Visual communication for improved safety learning and safety culture in mining industry

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Work related accidents do occur in heavy industry even though written safety instructions and routines exist. In order to improve work safety, the impact of different artefacts for visually communicating safety aspects is explored. Posters, short animated movies, a longer documentary movie, and a game-like interactive training environment prototype were explored with interviews and questionnaires. The documentary movie showed the best effect for increasing risk awareness and motivation for applying safety routines. Results also revealed a discrepancy between knowing the safety routines and actually applying them. A conclusion is that visual communication improves learning and increases motivation to follow safety routines.

Keywords: Visual communication, gamification, safety at work, work related accidents, safety culture

1. Background and purpose
This paper reports the results from a study named AIM4S (Attitudes, Insights and Motivation for Safety), which was a collaboration between Luleå University of Technology, the mining company LKAB, and the game developer Zordix. The purpose of the study was to increase the knowledge of aspects that can contribute to learning and motivation among workers in high-risk industries in order to decrease the number of work related accidents.

‘Safety first’ is a strong motto at the mining company LKAB in Sweden. However, accidents do still occur and the company is continuously searching for new ways of improving safety. An assumption in line with the conclusions of Andersson (2012) is that many work related accidents occur due to a ‘culture’ or ‘attitudes’ among workers that contribute to an increased risk taking. Andersson (2012) shows that workers often want to maintain the general, but out-dated, perception of mining industry as something dangerous and physically challenging. These factors are often associated with masculine work culture and status and are often strived for in order to maintain an occupational identity when the industry changes towards higher safety with the help of automation and improved safety equipment (Andersson 2012).

Time constraints are also an issue that contribute to risk taking. Workers who
perceive time pressure or perceive demands on increased productivity are more likely to engage in risky actions if this is believed to reduce the time of the work task (Öhrling 2014). The physical environment also plays a great role in how tools and safety equipment are used and occasionally, the physical environment prevent the proper use of such artefacts (Öhrling, Kumar & Abrahamsson 2012). Safety culture is to some extent built upon how well safety is demonstrated by the management; they should communicate a positive attitude towards safety (Wiegmann, Zhang, von Thaden, Sharma & Mitchell Gibbons, 2004). Somerville and Abrahamsson (2003) investigated means of learning safety and found that, in excess of learning through practice, incidental learning from accidents and a focus on body care was important.

Many companies only use written documents to communicate safety policies and routines. A problem with written material is that it may not reach all employees; especially employees with reading disabilities or lacking language skills. Therefore, LKAB has developed alternative ways to communicate safety with purpose to (1) increase learning of safety routines (2) remind about the safety routines and (3) create an attitude and habit to follow safety routines at all times. The focus of the study was to investigate how employees and subcontractors at LKAB perceive the alternative ways of communicating safety. The study includes different types of visual communicating artefacts and a gamification based interactive training environment, and if they can mediate safety routines in a way that contribute to workplace safety. There is a need to explore if visual communication can contribute to a safer work environment and the reasons why employees do not always follow safety procedures.

1.1 The visual communication artefacts
By using new artefacts for safety communication, LKAB is hoping the safety routines will reach employees and subcontractors to a higher degree than before. It is also hypothesized that visual communication will strengthen the building of a healthy safety culture. Visual artefacts can be used to evoke emotions, which are believed to create a motivation to follow the safety procedures. Gamification is another approach, believed to create motivation for learning and training. With gamification we mean using game mechanisms in an area where games are not normally used (Deterding, Sicart, Nacke, O’Hara & Dixon, 2011), in this case as an interactive safety training game.

