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The Use of Hazards Analysis in the Development of Training

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Abstract

A hazards analysis identifies the operation hazards and the positive measures that aid in the mitigation or prevention of the hazard. If the tasks are human intensive, the hazard analysis often credits the personnel training as contributing to the mitigation of the accident's consequence or prevention of an accident sequence. To be able to credit worker training, it is important to understand the role of the training in the hazard analysis.

Systematic training, known as systematic training design (STD), performance-based training (PBT), or instructional system design (ISD), uses a five-phase (analysis, design, development, implementation, and evaluation) model for the development and implementation of the training. Both a hazards analysis and a training program begin with a task analysis that documents the roles and actions of the workers. Though the tasks analyses are different in nature, there is common ground and both the hazard analysis and the training program can benefit from a cooperative effort. However, the cooperation should not end with the task analysis phase of either program. The information gained from the hazards analysis should be used in all five phases of the training development. The training evaluation, both of the individual worker and institutional training program, can provide valuable information to the hazards analysis effort.

This paper will discuss the integration of the information from the hazards analysis into a training program. The paper will use the installation and removal of a piece of tooling that is used in a high-explosive operation. This example will be used to follow the systematic development of a training program and demonstrate the interaction and cooperation between the hazards analysis and training program.

1 Introduction

A hazard is defined by Sanders and McCormick [1] as a condition of a set of circumstances that has the potential of causing or contributing to injury or death. A
hazards analysis is a systematic identification of the hazards encountered during the performance of a job. During the task analysis phase of the hazards analysis, the required actions of the workers are documented. Based on the task analysis the potential accident scenarios are developed, and possible associated human errors are identified and classified.

This paper uses an example based on the disassembly of a high explosive in which the extreme consequence is the death of the workers in the immediate area and possibly the death of other on-site workers as well as the destruction of the facility. The disassembly process is a psychomotor intensive job that requires human handling at every step of the process. Thus, because of the high level of human interactions with the system, the safety of the work is greatly influenced by human performance and the probability of an accident is tightly connected to the likelihood of a human error. One way to aid in the reduction of human error is through training. Thus, the training program must be closely tied to the hazards analysis to incorporate the hazards found on the job.

The training program is developed using a formal, systematic approach known as systematic training design (STD), performance-based training (PBT), or instructional system design (ISD). It is based on five basic phases: analysis, design, development, implementation, and evaluation. The analysis phase uses a task analysis that is similar to the task analysis performed for a hazards analysis. Therefore, it seems to be a clear connection between the analysis phases of the two processes; however, the use of the hazards analysis should not stop at the analysis phase but should be carried throughout all of the training phases.

2 Description of Example

As stated earlier, this example is based on a small action performed during the disassembly of a high explosive. The assembly is partially disassembled, and the worker is about to separate the spherical high explosive into two parts. The high explosive has a protruding component extending up from the side of the sphere. The worker is required to place a vacuum fixture on a workstand with a high explosive sphere in the workstand. The sides of the vacuum fixture are rectangles that fit into the workstand legs, and the center of the fixture has two circular vacuum seals that rest on the high explosive. The vacuum fixture is relatively lightweight with good hand-holds for control. The training activity is the installation of the vacuum.

3 Training Analysis Phase

During the training analysis a task list is developed, and then the activities that require training and the level of training are identified. The task list is very similar to the task list developed in the hazards analysis. The two task lists may be developed simultaneously with one serving as the preliminary list for the other. After the task
list is developed, the need and level of training are determined. A common method used to determine training needs and levels is the application of a training decision-tree based on frequency, difficulty, and importance (consequence of improper performance) of a task. The training importance is closely related to the consequence and probability of the accident scenarios developed in the hazard analysis. In our example, a possible consequence is a detention of the high explosive. This places the task in a category that requires training, and furthermore, requires hands-on practice of the activity.

While the primary goal is the correct installation of the vacuum fixture, from the hazards analysis the training analysis identifies three considerations when installing the fixture; (1) reduction of possible drops of the fixture on the sphere, (2) reduction of the potential for damaging the protruding component, and (3) reduction of the possibility of an injury to the worker, in particular the worker’s eye, from the protruding component.

4 Training Design and Development

During the training design and development phases, the course content and the instructional methods are determined. This includes the selection of the training setting, the development of learning objectives and lesson plans, and the development of the method of the trainee evaluation and the associated evaluation instrument. Finally the training try-outs are held.

As in the training analysis phase, the information from the hazard analysis can be integrated into the training design and development phases. In order for training to be effective in the reduction of errors, it mimics the actual work conditions as closely as possible and gives the workers the opportunity to practice potentially hazardous activities in a safe environment.

In the example, the hazard analysis indicated that one accident initiator was the drop of the vacuum fixture onto the high explosive during the installation. The training developer/designer now knows that the installation of the fixture is human-action intensive, and the installation of the fixture should become a skill-based activity for the worker.

