction.

___ Other? (please list) _____

___ I don't attempt to evaluate the effectiveness of the simulation exercises.

15. Compared to other health and safety training materials (like videotapes, slides, overheads, lecture notes, printed materials), how useful are the latent-image simulation exercises?

(check one) ___ more useful ___ as useful as other materials ___ not as useful

16. Are the latent-image simulation exercise materials a good value? ___ Yes___ No

17. Did you use any latent-image simulation exercises before 1994? ___ Yes___ No

18. Did you order and use any latent-image simulation exercises in 1997? ___ Yes___ No

19. Will you order and use any more latent-image exercises in the future? ___ Yes___ No

20. Would you purchase simulation exercises (similar to the latent-image materials) if they were available for use on a computer? ___ Yes___ No

21. How have the simulation exercises influenced your training program? (check all that apply)

___ Have <u>not</u> influenced our training program.

___ Helped us to develop other simulation exercises on our own.

___ Helped us to adopt more of a problem-solving approach to training.

___ Helped us to make better use of workers' knowledge and experience in training.

___ Helped to improve instructor effectiveness in worker training

___ Other? (please list) _____

22. How would you be willing to assist in creating new exercises? (check all activities that apply)

___ attend development workshops ___ review new exercises ___ field test new exercises

23. Would you like a copy of the summary report for this study? ___ Yes___ No

24. May we call you about your ideas about the exercises and their use? ___ Yes___ No

If "Yes," please list phone number and name. (_____) _____ - _____

Name _____

25. Would you like to have new simulation exercises developed? ___ Yes___ No

26. If "Yes," what formats would be best for you? (check all that apply)

___ latent-image ___ paper & pencil but <u>not</u> latent-image ___ role play
___ computer

___ other (please list) _____

27. Please tell us what additional topic areas you would like to have developed as simulation exercises for use in you health and safety training classes. List the topics on the blank lines on this page. Thank you!

APPENDIX B.—FREQUENCY OF EXERCISES ORDERED BY 52 ORGANIZATIONS

Table B-1 is a frequency listing of the exercises ordered by the 52 questionnaire respondents. The 52 organizations placed a total of 249 orders for 55 different simulation exercises. Of the exercises, 43 were latent-image, 6 were paper-and-pencil, 4 were role-play, and 2 were latent-image with 3-D slide reels.

Table B-1.—Frequency list of exercises ordered by 52 organizations

Exercise	Content	Format	No. of organizations
Apparent Diving Accident	First aid (spinal injury)	Latent-image	4
Arnel V. Beam	First aid (pneumothorax)	Latent-image	1
Basics of Transformers and Ground Fault Monitors	Electrical (technical)	Paper-and-pencil	7
Belt Fire Exercise	Mine fire escape	Latent-image	7
Bennie J. Floyd	First aid (heart attack)	Latent-image	2
Bernie T. Reddish	First aid (crushed limb)	Latent-image	3
Bob Hall	First aid (electrical shock)	Latent-image	5
Bob Woods	First aid (electrical shock)	Latent-image	2
Bull's Double Header	Roof control (deep cut)	Paper-and-pencil	10
Carl T. Donaldson	First aid (conveyor belt entanglement and rescue).	Latent-image	10
Cecil	Mine fire escape	Latent-image	5
Cleo C. Pike	First aid (crushed hand)	Role play	2
Continuous Miner Fire	Firefighting and first aid	Latent-image	11
Cutthrough Ventilation Arrangement	Mine ventilation (methane ignition)	Latent-image	3
Delta Mine Cutthrough	Mine ventilation (methane ignition)	Paper-and-pencil	7
Douglas O. Sanders	First aid (dislocated shoulder)	Latent-image	5
Douglas O. Tackett	First aid (dislocated shoulder)	Latent-image	5
D. R. Light	Roof fall hazards	Latent-image with 3-D slide reel.	2
Drainway	Gas inundation	Latent-image	1
Escape From a Mine Fire	Escape from a mine fire	Latent-image	7
Everett M. Arnold	First aid (chest injury)	Latent-image	1
Fix-It	Electrical cable splice and first aid (electrical shock).	Latent-image	8
Good Ole Bill	Alleged tool theft, due process, communication.	Latent-image	3
Harry Harlan	First aid (crushed chest)	Latent-image	4
Harry Harlan (role play)	First aid (crushed chest)	Role play	1
Harry Hastings	First aid (crushed chest)	Latent-image	8
Hot Shuttle Car	Electrical hazard	Latent-image	4
J. J. Johnson	First aid (overexertion heart attack)	Latent-image	3
J. J. Parsons	First aid (overexertion heart attack)	Latent-image	5
J. J. Smith	First aid (overexertion heart attack)	Latent-image	3
Leroy B. Perkins	First aid (broken ankle)	Latent-image	4
Low Coal Fire	Escape from a mine fire	Latent-image	2
Lynwood W. Puckett	First aid (electrical shock)	Latent-image	6
Man in the Bin	Rescue and first aid (entrapment in a bin)	Latent-image	8
Marvin Letcher Highwall	Rescue and first aid (fall of highwall)	Latent-image	15
Marvin R. Letcher	Rescue and first aid (roof fall)	Latent-image	3
Marvin R. Letcher (role-play simulation exercise)	Rescue and first aid (fall of highwall)	Role play	3
Paul Pancake	First aid (machinery runover and crush injury).	Latent-image	3
Persephone Mine Explosion	EMT triage	Latent-image	1
Pete's Predicament	Roof control hazard	Latent-image	10
Pipe Repair Problem	Falling, climbing, fire hazards	Latent-image	6
Pit Distribution Trouble Shooting	Electrical ground fault problem	Latent-image	3
Pot Luck Mine	Roof hazards and roof control	Paper-and-pencil	4

Table B-1.—Frequency list of exercises ordered by 52 organizations–Continued

Exercise	Content	Format	No. of organizations
Problem at Maxmore Mine	Injury prevention (requires up to 8 hr to complete).	Paper-and-pencil	1
Problem on Dragline #1	Electrical hazard and first aid	Latent-image	1
Raggs and Curly Guarding Exercise	Machine guarding	Latent-image with 3-D slide reel.	8
Roof Fall Entrapment	Roof fall during pillar extraction	Latent-image	4
Tipple Heater Exercise	Electrical technical exercise (NEC standards).	Latent-image	2
Traumatic Arm Amputation	First aid for amputated arm	Role play	1
Traumatic Head Injury	First aid (crushed head)	Latent-image	3
Travel Through Smoke	Escape from a mine fire	Latent-image	11
Trouble in the Training Room	Sexual harassment (in the context of first-aid training).	Paper-and-pencil	3
Vulcan Mine Ignition	Methane ignition at the face, first aid, and escape.	Latent-image	4
Vulcan Mine Recovery	Recovery of a mine following a methane explosion and evacuation.	Latent-image	3
Water Line Repair	CO symptom recognition and exposure, and first aid.	Latent-image	1

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