Making Training More Cognitively Effective: Making Videos Interactive

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Abstract

The cost of health and safety failures to UK industry is currently estimated at up to £6.5 billion per annum with the construction sector suffering unacceptably high levels of work related incidents. Better health and safety education across all skill levels in the industry is seen as an integral part of any solution. Traditional lecture-based courses often fail to re-create the dynamic realities of managing health and safety (H&S) on-site and therefore do not sufficiently create deeper cognitive learning (which results in remembering and using what was learned). The use of videos is a move forward, but passively observing a video is not cognitively engaging and challenging, and therefore learning is not as effective as it can be. This article describes the development of an interactive video in which learners take an active role. While observing the video, they are required to engage, participate, respond, and be actively involved. The potential for this approach to be used in conjunction with more traditional approaches to H&S were explored using a group of second year undergraduate civil engineering students. The formative results suggested that the learning experience could be enhanced using interactive videos. Nevertheless, most of the learners believed that a blended approach would be most effective.

Introduction

The level of accidents and ill health within the construction industry still remains at an unacceptable level with around 70 workers being killed annually (HSE, 2006). Significant gaps in the training of senior management (technical and leadership skills), project managers (project integration and performance monitoring), site supervisors and designers have been identified, impacting on H&S (Egan, 1998). Current training regimes also have to cope with increasing numbers of ethnic and migrant workers entering the industry at all levels with varying levels of English ability and potentially, different perceptions of risk. It is now considered that H&S in education should be presented 'as an intellectual challenge illustrated by practical example' (HSE, 2001; HSE, 2004), following on from the Governments target set out in the 'Revitalising Health and Safety' strategy (DETR, 2000). Current approaches to delivering health and safety material can sometimes promote surface learning where students learn to meet presumed assessment requirements and do not adapt and use the information gained in the way it would be in reality. This can manifest itself in several ways, but most noticeably through the repetition of course content in exams (Entwistle and Entwistle1, 1997),

A key question concerning the current educational delivery mechanisms is whether the basic recall of lecture notes in an exam environment (e.g. for NEBOSH, National Examination Board in Occupational Safety and Health or undergraduate degrees), or the recognition of answers in a multiple choice setting (CSCS test, Construction Industry

Training Board ‘Construction Skills Certification Scheme test) is preparing individuals to execute, apply and prioritize matters of H&S in the field (Biggs, 2003 p.43). Methods of assessment that encourage and require students to engage directly with problems will also encourage them to use and apply their learning, facilitating the deep approaches which are desired (Entwistle, 1988)

The scope for improving health and safety training using interactive video

Despite the extensive use of video streaming as a tool to support and facilitate learning, (Shephard, 2003) one of its major drawbacks is the inability of the learner to fully interact with the medium (Laurillard, 2002) and the lack of user control. Interactive video can be defined as, ‘the use of computer systems to allow proactive and random access to video content based on queries or search targets’ (Zhang *et al*,, 2006) representing the fusion of two pervasive technologies. With the recent advances in multimedia technologies, interactive video can be synchronised with a wide range of media formats (e.g. PowerPoint slides, graphics, simulations) which increase the intensity of visual and verbal cues.

An early example of interactive video applied to the area of interpersonal skills training was undertaken by Rushby (1987). ‘Who do you think you’re talking to?’ used video sequences as part of a training package designed to aid bus drivers learn how to deal with difficult and potentially aggressive passengers. In related research, Rushby and Schofield (1988) developed a tool to allow trainee recruitment managers to interview simulated applicants. The applicant was generated using 150 short video sequences ‘triggers’, each showing a different type of organizational issue. Applicant responses were played to the trainee manager in response to the questions chosen from a comprehensive database. The technique brought reality to the issues concerned and the trainee could experience the range of possible behaviours that could be expected by a candidate.