The newly introduced artefacts of visual communication at LKAB are here called: Silent boards, Silent movies, Documentary movie and Posters (Figure 1). In addition, Zordix developed an Interactive training environment (Figure 1) for evaluation purposes during the project. The silent boards and silent movies demonstrate safe work procedures using pictures and animations without text and sound. The silent boards are placed at the worksites. Hence, workers can view the safety instructions and routines while performing the task that are addressed in the artefacts, as an instruction and a reminder. Monitors with silent movies are placed next to elevators, inside internal buses, and at bus stops within the LKAB industrial area, i.e. at places where employees
and subcontractors are awaiting and have time to watch them. The posters, which are placed in connection to offices and in corridors, portray workers and management personnel performing high-risk leisure time activities, dressed with proper safety equipment. The purpose with the posters is to remind the employees to apply safety routines and to use safety equipment all the time, not only at work. The posters can also be interpreted as a reminder that you need to be safe at work in order to keep living an active life outside work. As some of the posters portray managers, LKAB also want to signal that safety thinking concern all employees, from the floor up to the highest levels. The documentary movie depicts a real and severe workplace accident where the employees involved describe the accident and reflect upon how it could have been avoided. The documentary movie has been used as workshop material with all LKAB employees where they have watched the documentary and discussed it in small groups. The interactive training environment, developed as a prototype by Zordix, was a new concept never tried before at LKAB.

Figure 1. The visual communicating artefacts
2. Methodology
Data was collected at LKAB through qualitative interviews and questionnaires. These methods are described below.

2.1 Participants
Eight employees (process operators, control room operators, mechanics, and production managers, all with different age, gender, and years employed) and two subcontractor electricians participated in the investigation. All participants had seen the visual artefacts investigated in the study. The exception was the interactive training environment, which were developed during the project.

2.2 Material
During the study, pictures describing the visual artefacts and the interactive training environment were used as support in discussions and during evaluations (Figure 1). The short silent movies were shown in full length to the participants during the study. However, the documentary was too long to show in full length. A short passage (1 minute) of the documentary movie was shown. In addition, the main parts of the documentary movie were printed as a series of images (Figure 1). The interactive training environment was also shown as a series of images.

2.3 Interviews
The interviews were semi-structured and all respondents, except for the subcontractors, were interviewed individually. The interviews lasted for 30-45 minutes. The purpose with the interviews was to investigate how the participants perceive the artefacts (including the interactive training environment prototype), used for visual communication of safety. In addition, the employees and subcontractors were asked questions regarding possibilities to control their own work, as well as perceived workload and perceived safety culture. Another purpose of the interview was to investigate how the ‘safety first’ motto was respected in relation to demands of production rate. The interviews were transcribed verbatim and the responses were categorized and summarized. In order to keep objectivity, three researchers read, coded and summarized all interview material in collaboration.

2.4 Questionnaires
All of the interviewed participants filled in a questionnaire with purpose to complement the interviews by quantifying their opinions regarding the visual communication artefacts. The questionnaires were also used as a basis for discussion during the interviews. The first part of the questionnaire was based on the technology acceptance scale developed by Van Der Laan, Heino, and De Waards (1997). The assessment method consists of nine 5-point rating scale items in form of word pairs, translated to Swedish. One of the original item (Nice-Annoying) was excluded. The
word pairs used in the study were: Useful - Useless, Pleasant - Unpleasant, Bad - Good, Effective - Superfluous, Irritating - Likeable, Assisting - Worthless, Undesirable - Desirable, and Raising alertness - Sleep-inducing. The results were analysed with nonparametric analyses in SPSS with a significance level of .05. In addition, the questionnaire included a matrix with all artefacts and the categories: Learning, Reminding, Increase risk awareness, and Motivate action. The respondents were asked to tick the categories that best described the purpose of the different artefacts. The respondents were allowed to tick more than one category for each artefact. The results were summarized in a table.

2.5 Procedure
All interviews began with general questions regarding the participants work tasks and how they perceive their control, workload and safety at work. Thereafter, the different artefacts were shown, discussed and rated, successive, i.e. one artefact was discussed and rated before the next artefact was introduced. The interviews ended with the categorization of all artefacts.

3. Results
Both the result of the interviews and the questionnaires show that the silent boards and silent movies were primary perceived and rated as good reminders of already familiar safety routines, and not primary as learning material (Table 1). However, a majority of the respondents said they believed that the effect of the boards would decrease with time. The silent movies were believed to be more effective, however, they are less suited within the working area because they demand some viewing time and, hence, cannot replace the boards as reminders during specific work tasks.

The perception of the posters varied. Some respondents thought that the mediated message was to remain safe also in spare time. Others thought that the message was to bring safety awareness at home to work. Further, some interpreted the posters as a message saying that it is important to stay well and healthy at work in order to maintain the leisure activities you like. However, a majority of respondents were doubtful that the posters would increase the safety awareness at work. They were more seen as posters building closeness between management and operational employees, showing that all were alike at leisure time, sharing the same interests.

