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ABSTRACT

To advance nuclear plant simulator training, the industry must focus on a more detailed and theoretical approach to conduct of this training. The use of semiotics is one method of refining the existing training and examining ways to diversify and blend it with new theoretical methods. Semiotics is the study of signs and how humans interpret them. In instructor semiotic analysis, the two most critical areas to be examined are non-verbal feedback and verbal signs. Instructors must attempt to eliminate any non-verbal feedback, since at the moment of execution in the plant, that feedback will not be present. They must choose verbal signs carefully and characterize behavior based on facts with clear, concrete wording to elicit correct behavior. In student semiotic analysis, impact of visual and verbal signs on the student is explored. In instructional application to effectively take advantage of semiotics, one must alter one's thinking to push the bounds of one's own rationality. The goal as related to signs and processing is to produce a correct outcome based on the interpretations and understanding of these interactions. Consistency is required. Whether to train individually or in teams must be examined from the perspective of the end product. A constructivist learning environment provides consistency in operator performance during all operating conditions. (Contains 11 references) (YLB)

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Abstract

To advance nuclear plant simulator training from its' current state to a higher state the industry must focus on a more detailed and theoretical approach to conduct of this training. The current training system development model is inadequate to support training at this new higher state. Through the use of new theories and models the training should advance to a new higher level. The use of semiotics is just one method of refining the existing training and examining ways to diversify and blend the old style training with new theoretical methods.

Background

Early in the 1980s after the tragic events at Three Mile Island, an industry watchdog group was formed and incorporated as The Institute for Nuclear Power Operations, heretofore known as INPO. The charter for this organization was to provide oversight and assistance to the nuclear industry and drive the industry to top-quartile safety status. One of the functions of INPO was to accredit each nuclear station's training program. As a basis for this accreditation they used as a foundation the Systematic Approach to Training; specifically the Analysis, Design, Development, Implementation and Evaluation (ADDIE) model (INPO, 1993). This model was used by the military and proved to be a successful platform for the initial accreditations and renewals.

As the industry has aged, INPO has shifted from an organization that ensures each and every facet of the guidelines are met to one that verifies that the training organization is driving the performance of plant staff to a high level of flawless performance. Therefore, a change in the methodology of training is

necessitated. No longer will following the ADDIE process-to-the-letter training method work; although, not to say it will be discontinued, but the shift will be to develop the training from a performance basis using human performance reviews as a basis for the selection of training topics. The two processes should complement each other and ensure a better product in the end.

Introduction

The use of a simulator can greatly enhance the skills of an operator. To properly prepare each operator for their job, all facets of the environment must be examined, including the instructor interface. This paper will explore what semiotics concerns, how it applies to the simulator environment, the training methodology, the instructor, student and instructional implications.

Simulator Training Methodology

To effectively implement any training program, the instructor/developer must understand the environment of the trainee. The environment at a nuclear plant is one of high stress, potentially long hours and sometimes confusing information, both technical and non-technical. Operators are trained using a highly advanced simulator capable to simulating real-time events with near perfect feedback that is output to the panels.

Operators are trained on all procedures and processes, and are even trained in dealing with other team members in a team training format to discover their own strengths and weaknesses, as well as the other team member's strengths and weaknesses.

A closer look at how semiotics is involved in the trainee can potentially reveal a weakness in a crewmember that may have been unseen up to this point. Now a review of semiotics and its' meaning to us.

What is Semiotics?

Semiotics is the study of signs and the interpretation thereof. Semiotics consists of 3 parts, the sign or representamen, the semiotic object, and the interpretant, represented by figure 1 below. (Merrell, 2003)

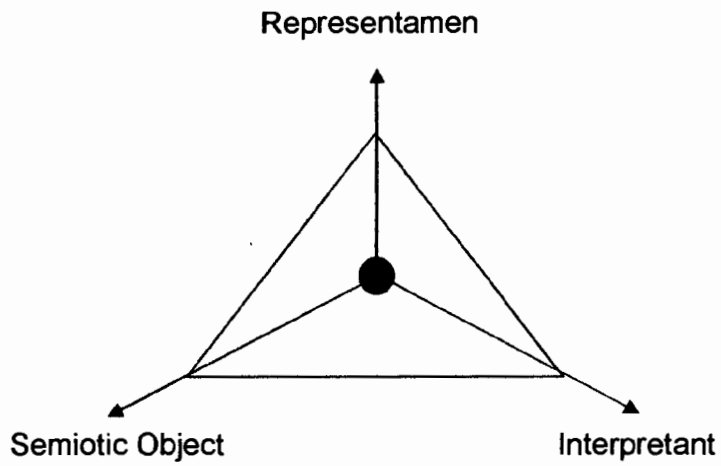

Figure 1 – Semiotic Triad

The representamen is the actual or real object; the semiotic object is as near as possible perception of what the sign is, while the interpretant is the meaning of the sign. Signs can be indexical, or related through similarity. They could be iconic, which means they are related through actual or imagined connection or they could be symbolic, related by language. Signs also can be non-verbal or verbal. The developer of semiotics is C.S. Pierce, who believed that as we make sense of signs, and cast aside our doubt, and we fix our beliefs is the function of

cognition as semiosis. The methods by which we infer these beliefs are abduction, induction, and deduction (Cunningham, 2002).