The University of St Andrews developed an interactive video library of case studies for teaching and assessing the communication skills of medical undergraduate students (Laidlaw, 2007). Video clips were used in combination with question sets and transcripts of doctor-patient interactions to investigate student's communication skills. Newcastle University used similar interactive approaches to provide a realistic learning alternative to performing rat dissections. The 'Rat Stack' project used a digital video library containing over 2000 high quality still video frames along with 500 short dissection sequences (Quentin-Baxter, 2007) to quiz students on techniques and procedures. Staffordshire University's Law School developed a series of interactive video lessons to help students practice their legal skills in a simulated court room (Hibbs and Vaughan, 1994). The student played the role of the defendants advocate and could halt the screen action at any point to object to questions which they believed contravened the rules of evidence. When the correct grounds for the case have been identified, the trial was completed and the user awarded a performance score and provided with the opportunity to view all the objectionable sequences.

Powell et al (2008) addressed the use of interactive video as part of a simulated environment to help train fire officers to deal with major fires. The tool was used to address the fundamental problem of how best to balance basic fire fighting demands with the need to maintain an accurate and up-to-date picture of an incident, particularly when command structures change as fire size increases. Videos of real fires were used with subjects interacting with the footage dependant on the demands of the scene (asking for more fire appliances etc). The subjects were evaluated according to their performance (resources used, effectiveness of communications, and the impact of their response). The results suggested that the tool was effective in engaging the trainee fire officers but certain characteristics of real fire fighting (feedback from colleagues, smoke, noise) were hard to replicate in a simulated setting.

The multi-sensory learning environment created by video (Zhang *et al*, 2006) has the capacity to i) increase an individuals ability to transfer information from the short-term to long-term memory, whilst creating a more effective learning experience (Cairncross & Mannion, 2007) and ii) enable learners to engage in a variety of ways with the learning material which appeals to the different learning styles. However, videos do not automatically and necessarily achieve these goals unless they are designed carefully to enable the information to be retained in long term memory and that the user will not be overloaded and distracted from the actual learning materials. Interactive learning environments can also generate effective instruction and a flexible and motivating learning experience (Wong *et al,* 2006) which is important for knowledge acquisition. The use of interactive video to enable learning through the process of experiencing failure (Schank, 1997) has great potential for fostering 'deeper learning' (Bloom, 1956) and enabling a more effective application of principles learned in the workplace, accelerating the process of skill acquisition (Schwan and Reimpp, 2004). A recent project (Boyle, 2007) investigated the available professional qualifications in construction management, the current delivery mechanisms related specifically to H&S training, and the potential for improved training through innovative pedagogical approaches. From a sample of 55 training providers, ‘chalk-and-talk’ was the most widely used teaching method (approximately 95% of providers) with some student centered learning and problem based learning techniques also being utilised. No evidence was found of interactive video being used as a learning tool.

Despite these potential benefits, the very nature of an interactive learning environment implies an increased cognitive load on the learner due to the number of activities required and decisions needed (Schwan & Reimpp, 2004). If learning is to occur, and information is to be coded effectively by the cognitive system for long-term retention, it is imperative to design and construct the learning tool in a way that correctly utilises the cognitive attention mechanisms. To achieve this, one needs to design learning with the ‘Three C’s of Learning’ in mind: Control, Challenge, and Commitment (Dror, 2008). When learners have control over their learning, they are more involved and participate in the learning process which is critical in maximising engagement. Similarly, when the learners are challenged and are committed to the learning process, then they are active and the cognitive system is utilised properly (Dror, 2008).

Aims

Using the knowledge gained from the substantial literature in both health & safety training and cognition & interactive educational systems, this study set out to produce and assess a prototype interactive risk assessment video, designed to complement an existing lecture given to second year civil and environmental engineering students on the subject. A key objective of the work was to determine if (and how) interactive videos could enhance the learning experience in this field.

Methodology

Risk assessment is taught as part of a Construction Management module given to second year undergraduate civil and environmental engineering students. This takes the form of a 45-minute lecture using a static example of a traffic engineering case study as a group exercise. Images of the survey site are presented to the students and the group have to complete a standard risk assessment form stating the key hazards involved in the experiment (collecting vehicle registration plate data by the roadside using cameras) and how they would mitigate the negative impacts. A fundamental part of the lecture is to demonstrate the importance of lateral thinking in risk assessment, particularly during initial experimental design.

Following the lecture, the students (n=75) were asked to access the interactive video through a web link and follow the instructions to complete the risk assessment task. Their responses were stored in a MySQL database and were analysed to assess their understanding of the significant risks associated with the experimental set-up. As part of the overall assessment, the students were finally asked to complete a questionnaire, designed to assess the students' reactions to the interactive video as a teaching aid, alongside the existing lecture.

