Improving designers' knowledge of hazards

www.iosh.com/designershazards

Research summary

Our research and development programme

IOSH, the Chartered body for safety and health professionals, is committed to evidence-based practice in workplace safety and health. We maintain a Research and Development Fund to support research, lead debate and inspire innovation as part of our work as a thought leader in safety and health.

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Improving designers' knowledge of hazards

What's the problem?

The importance of designers in the management of OSH risks relating to construction is well documented. The UK's Construction (Design and Management) Regulations (2015) place duties on designers of construction projects to consider the health and safety implications of their designs in relation to the construction, use and maintenance (including cleaning) of structures. However, the majority of designers fail to recognise the impact on health and safety that they can make.

A knowledge-based system seems to be the favoured method of giving designers the ability to make informed decisions on Designing for Occupational Safety and Health (DfOSH). However, text-based systems have proven to be cumbersome, whereas visual (pictorial, multimedia) databases may be able to overcome the problems posed by such systems and provide a more effective solution.

What did our researchers do?

The aim of the research was to improve how designers involved in construction projects learn about how their design can influence the management of OSH. It focused on the impact of design decisions on OSH risks during the construction, use and maintenance of structures.

To achieve this aim, the following objectives were set:

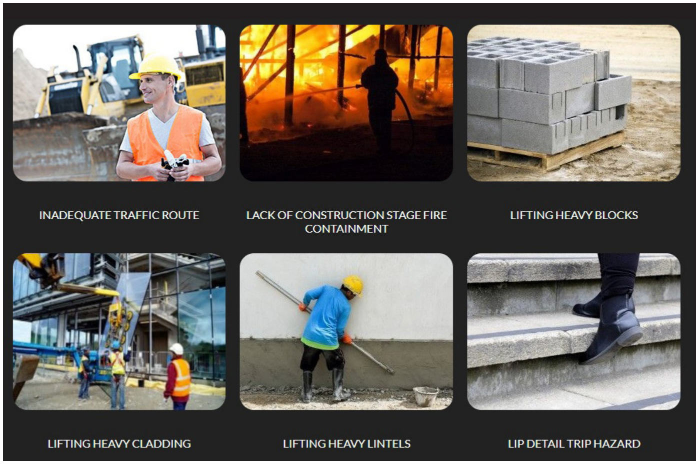
1. identifying sector-specific hazards that can be influenced (either mitigated or aggravated) by designers of construction.
2. evaluating strategies by designers of construction to prevent or mitigate the hazards identified in objective 1.
3. developing a 'hazards test' for designers, tailored to sector-specific hazards (based on the findings of objectives 1 and 2).
4. developing mixed-media strategies to fill the 'experiential knowledge gap' of designers who work on construction projects, to improve their ability to complete the 'hazards test', thereby improving their ability to identify, prevent and mitigate hazards.
5. validating the mixed-media strategies (of objective 4).
6. developing a pilot database of mixed-media materials to aid designers of construction in their statutory duty to identify, prevent and mitigate hazards flowing from their design.

The method used was initially exploratory, combined with an experiment to evaluate the ability of a multimedia digital tool intervention on designers' OSH knowledge and practices. Sector-specific hazards, which can be influenced by designers of buildings and structures, were identified through a systematic review of academic and industry literature. Other experienced professionals were recruited from the research team's industry network. The 'design-influenced hazards' informed the development of the multimedia digital tool and linked hazard tests in the form of Computer Aided Design (CAD) drawings.

A sample of 40 (20 novices and 20 experienced) designers from two typical industry groups of architects and civil engineers was recruited for the next stage of the research. The designers were invited to engage with the developed materials in a carefully controlled experiment, which evaluated the effects of the multimedia materials on decision-making and users' capability in designing for OSH in the construction industry. The experiment determined whether use of the multimedia materials improved users' ability to foresee OSH hazards in designs by measuring both the quantity of specific hazards identified and the quality of design outcomes (design controls) put forward.

The designers were randomly assigned to multimedia user (experimental) and non-user (control) groups, who were permitted to use the internet for help. The experiment tested the multimedia digital tool against general internet searches.

Screenshot of hazards on homepage



Participants were asked to review the set of CAD drawings in these sessions, identify hazards and make decisions about designing for OSH. A weighting was allocated to designers' decisions, based on their recommendations against the following hierarchical list:

Control	Examples	Score
Eliminate (through design)	prefabrication; locate item at ground level	5
Reduce (through design)	design-in edge protection; substitution of lesser hazard	4
Reduce (engineering controls)	local exhaust ventilation; temporary edge protection	3
Inform of administrative procedure	'contractor to provide method statement'	2
Control through PPE	'contractor to provide PPE'	1

Data were compared for multimedia-user and non-user groups and also for novice and experienced designers. This consisted of collecting data before and after use of the multi-media tool and corresponding data for the control group. Statistical analysis of the resulting quantifiable data allowed identification of any rise in frequency of hazards identified, or 'hierarchy' score for controls, among the designers.

What did our researchers find out?

The 40 designers identified hazards a total of 599 times. These were sorted into 29 categories. The most common types of hazards identified by all designers were in relation to work at height. But this was supplemented by mostly health-related hazards after the introduction of the multimedia tool. The experimental group (who used the digital tool) identified 339 hazards in total, whereas the control group only identified 260. This difference was due to the post-intervention differences: experimental group 105, control group 27. The largest increases in the experimental group related to issues highlighted in the tool – for example, high-level lighting; flooring and paint COSHH; and welding steel frame. The smaller increase in the control group (using the internet) included hazards relating to dust and hazardous substances.