No attempt to completely explain the science of semiotics will be included. In researching the topic, documents numbering in the hundreds were discovered that attempt to explain this topic. The study of signs and how humans interpret them is known as semiotics. A closer examination semiotics and an analysis of instructors and students are discussed next.

Semiotic Analysis

An advantage of a semiotic analysis is that it can be a basis for the integration of knowledge, thoughts and emotions (Driscoll, 2002). On any given day in a nuclear plant environment, stressful situations occur they require the use of knowledge, meta-cognition and display of emotions. The analysis of the trainee can prove to be invaluable when developing training, so the instructor can know how the trainee may interpret the signs in their environment.

Another advantage of semiotic analysis is that it analyzes how the instructor interacts with their student. It also analyzes the language they use which can also affect outcome, both verbally and non-verbally. The advantages of semiotic analysis are the observation of potential communication error traps and potential problem areas for instruction and evaluation that can be accommodated in the course design.

The first analysis is of the instructor and then the student.

Instructor Semiotic Analysis

In the instructor semiotic analysis the two most critical areas are examined, verbal, non-verbal feedback and verbal signs. In simulator training, the impact the instructor has can be seen in the students as a change in behavior. This behavior is usually based on a specific verbal feedback from an instructor after students have performed an operation, or task, or by non-verbal feedback during performance of the task. The most basic behavior changes are seen by an instructor during the performance of a task when students, when some, not all students, often referred to by instructors as "watchers," will perform a task or manipulate a component and then observe the instructor for non-verbal feedback. This feedback may be a grin, smile, and turning of the head or frown from the instructor, while waiting for more non-verbal feedback from the instructor. In this case, the student is undergoing the semiotic act of induction (Cunningham, 2002). This behavior or semiosis is apparently unknown to both parties. During interviews with both the instructor and student, both admitted to not even realizing that they were providing these non-verbal actions, or modifying their behavior based on the feedback. Thus, to maintain the learning as student-centered and self-taught the instructor must be conscious that they may be providing non-verbal clues. In all cases, they must never intentionally provide these clues.

As instructors, we must attempt to eliminate any non-verbal feedback, since at the moment of execution in the plant that feedback will not be present. If the individual's supervisor provides the same or similar non-verbal feedback, the

employee may modify their behavior based on the same. This could cause an adverse outcome if the non-verbal clues had different meaning in the instructor and supervisor.

The other area affecting the instructor is a verbal sign. In choosing his words to focus student behavior the instructor must choose their words carefully. In the very subjective world of simulator training the choice of words can alter behavior dramatically. A student may perform a task and the instructor critiques this behavior as "too slow". The next time the student performs this action the outcome may be "too fast." When critiquing student behavior it is important to use wording that is as generic in nature as possible, so not to have the student abduct meaning to the words and overcorrect the behavior. To replace this wording, the instructor should choose to characterize the behavior based on facts with clear concrete wording to elicit the correct behavior. We have explored the instructor, now we will explore the student.

Student Semiotic Analysis

In this section the impact of visual and verbal signs is explored and how the student is affected by these signs. The students in the simulator have many opportunities to be placed in situations that where they construct their knowledge through cognition of signs. They range from reading meters, pushbuttons, annunciators, wording on labels, and interactions with various personnel all throughout their time as a students.

One of the largest juxtapositions students have to undergo is the shift from the color red meaning "stop" to meaning "start" in a power plant; the opposite is

the color green, meaning "go," while in a powerhouse it means, "stop". Red and green also mean open and closed, respectively. To the first time students this can be a challenge to learn. In the language of semiosis this cognitive action is tacit, in that the information is stored in the mind with other information relating to the powerhouse, and thus when immersed in the environment of the work location, the knowledge relating red to start and green to stop is automatic and requires no other prompting. This ability to juxtapose this information is given by the student learning the information in a social constructivist environment and then socially reconstructing the information in the same environment (ERIC Digest, 1998).

From a symbolic or spoken perspective, the use of words such as rapidly, stable, rising, and uncontrolled all have meaning that relates to specific situations. In many cases, students struggle with these words when relating them to operating conditions and deducing hypothesis as to the nature of the failure or event. A given indication lowering at five psig/min is rapid to one individual, while to another it is slowly lowering. Students have their own interpretation of this sign. The process is also iterative, in that as the situation develops, the students may alter their belief based on additional input from the sign. This is the effect of an on-going semiosis. In most cases, these effects are non-linear and require us to focus on these ever-changing signs. (Pierce, 1878)

Vygotsky, (Minick, 1987) argued that our higher mental functions are semiotically mediated; Cole and Wertsch (2003) reinforced this argument and maintained that these functions are also culturally mediated and we use prior

material, and practices to create an outcome. With various factors affecting development of an interpretation, one can construe the difficulty when additional dissonance is introduced by the use of vague words. To conclude our review of semiotic analysis we will examine how to apply the information we have gathered.