Developing the video

Due to the inherent difficulties associated with gaining access to working construction sites, particularly when the intention is to film issues related to health and safety, a traffic engineering subject, familiar to the author's was chosen for the prototype. The subject matter was based on a well practiced technique used for vehicle registration plate capture and was designed to show the risks associated with the set up and filming of traffic on a busy road. The footage was taken from the perspective of how not to undertake the fieldwork.

The experiment set-up was digitally filmed in one continuous take lasting just over two minutes. Students play the footage and identify issues they feel are risky, giving free text details of how they would mitigate the negative impacts. After the student has played the video and identified the risks, a series of still shots are shown relating the correct method of experiment set-up relative to each key risk involved   These are finally shown in real-time when the video is played again. The video scenes were meticulously planned and the real on-street hazards minimized during the filming by having 'off-camera' safety personnel. Camera positioning, hazard identification, incorrect and correct equipment set-up was all planned in set 'scene' sequences.

Making the Tool Interactive

The digital footage was imported into the Adobe Flash authoring environment. The interactive video was designed to operate in three distinct stages:

1) The footage is watched and hazards identified by clicking on locations in the video which generate free text boxes and statement declarations that the player completes. Once finished, this information is submitted to a database along with the name of the player.
2) Each hazard which is apparent in the video is then shown to the player with text and images to explain why it is a hazard and how to avoid this situation arising.
3) The video is viewed again as in 1) however this time each hazard is identified for the student in real-time as the video plays.

The video is played through a web browser and can be stopped, paused and re-wound at any point until the end is reached. The act of clicking on any part of the footage pauses the video and brings up the hazard identification form (Figure 1). At the same time, the x and y position of the mouse pointer at that specific point are recorded along with the time the player clicked the mouse button. The hazard identification form asks the player to describe the hazard at that particular point and who may be affected by it. They are then asked to describe how they would mitigate its impacts and rank the hazard in terms of the likelihood of an accident occurring as a result (1 to 5, 1 = ‘very unlikely to happen’, 5 = ‘certain to happen’) and what the consequences would be (1 to 5, 1 = ‘no injury but a near miss (possible minor property damage)’, 5 = ‘fatal accident or multiple injuries’).

This information is then stored within the system ready to be sent to the database. The player can revisit all incidents that have been selected to make amendments if needed.

Figure 1 here

After the video has been viewed once in its entirety, a basic calculation (unknown to the player) is carried out comparing the number of hazards identified against the actual number present. If there is a disparity, the system suggests that the student re-examine the video and either look again for more hazards or review the hazards already identified. Upon reaching the end of the video a second time, the interactive element finishes and all hazard information along with the student's name is sent through the web browser via the HTTP POST protocol to a MySQL database.

Once the video has finished, the official hazards are then shown to the player. A still image of each hazard (taken from the video) is chronologically displayed accompanied by text explaining the hazard along with still images illustrating various solutions. (The approach of presenting subjects with images of the correct procedure, post-response follows that adopted by Quentin-Baxter, 2007). The player can navigate between hazards by using the 'next' and 'previous' buttons.

After viewing all the still images of the hazards (e.g. Figure 2), the system then asks the student to watch the video one more time from start to finish. During this phase of the learning cycle, the video is replayed from the beginning and the hazards identified in real-time, the footage momentarily pausing and highlighting each particular issue.

Figure 2 here

Capturing player responses

The MySQL database contains the information submitted via the hazard identification form for each hazard identified by the player. This contains their free text responses describing each hazard and the ways they would design out the risk along with their ‘accident likelihood’ and ‘accident severity’ scores, the co-ordinates of the mouse pointer and the run time elapsed since the start of the video. A novel element to this research was establishing cue points when encoding the video to allow the course instructor to jump to the appropriate point where the hazard was identified. The instructor is then able to view all the submitted data from players using the administration panel. By clicking on a hazard identified by a player, the video jumps to the appropriate time and shows where the player clicked in the footage (Figure 2).