Number of hazards identified

	Before	After	Total
Experimental group	234	105	339
Control group	233	27	260

Civil engineers identified more hazards than architects; 318 and 281 respectively. Architects tended to identify more building-related hazards: open edges and structural openings, trip hazards and so on. Civil engineers gravitated towards civil engineering issues such as piling, temporary works and excavations.

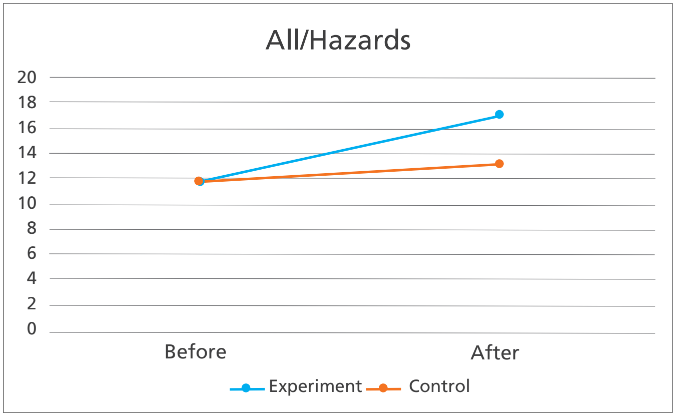
Novice designers identified 293 hazards while experts identified 306. However, these figures constitute an increase of 105 hazards identified post-intervention by novices and only 27 by expert designers. This increase in the novice figure was due to 70 additional hazards identified by the experimental group. The novice-experimental group also improved the scope of hazards identified, with increases in 21 categories compared to only 16 in the control group.

Filtering architects and civil engineers into experimental and control groups revealed a similar pattern: architects using the tool identified over three times the number of hazards as their control group post-intervention; for civil engineers the figure was five times. In both cases the scope of hazards identified was double that of the control group.

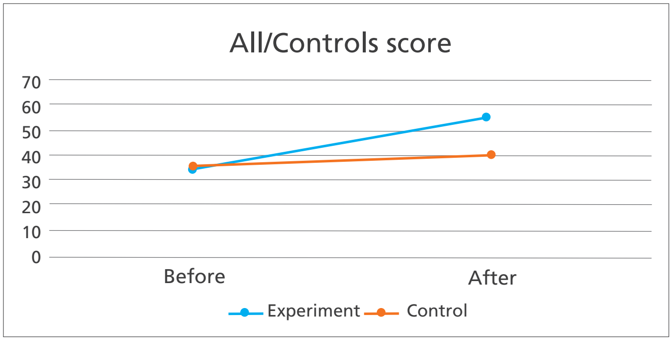
Mean averages were used to measure changes pre- and post-intervention. Hazard data were used, supplemented by a weighted score for the level of controls recommended by designers to address the hazards identified. The average number of hazards identified by designers pre-intervention was almost identical for experimental (11.7) and control (11.75) groups. However, post-intervention figures were 16.95 and 13.1 respectively, which were statistically significant. This pattern was repeated throughout the sub-groups of novice, expert, architect and civil engineer.

The average scores for 'controls' changed pre- and post-intervention in a similar way. The pre-intervention average scores for experimental and control groups were 34 and 35.6 respectively. However, the experimental group increased to 55.85 post-intervention, while the control group increased to only 39.1. This change was statistically significant.

Average hazard numbers per designer



Average score for 'controls' per designer



What does the research mean?

The results showed that all experimental groups out-performed control groups, with the novice groups demonstrating the greatest increase in both hazards spotted and quality of alternative options recommended. This means that using the multimedia digital tool was more effective than merely searching the internet, especially for inexperienced graduates.

Future integration of the tool with Building Information Modelling (BIM) technology would provide an ideal opportunity to develop further and test the theories around visualisation and the application of knowledge databases through visual means. This may also help to determine additional strategies to help architects in particular gain more from use of the tool.

Don't forget…

The research had the typical constraints of a 12-month study, which limited the scope to only two types of designer and a maximum of 40 participants. This had implications for statistical tests once filtering was performed to the point where only five cases per group could be used.

Practice points

The research highlights several issues that practitioners should consider:

- The prototype database and CAD drawings make for excellent training and educational resources. These should be recommended for training and educational purposes, particularly for architects.
- The digital tool should be developed and expanded for eventual use as a project tool, aligned with BIM PAS 1192-6 as a means to help designers identify hazards and recommend suitable controls when developing and reviewing designs and specifications.
- The digital tool should be owned by an organisation capable of monitoring, updating and sharing its contents in a transparent way. It is anticipated that its future success will depend on an 'open' format, with gatekeepers, so that experienced designers can continue to share their experiential knowledge with novices. This way, the content will grow and remain relevant.

Other IOSH resources

We have a range of resources on some of the topics covered in this research, including:

- Building safely by design - Using digital design models to improve planning for safe construction **www.iosh.co.uk/designsafely**
- Teaching health and safety in undergraduate engineering course **www.iosh.co.uk/teachinghs**

Our summary gives you all the major findings of the independent study by Glasgow Caledonian University. If you want to read about the study in more depth, you can download the full report from www.iosh.com/designershazards

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PS0825.2/020719/PDF