Knowledge elicitation solutions for improving performance and efficiency

Presenter: Sue Leveritt

Authors:
Sue Leveritt (Senior Research Officer, MISHC)
Tim Horberry (Assoc. Professor, Director of Research, MISHC)
Tristan Cooke (PhD Candidate – Human Factors & Risk Management)

Minerals Industry Safety & Health Centre (MISHC)
Sustainable Minerals Institute (SMI)
The University of Queensland

Despite advances in mechanisation and automation processes, mining remains a people intensive industry, a large proportion of whom are responsible for operating and maintaining mining equipment under conditions that challenge even the most experienced people. Mining techniques, equipment designs and the work environment are constantly evolving and changing, imposing new demands on the technical competence of workers. With the trend towards global mining companies and ease of international travel, the workforce of the future may well encompass social and cultural changes that need to be addressed. The system of work rosters used by mine sites adds a further element of change to the situation, all of which contribute to the potential for unwanted events during normal operation.

Learning from past experiences/unwanted events
Information about incidents is shared freely around the industry, but new incidents, similar to those of the past, continue to reoccur. The description of what happened is generally well documented, but too often information about why it happened and how reoccurrences could be prevented is missing or limited in detail. Thorough investigation by an experienced team of investigators can elicit useful information, but by the time the outcomes are published, the initial impact of the incident has been lost.

Many sites encourage proactive reporting of high potential incidents to help create situational awareness about hazardous situations relevant to their site workforces. Queensland Mines and Energy collates high potential and serious incident reports in a monthly summary to raise awareness about the nature and frequency of these events. The July 2010 report of high potentials resulting in a collision or loss of control of a vehicle suggests that equipment design limitations, less than adequate work environment, ineffective communication, lack of situational awareness and poor decision making skills could have been causal factors associated with these incidents.

Why do we not learn from the past? How can we equip people with the essential skills and experience to apply good decision making to unexpected situations arising in the course of normal operation?

When change occurs during the course of a shift, it is up to those directly involved in the work to manage these changes, with the operator often the last line of defence in the incident pathway. People who have a good understanding of what can go wrong and how this might happen are likely to make effective decisions that help avoid unwanted events. Others may fail to respond effectively to the situation as they do not recognise the cues and prompts familiar to more experienced operators.

Training is the recognised building block for skills acquisition used by the mining industry. The traditional approach to haul truck operator training of placing trainees in a haul truck with an experienced operator demands a high level of verbal and interpersonal skills to mentor trainees through the skills acquisition process, along with good recall of information needed to develop effective decision making skills. The quality of training outcomes relies heavily on the skills, abilities and experience of trainers to instruct, explain what might happen and how to deal with it, and to act as mentor to trainees demonstrating driver behaviours that negatively impact on safety and equipment performance.

Mentors play an important role in improving the performance and efficiency of inexperienced operators, who often have little or no experience with haul trucks or even with the mining industry. The steps to real experience are incremental, progressing at a rate determined by a number of factors, including personal experience over time and mentoring. Trainers, particularly ‘field’ trainers or mentors, draw on their personal experiences to help inexperienced trainees acquire new operational skills and to guide decision making in potentially hazardous situations.

Many sites are now using simulator training to provide trainees with a reality ‘hit’ in a safe, controlled environment that they could not experience during other modes of training. This setting offers the opportunity to give trainees firsthand experience of situations where good decision making is required to cope effectively with unexpected situations. Access to a large pool of experiences about decision making in risky situations has the potential to expand the trainer’s repertoire of advice, and so improve performance outcomes derived from interaction between the trainer and trainee, particularly during simulator training.

Trainer coaching ability is an important attribute that further enhances the potential of simulator training to help trainee operators understand WHY they have succeeded or failed to align the truck during dumping and loading tasks and HOW to cope with distractions such as 2-way chatter and proximity detection alarms. The challenge is to ensure that trainers have access to current information about decision making and problem solving that is relevant to the activities occurring at site while training is in progress.

Knowledge elicitation to understand the complexity of the decision making and problem solving process

Providing people with good decision making skills is a complex problem that changes with every new or modified piece of equipment or technology introduced into an ever changing work environment.