Evaluation

Hazard identification

An analysis of the MySQL database suggested that over 60% of the students correctly identified the major risks associated with stopping on double yellow lines, obstructing the pavement during unloading and equipment set-up, heavy lifting (related to the car battery) and the lack of high visibility clothing and safety footwear being worn by the technician (Figure 3). All these hazards were displayed during the first minute of the two minute video and suggest that player engagement and interaction could be at its strongest during the initial scenes. Of the significant hazards that were not well recognised, students failed to identify the vehicle hazard lights or roof mounted wig-wag as not operating (60%), and any shock risk (76%) or more importantly, any acid risk (96%) associated with using a car battery as a power supply for the camera.

Figure 3 here

The two other major hazards associated with the experiment (conflict with members of the public associated with i) attempted theft of the equipment or ii) filming individual vehicles and drivers) did not feature as specific scenes but should have been identified by the students. Sixty eight percent of the students did not highlight theft of equipment as an issue likely to cause harm to the technician whilst 84% did not recognise the risk of conflict through being seen to infringe civil liberties. The findings from the database analysis suggest that although some of the key hazards which featured earlier in the footage were recognised, the more subtle hazards requiring lateral thinking were not picked up. The second and third parts of the interactive video were designed to in-grain the learning by demonstrating the hazards and respective solutions that would be considered 'reasonably practicable' to mitigate their impacts. The qualitative questionnaire gave an insight into how the students found this part of the process having completed the first stage hazard identification.

Student perception of the interactive video as a learning aid

The students were asked whether they felt that they learned effectively from i) the lecture only, ii) the video only or iii) the lecture and video combined. A Likert scale (1 to 5) was used where 1 indicated that the student 'strongly agreed', to 5 representing 'strongly disagreed'). The results showed that 64% 'strongly agreed' that the lecture and video combined was the most effective delivery mechanism (a mean score of 1.4 on the Likert scale) being significantly preferred to the video on its own which was felt to be less effective, (3.65 on the Likert scale), using a one-way ANOVA and subsequent Scheffe multiple range test ($F = 57.2$, $p<0.001$, $MS_e = 25.6$). When the students were asked to describe what they liked about the interactive video, the presentation of hazards as still images and then in the context of the moving footage after the initial hazard identification was highlighted, *"I liked the fact that it was interactive and held your attention. I also liked how it goes through all the hazards at the end so you can see what you've missed*." *"The showing of the solutions was very good allowing time for the hazard to be accepted and showing when it occurred."* Many students commented that their hazard awareness was heightened using this medium of presentation and helped contextualize the concepts discussed in the lecture, *"It put into context what I had learnt from the lectures. Also demonstrated the many different risks associated with something as simple as erecting a camera." "It showed what was learnt in the lecture in a real life situation which is very memorable." "Easy to follow, visual things usually make you learn a subject easier."*

Aspects of the interactive video that were not well received were when multiple hazards were present in the same defined area which the student wished to identify but was unable due to the single entry form. The initial instructions were criticized by some for not providing enough detail on the task and an example hazard, risk and related mitigation measure presented to the player was suggested as a useful way to introduce the interactive video.

Finally, the students were asked whether their experience of using the interactive video following the lecture had enhanced their learning experience. On a 1 to 5 scale, (1 = 'strongly agree', 5 = 'strongly disagree'), 75% of the students either 'agreed' or 'strongly agreed' that the interactive video had enhanced their learning experience. The results do suggest that the interactive video is best used to complement the existing lecture as a means of 'hands-on' experience, as one student stated, *"Lecture should teach concept, videos very good at reinforcing this concept."*

Conclusions

This research has helped to qualify the ways in which interactive and graphic-rich videos could be used to make the risk appraisal and management learning experience more 'inclusive' and exciting. Sixty five percent of the students 'strongly agreed' that the lecture and video combined were an effective combination of learning tools for new students with 75% stating that the interactive video had enhanced their learning experience.