There are several different training methodologies to select from. The instructional methodology is selected to aid in a high transfer of learning from the classroom to the job performance. One of the most common methods of training is lecture. However, the example requires continued involvement of the worker with the disassembly and requires physical responses. While the instructor can describe the process and the trainee respond verbally, correct verbal responses do not always correlate to correct bodily responses. Trainees cannot always translate verbal instructions into perceptual-motor activity (Holding, [2]). Thus, while a lecture may
constitute part of the training, the training must not be limited to a lecture but also include observation of a demonstration and practice.

During the demonstration the instructor draws attention to the perceptual cues that aid in the correct performance of the task and discusses and demonstrates error mitigating techniques. The demonstration should provide the worker with a standard of performance to be mastered. As with the lecture, observation of a demonstration does not always translate into correct perceptual-motor activities, and the demonstration and lecture are followed by practice.

Practice is the basic training activity. The value of training depends on the degree the practice transfers to the real task. The transfer between training and the job depends on both the perceptual and response similarity. The following table by Holding [2] shows the correlation between the transfer results and the similarities between the practice and the real task.

<table>
<thead>
<tr>
<th>Task Stimuli</th>
<th>Response Required</th>
<th>Transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same</td>
<td>Same</td>
<td>High</td>
</tr>
<tr>
<td>Different</td>
<td>Different</td>
<td>None</td>
</tr>
<tr>
<td>Different</td>
<td>Same</td>
<td>Positive</td>
</tr>
<tr>
<td>Same</td>
<td>Different (but similar)</td>
<td>Negative (?)</td>
</tr>
</tbody>
</table>

Table 1  
Quality of Transfer from Training to the Job

As can be seen, the highest transfer rate occurs when the task stimuli and the required response are the same in the practice arena and in the job. This suggests a simulator as the training tool. However, because it is important to prevent the occurrence of negative transfer to the real job, the simulator should be a high fidelity simulator that requires the same response to the same stimulus as the process.

In the example, the simulator is identical tooling and a very similar assembly with inert materials.

The terminal objective is directly associated with the task to be performed and may include the action statement “install the fixture.” Because of the potential high consequence of this task, the workers should understand the hazards involved. Thus, the supporting objects may be directly coordinated to an understanding of the potential hazards.

The training tryouts are an opportunity to refine the training techniques before implementation. In this example, the idea of taking the fixture and placing it on the stand seems very straightforward. However, from one side of the work stand, the fixture is lifted over the protruding component and placed on the stand. This means a
lift of shoulder height with the worker leaning over the protruding component to place the fixture. The hazards analysis indicated that the potential for a detonation was related to the drop height. Thus, minimizing the drop height is important, as to a lesser extent the need to avoid damaging the component and to avoid a worker injury. While attempting the installation prior to the training session, it became clear that a simple change in technique could have positive effects on the potential for a hazard. By installing the fixture from the other side of the workstand, the protruding component was avoided, the lift of the fixture did not require extending the arms, and the potential drop height was reduced to a few inches. This change reduced the probability of dropping the fixture, reduced the drop height to a few inches, which reduced the probability of a detonation if the fixture was dropped, and virtually eliminated the potential for worker injury or damaging the protruding component; thus, the training used in the hazard analysis to design and develop the training. In turn the training, became a positive measure in the hazard analysis and aided in decreasing the potential for an accident scenario.

5 Training Implementation

During the training implementation phase the training is conducted and the trainee is evaluated. Based on the input from the hazard analysis into the training design and development, the course emphasizes the dominant hazards and provides the workers an opportunity to practice the tasks to be performed.

During the practice the workers become familiar with the perceptual cues that aid in the correct performance. The practice provides the opportunity for the correct installation of the fixture to become a skill-based behavior that the worker performs smoothly and almost automatically. As the worker becomes more proficient in performing a task, the likelihood of a human error decreases.

The evaluation of the trainee is based on performance and an understanding of the hazards that may be encountered on the job and leads to a qualified worker. Again, there is the interaction between the hazards analysis and the training.

6 Training Program Evaluation

During the training program evaluation phase, it is not the trainee that is evaluated but the training program. Various indicators such as the lessons-learned program are monitored. The information from the indicators is fed back into the training program and into the hazards analysis.

If the hazards analysis indicated that training is a positive measure, it is important that the effectiveness of the training is evaluated and that information given to the hazards analysis for possible adjustment.
7 Conclusion

For the training to be effective it must mimic the actual work conditions as closely as possible and give the workers the opportunity to practice potentially hazardous activities in a safe environment. The training program uses the information from the hazards analysis in all phases of the program and in turn lessons learned in the training program are used to update the hazards analysis.

In this simple example the knowledge of the hazards led to the optimal technique for installing a fixture. In turn the implementation of the installation of the fixture influenced the hazards analysis by reducing the probability of an event.

References