Instructional Application

If we are to break the paradigm that all training must be predetermined and outcomes easily measured, then surely we are bound to produce the same types of operators we have produced in the past. To effectively take advantage of the science of semiotics, then we must alter our thinking to push the bounds of our own rationality.

To do this we must attempt to answer the questions:

1. What is the goal as related to signs and processing thereof?
2. Must we be consistent from operator to operator?
3. Do we train each operator individually or in teams?
4. How might a constructivist-learning environment assist the learner, and what might the environment be?

The first question to answer is what is the goal as related to signs and processing? To answer this question we must refer back to what the operator encounters on a daily basis in the simulator and job environment. The range is from meters, changing, lights illuminating, conversations and interactions with their peers and supervisors. All of these produce an outcome for any situation

that occurs. The goal, then, must be to produce a correct outcome based on the interpretations and understanding of these interactions.

The second question to answer regards consistency, an answer that is really mandated by procedures, processes and managerial expectations of the organization. Therefore, the answer to requiring consistency is a resounding, yes. To effectively combat any situation the operator is presented with, it is warranted that the organization produce consistent responses from all operators. The question to be answered then, is it possible to attain consistency across all of the operators? Based on semiotics and constructivist environments, it appears that complete and total consistency is not possible (Williams, 2001). All individuals process and report information differently based on their prior approach to the information.

The third question of whether we train individually or in teams must be examined from a terminal perspective; what is the end product for which we expect from each particular training module? Each module or unit of training has a different outcome expected. Currently, we have classroom training in small groups and simulator training in small groups no larger than six people. The group consists of a manager, supervisor, technical advisor, and three operators. During any given training session, the group works together to combat various events presented to them. As a team, they formulate a plan of action and determine the eventual end state of the plant. During this process they use established procedures and processes to reach this end.

An additional facet of working as a team is enculturating the team members. This is a form of constructivist learning in that the team members must listen and process the subtle vagaries of their particular crew and then practice with them to learn their crew's culture. The individual, to form a change in behavior to fit in the culture, pieces the building blocks of the culture together such as the language, behavior, and attitudes.

The fourth question, how might a constructivist-learning environment assist the learner and what might that environment be? I believe that a potential future instructional method may be to separate the group and place the individuals in separate training areas. The simulator can then have an event entered and the group brought in individually and asked a series of questions. The questions would run the gambit from what event is occurring, at what rate is pressure dropping, at what rate is temperature falling, is pressure stable. Once the group has provided the answers to the questions, then they would be reunited and then the answers shared with the group and each asked to explain how they arrived at the answer. In this method, they could share their thoughts and ideas about how they reached their conclusion. In this fashion it is taking advantage of semiotics and constructivism, since when together they create the meaning for the situation and validate each other's interactions. In the end this may help to achieve some consistency in response.

Although this method would not be used for all sessions, it could be used for some classes to facilitate a better understanding of each other's positions.

The primary method still must be team training; since, this indeed, is the terminal result, the group must work together as a team in the plant.

Another potential method may be to allow the students to swap roles, thereby promoting learning from a different perspective and viewpoint. Once the roles were swapped and the students were again allowed to problem solve together and interact, they could critique themselves and discuss how their interaction together either supported or hampered each other's role. With this swap in roles the students could analyze a situation from several different perspectives.

From a constructivist viewpoint the placing the students together and allowing them to ask questions, problem solve, create new meaning and interact is an idea supported by Sharan (1985) and in his terms is called Group Investigation Method. It is how learning takes place in a constructivist world. So with this in mind, allowing the students to work independently and in teams should truly promote learning.

John Dewey and Jean Piaget also agreed that from a traditional education perspective that what a student heard was not necessarily what the teacher said. (Piaget, 1941, 1995) This would certainly seem to support the semioticist's point of view.

Summary

This paper was a review of how through the use of semiotic analysis of the instructor, the student, and the demands from the organization for consistency in operator performance training, could be developed using a constructivist

approach to provide this consistency in operator performance during all operating conditions.

Future demands of simulator training will be different approaches for each individual. What is blue to one, is teal to another. To ensure uniformity and consistency, each student must be allowed to develop the interpretation and then guided to the correct answer through group interaction. By allowing the group interaction and discussion, the knowledge can be deeply embedded and used more effectively when required. The only issue the instructor will need to continue to focus on is that the students are attaining the required knowledge and skills required for the job. Not every student may enjoy group interaction and problem solving and some may require this one on one coaching in more detail than may now be provided.

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