With the emphasis on 'multi-skilling' and continual professional development, interactive video could be used to empower learners from across the spectrum (professionals seeking refresher courses to unskilled labourers preparing for CSCS) from a place and at a time best suited to their needs. Such tools could be used to teach both ‘hard skills’ (e.g. site emergency evacuation procedures) and ‘soft skills’ involving human interaction (e.g. decision-making under time pressure, communication, motivation and leadership) and help promote a deeper learning approach by linking multiple ideas and concepts together within a personally engaging environment. To do this effectively, it is critical to develop such learning technologies in a way that takes into account (and harnesses) the cognitive mechanisms underlying learning and memory (Dror *et al*, 2008). It is envisaged that this pilot project will be the start of a programme to provide interactive H&S training for construction site workers. This could lead to a ‘European Health and Safety Construction Skills License’ in the same vein as the European Computer Driving License that is recognized across Europe. It could also create spin-offs in many other industry sectors that are bound by H&S legislation.

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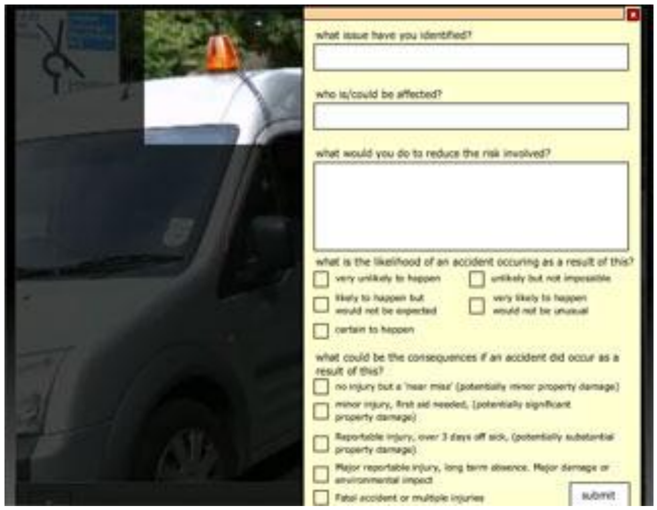

Figure 1: Interactive video screen shot showing the hazard identification form relative to the hazard identified by the player (highlighted square with mouse pointer in centre)

Watch Video | Admin

	Hazard	Who is affected?	Reduce hazard by..	Likelihood	Severity
Player 1	large heavy battery	anyone who lifts the battery	try to obtain lighter batteries, if not possible then ensure all persons who lift the battery are properly trained to avoid injury.	Unlikely but not impossible	Minor injury, (first aid) less than 3 days time lost (significant damage)
	unloading the van into the pavement	general public, passers by	stack objects out of the way	Very unlikely to happen	Minor injury, (first aid) less than 3 days time lost (significant damage)
	inapoppriate footwear	the person unloading the van	ensure proper footwear is worn	Unlikely but not impossible	Minor injury, (first aid) less than 3 days time lost (significant damage)
	passing traffic have to change their course to avoid the van	persons in the passing cars, people on the pavement, van driver.	minimise the time the van has to be stopped, try to pick a time of day to set up the equipment when the traffic flow is not too heavy.	Unlikely but not impossible	Fatal accident or multiple injuries
	van pulling off into busy road	van driver, other drivers, pedestrians	ensure the van driver has a licence and is aware of the risks.	Unlikely but not impossible	Fatal accident or multiple injuries
	loose wires, trip hazard	pedestrians and the operator	ensure the operator is properly trained and aware of any pedestrians around him.	Unlikely but not impossible	Minor injury, (first aid) less than 3 days time lost (significant damage)
	traffic passing the site at speed	operator of equipment	wear high visibility jacket	Very unlikely to happen	Fatal accident or multiple injuries
	tripod in the middle fo the pavenemt	pedestrians	move it further out of the way or put a barrier around it to alert pedestrians of the danger	Very unlikely to happen	Minor injury, (first aid) less than 3 days time lost (significant damage)
	improper lifting of the battery	lifter	ensure proper training is provided	Unlikely but not impossible	Minor injury, (first aid) less than 3 days time lost (significant damage)
	unstable deck chair	person sitting on the chair	ensure chair is on a stable surface	Very unlikely to happen	Minor injury, (first aid) less than 3 days time lost (significant damage)
	operator is not paying attention to his surroundings as he is engrossed in setting up the camera	operator	ensure the operator keeps all round observation up whilst setting up the equipment	Very unlikely to happen	Fatal accident or multiple injuries
	pedestrians may be distracted by a man bending ove infornt of them, which could result in them tripping over the equipment, or walking into the road	pedestrians with a wandering eye	ensure the operator doesnt wear flattering clothes	Unlikely but not impossible	Fatal accident or multiple injuries