All of the respondents were familiar with the documentary movie and stated that it was the most effective artefact for preventing prevailing attitudes and risk taking. The documentary movie caused emotional responses and was described as good at giving insights of how easily accidents can occur and what the consequences could be. The respondents also stated that the documentary movie would be useful for education of newly employed and subcontractors but also as a reminder for all employees. They thought it was well suited at workshops since documentaries takes time and is good to discuss. They did not think a documentary would be suitable to show during work, as the silent boards.

None of the respondents had previous experience with the interactive training
environment prototype. The majority were vaguely positive and thought that it could be useful for educating purposes. Most respondents agreed that the interactive training environment should offer some challenge, as a game, and not be too easy to complete. They also believed that the more text could be replaced with images, video, or audio, the better it would be for learning. Many thought that if the interactive training environment would become a recurring element in their work, some kind of incentive in the form of prices or rewards would motivate use. The categorization of the artefacts according to learning, reminding, increase risk awareness, and effect actions are summarized in Table 1.

Table 1. Perceived purpose of different media types.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Silent boards</th>
<th>Silent movies</th>
<th>Documentary movie</th>
<th>Posters</th>
<th>Interactive training environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning</td>
<td>7%</td>
<td>43%</td>
<td>86%</td>
<td>0%</td>
<td>71%</td>
</tr>
<tr>
<td>Reminding</td>
<td>86%</td>
<td>86%</td>
<td>57%</td>
<td>43%</td>
<td>43%</td>
</tr>
<tr>
<td>Increase risk awareness</td>
<td>36%</td>
<td>57%</td>
<td>93%</td>
<td>36%</td>
<td>29%</td>
</tr>
<tr>
<td>Motivate actions</td>
<td>36%</td>
<td>50%</td>
<td>93%</td>
<td>21%</td>
<td>29%</td>
</tr>
</tbody>
</table>

The questionnaire results considering word pairs showed that the documentary movie were rated more positive than the Poster ($p = .007$) and the Interactive training environment ($p = .023$) in general. The documentary was rated higher than the other media regarding the adjectives Useful, Good, Effective, Assisting, Desirable, and Raising alertness.

3.1 The need of reminders and learning
None of the respondents stated that they felt unsure about how they were supposed to follow the safety routines. Instead they said that they know how to work in a safe manner but thought that the silent movies and the silent board still could work as reminders or injunctions in the working areas. They mentioned that safety routines sometimes were neglected due to different reasons (see part 3.2). Some of the respondents also stated that the silent boards and movies could be useful before a safety inspection.

When introduction of safety to new colleagues were discusses several employees expressed a need of standardised routines. More experienced employees should educate the new employees of the safety routines and many perceived a burdensome responsibility for ensuring no details in the safety routines were missed. This was something that most of the respondents felt uncomfortable with and one suggested some form of checklist as support. The majority of the respondents also reflected upon the fact that “bad habits” easily could be transmitted from them to new employees, unintentionally.
The two subcontracted electricians stated that LKAB felt as one of the safer work sites that had been working at. Even so, they wished for better information about safety routines and did not feel that they knew enough about the routines to feel safe during work. This was described as a general problem for subcontractors and not as a specific LKAB problem. The subcontractors thought the visual artefacts could help in this aspect and suggested that information should be displayed in the waiting room at the guard at the entrance. That visual information could also be adjusted to show more general subcontractor tasks.

3.2 The need to motivate the ‘safety first’-motto
The respondents were all familiar with the ‘safety first’-motto but the perceptions of how well it was followed varied. Some of the respondents said that the motto was followed without exceptions while others (mainly employees with a long employment) admitted that the safety instructions were not always followed. The most critical factor, when it comes to neglecting safety routines, was a perception of non-easy accessible safety equipment. Some respondents mentioned they considered the effort and time it would take to find or fetch the safety equipment in relation to their apprehension of risk. One of the respondents gave an example of a ladder, which seldom was close by when needed. So instead of fetching the ladder the employee climbed and balanced on the safety railing even though the respondent was well aware of the risks and that the type of climbing was against regulations. Some employees also described that they degraded the safety routines if the routines were perceived to be in conflict with personal comfort and with a more desirable method of conducting the work. The respondents also mentioned situations when the safety routines actually could not be followed, e.g. the use protection glasses in warm environments due to problems with mist.