The Critical Decision Method (CDM) is a structured interview process that can be used to elicit knowledge from operators about their decision-making and problem-solving processes during critical incidents. The method involves the use of 'probe' questions to uncover the kinds of knowledge on which decisions are based, and the technique allows interviews to shift operators' thinking from operational and general accounts of an incident into more descriptive retelling of how they solved problems, including using cues from their environment, during the critical incident.

Over time, operators and maintainers develop tacit knowledge that helps them perform their jobs safely and effectively. Sharing of tacit knowledge acquired by experienced operators can be a hap hazard process, performed on a needs basis.

During a recently completed ACARP project (C18025), the CDM technique was introduced to two open cut coal sites to gauge its effectiveness as a knowledge elicitation tool for the mining industry. The main findings of the research showed that CDM is indeed a very useful tool to '*get in the head*' and better understand the mindset of the personnel involved in incidents. The method has proven to be of increasing value with more complex incidents. CDM interviews conducted with mobile equipment operators also revealed a level of detail about decision making directly related to causal factors that was not found in current incident investigation reports.

Knowledge elicitation as part of a process for improving performance and efficiency through application to simulator training

Information about decisions made 'on the job' is often communicated verbally during the shift, but in the absence of a recognised process to capture and communicate this information to the wider workforce, the extent of its impact may be limited to the network of people in a particular crew. ACARP project C18025 examined verbal interactions occurring across the simulator training, haul truck operation and maintenance areas in an attempt to identify a process for capturing and acting on information exchanged in this manner so that it might provide a better understanding about the risks associated with operating and maintaining mobile mining equipment.

Three types of verbal interactions – for knowledge elicitation, mentoring and training - featured prominently amongst the targeted work areas. ***Knowledge elicitation interactions*** were primarily problem solving or investigative, commonly triggered by reporting systems, but also during the course of mentoring and training. Solutions to problems could be in the form of mentoring and/or training to modify driver behaviours contributing to poor performance. ***Mentoring interactions*** were primarily advisory in nature, mostly simple pieces of advice offered by the mentor when unusual or critical events occurred during the course of normal operation. ***Training interactions***, on the other hand, were usually planned in conjunction with the particular training module being undertaken in the simulator.

Communication barriers with the potential to weaken or strengthen the effectiveness of verbal interactions were identified during the course of this research. While barriers to free flowing communication may be viewed negatively, forced interaction of trainers/assessors in the field with simulator or other office based trainers can be put to positive use. For example, restricting access to documentation required for training signoff could be utilised as a means of managing document control, standardising the training regime and to discover issues concerning field trainers.

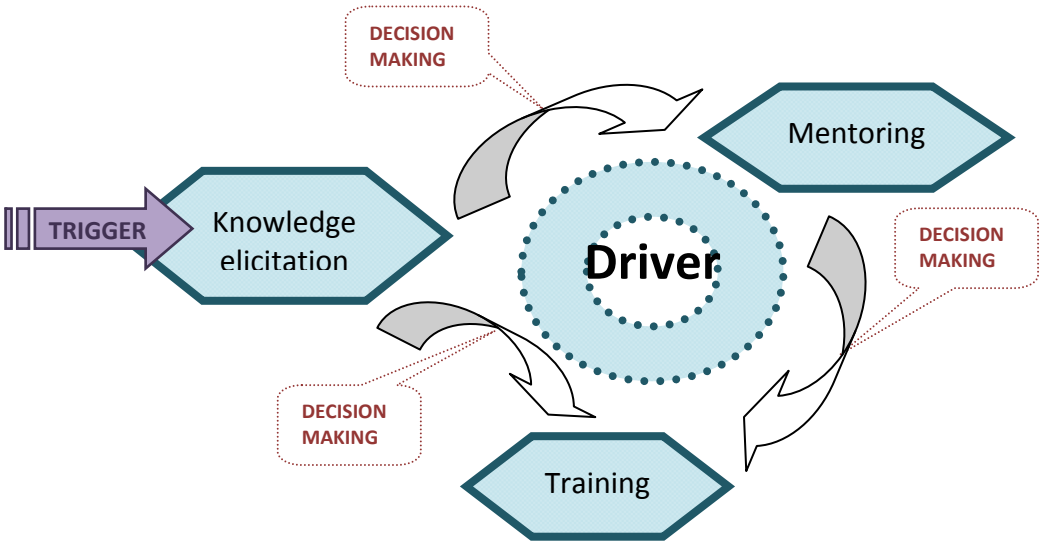
On the other hand, negative cultural attitudes, inadequate leadership and networking skills, a rapidly changing workforce, and organisational framework that leads to 'dead ends' in the communication process need to be addressed to ensure communication flows as intended.