Figure 2: An example of the database viewed through the administration panel (The 'unloading the van into the pavement' hazard identified by the player has been clicked to show the original mouse position)

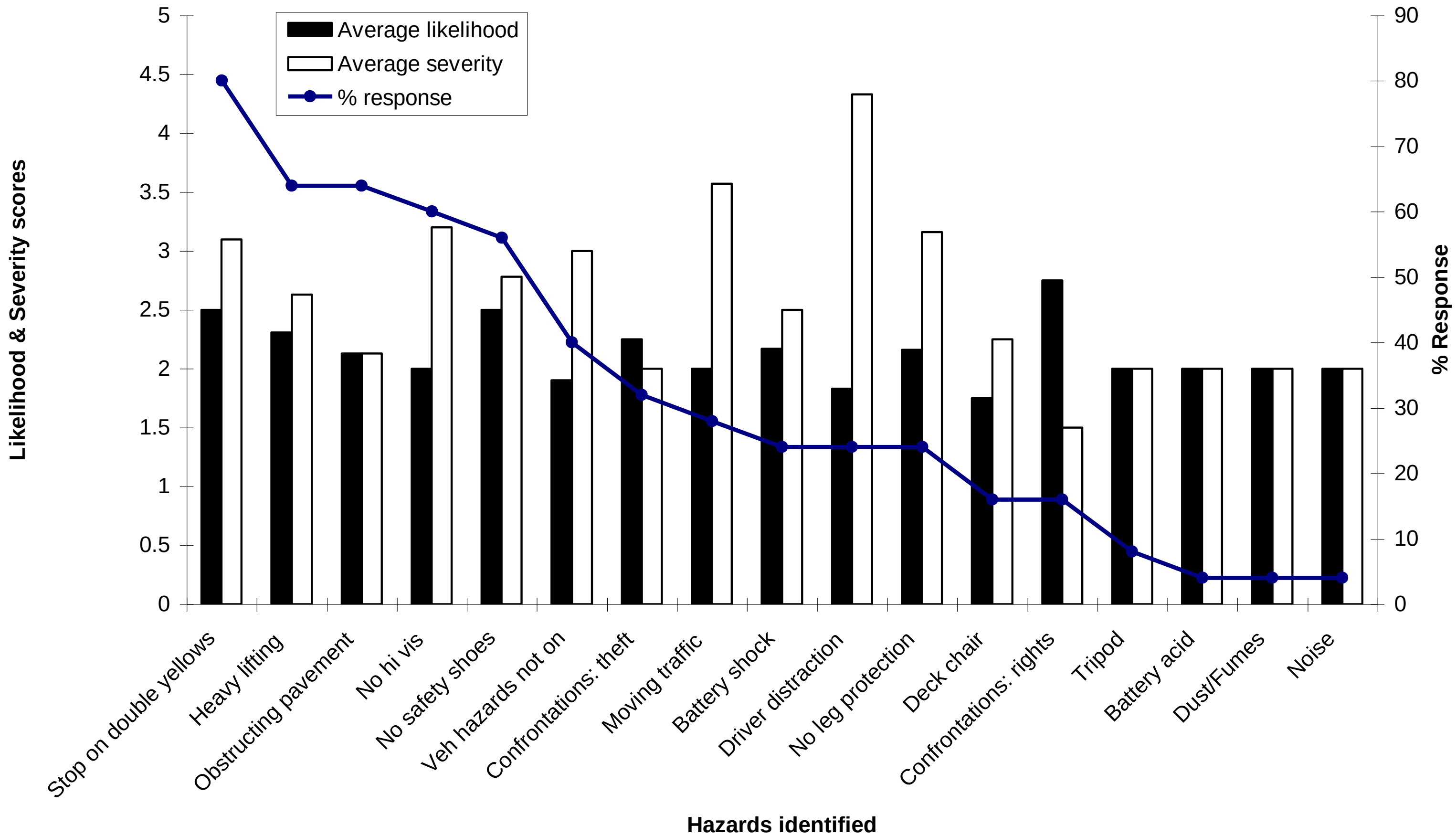

Figure 3: Significant hazards (%) identified by the students along with the mean likelihood and severity scores