4. Discussion and conclusion
According to this study, visual communication of safety routines was positive and promising, at least as a complement. No artifact could meet all criteria, being both a learning material and a reminder. However, a more ordinary introduction course or a text material would not fulfill all criteria either. A combination of several means of communication, including both verbal and visual messages and discussions are probably a good way. The study did not find any opponents to an increased communication of safety, rather the opposite. The respondents did not see the communication as reprimands but as a confirmation that safety matters and should be considered at all times. Among the artifacts discussed in the study, the documentary movie appeared to be the most effective means to motivate safer behavior at work. The movie was said to give an increased understanding of how easily accidents can occur and what the consequences could be. The documentary movie was emotional, perhaps because it described a real accident told by the affected employees with their own words. This made it more real and close to reality. The close to reality format created a
true feeling of “this could actually happen to me,” employees explained, and this was a key factor to increase motivation to mind safety.

The documentary was found effective in creating risk-awareness and to motivate safety actions, but it was clear it could not replace other types of visual communication. Documentaries demand time for viewing, contemplation and discussions in order to be fully effective. Other means of conveying messages are better for reminders. Silent movies, and to some extent silent boards appeared to work well for that purpose. Silent movies can advantageously be placed at even more locations, for example at the guard office at the entrance, in toilets or in lunch rooms, i.e. places where employees and subcontractors gather and spend waiting time.

The posters with colleagues conducting leisure time activities were liked by the employees and mediated a kind of family feeling. However, the posters were not perceived as a reminder of safety at work. However, viewing the effects of how a work related injury would affect life outside of work could be used as a motivator. Posters could mediate the importance of getting home safe to one’s family and not only communicate that rules must be obeyed.

The respondents were slightly positive to the interactive training environment prototype. The reason that the responses were not more positive or negative is probably due to the fact that no one had actually tried out the artifact. Thus, it was hard to draw conclusions regarding the usefulness of gamification as a tool for learning safety. A complementing study with a fully functioning game is needed.

When safety was discussed in general, the respondents expressed a need for additional visual material when introducing and supervising newly employed. This material could support them in their role as teachers. Also, the more experienced employees seemed to have a higher tendency to take shortcuts in safety procedures, and these shortcuts risk to be inherited by newly employed. Visual reminders, an accessible interactive training environment or a checklist may counteract this.

Some workers expressed worries that the ‘safety first’ motto will be challenged by cut downs and increased demands on efficiency and production rates. These worries indicate a good result in creating a well-functioning safety culture among employees. One employee explained that, previously, safety needed to be forced and taught top down, but now the employees want to feel safe at work.

This study also revealed a discrepancy between what employees say and what their closest management says. The middle management claims safety is never compromised. However, technicians and operators sometimes experience an indirect pressure to take shortcuts from the management. There exist situations when the ‘safety first’ motto comes in conflict with the production demands. When all focus lies on solving a production problem as quickly as possible safety is sometimes omitted in the communication. Production may never be put above safety, explicitly, but sometimes problems became difficult to solve in a safe way. The existing visual artefacts, together with an interactive training environment, could build a support to lean on and as a reference if, or when, contradictions occur on how specific safety
routines should be followed. A documentary could also be effective to watch in small
groups with both workers and management in order to discuss and elucidate the
priority conflict between safety and production demands.

Based on the findings in this study, visual communication could be
recommended as means to decrease work related accidents in mining industry.
Pictures and movies can be recommended as learning tools and as a reminder of safety
routines. However, in order to change attitudes towards safety and create a motivation
to follow safety routines it appeared to be important to create emotions and use close
to reality examples with severe effects. Further, the results suggest that an interactive
training environment may be a useful tool for learning and to validate knowledge.
However, further studies on interactive training environments are needed. The results
of this study also elucidates the conflict between different goals, i.e. production and
safety, and the problem with subcontractors not being equal the ‘in house employees’
when it comes to risk and safety education.

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