A model of verbal interactions was constructed, incorporating the three predominant types of verbal exchanges, predominant communication nodes and the interaction strength between haul truck operators/trainees and others in the operation / training / maintenance work areas.

Implementing the model

The model suggests a process that could be used to improve training outcomes for haul truck operator performance and efficiency utilising the existing organisational framework and preferred methods of communication.

The diagram below shows the model of verbal interactions proposed to provide information for training and to facilitate training strategies to improve performance and efficiency.



The model connects each interaction type in a way that facilitates useful and purposeful responses to the outcomes of each interaction. An effective communication flow on its own is not sufficient to produce positive outcomes. Decision making, facilitated by a key ***driver***, is needed to move the outcomes of one interaction type on to the next logical step in the process. The role of the driver would be to identify the point at which decision making should occur and to communicate the decision making outcomes to the other interactants.

Triggers prompting the need for knowledge elicitation include data on truck wear & tear, particularly related to brakes, gears, tyres, and other skills needed to optimize economy of operation. Discussion amongst technical experts from the maintenance department and production supervisors would be aimed at identifying the scope of the problem. Should it be attributed to poor operator skill levels or is it indicative of a wider equipment design issue? If a problem appears widespread amongst operators, the decision might be taken to provide refresher training for the entire crew or to focus on issues with the equipment that may be contributing to the problem. The suggested knowledge elicitation process, from trigger to decision, relies heavily on the driver to see it through to completion. In the case of simulator training, this may be the simulator trainer, who should be well placed to connect with others as the need arises and to direct the outcome to the appropriate decision maker.

Knowledge elicited during problem solving and mentoring or training interactions could be channelled into training strategies to improve the range of operator skills, such as situational awareness and decision making.

Refresher training for non-routine events, such as engine fire and loss of brake function, could be used strategically to introduce new skills for equipment that has been modified or to review driver behaviours that might be contributing to excessive maintenance demands. Used for this purpose, the verbal interactions model could be considered a ***change management tool****.*

Conclusions and recommendations

It was anticipated that experienced operators would be a valuable source of information to help improve trainee operator performance and decision making. Analysis of the data collected during the research confirmed this expectation. It also highlighted the need for a training protocol to refresh operator skills, regardless of experience, to improve decision making during critical events and situational awareness related to mobile equipment performance, equipment design issues, site hazards and procedures.

This overall strategy represents a proactive human factors approach to improving performance and efficiency across three key areas of the business - training, operations & maintenance – by implementing a process that fits comfortably with the characteristics of the workforce and the site organisational structure. Equipped with higher level decision making skills and a keen understanding of the situation at hand, it is anticipated that haul truck operators will be better able to maintain the last line of defence and avoid repeating the mistakes of the past.

The future step with this research is to validate the model by incorporating it as a training strategy to improve performance and efficiency, targeting better decision making and situational awareness related to proximity detection and collision avoidance systems. It is hoped that this can be achieved by means of future ACARP-funded research.

Industry wide, the knowledge elicitation techniques outlined in this paper could be suitable for use in other mining sectors, so may be powerful additions to help capture risks associated with other types of equipment and general mining activities such as risk assessments. It is also expected that adoption of the proposed verbal

interactions model will necessitate improvement in the capacity of individuals to participate in meaningful consultation about mobile equipment and other risks, contributing ultimately to a mining OHS culture that is considered to be leading practice.

.....

The authors would like to acknowledge the support provided by ACARP and the support of site personnel who participated in this research.