FALLS FROM HEIGHT-

RISK PERCEPTION OF LADDER USERS

WITHIN THE UK CONSTRUCTION INDUSTRY

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ABSTRACT

Accidents involving falls from portable ladders occur at a rate of forty per week in the construction industry. Ladders are so common that they are taken for granted and the perceived risks are often under-estimated. The purpose of this study was to analyse the risk perception of operatives using portable ladders, and to develop and test a ladder-use training aid. The research used a quantitative, within-subjects survey, consisting of three structured questionnaires administered to four hundred respondents attending construction related training programmes. The surveys used images of actual ladder-use situations, and were carried out in two stages; the first stage measured the level of risk perception and sensation seeking before any training had taken place, and the second measured any change in the level of risk perception following the use of the ladder training-aid. Initial pre-training results revealed that operatives over-estimated the risks from high-level ladder use situations, and under-estimated the risks from low-level ladder use situations. Post-training results showed an improvement in risk perception, especially for low-level situations. It was concluded that risk perception varies both with the individual and their level of experience, and that the training-aid had a positive impact on the improvement of ladder-use risk perception.

Keywords: Falls, ladder, risk perception, training aid.

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List of Abbreviations

ACSNI	Advisory Committee on the Safety of Nuclear Installations
ARCOM	Association of Researchers in Construction management
CBI	Confederation of British Industry
CCNSG	Client Contractor National Safety Group
COHS	Centre for Occupational Health and Safety
CITB	Construction Industry Training Board
CD	Compact Disk
CDM	Construction Design and Management
CLG	Constructors Liaison Group
CONIAC	Construction Industry Advisory Committee
CSCS	Construction Skills Certificate Scheme
DETR	Department of the Environment, Transport and the Regions
DTI	Department of Trade and Industry
DVD	Digital Versatile Disk
EPA	Environmental Protection Agency
EU	European Union
GB	Great Britain
HAS	Health and Safety Authority
HASS	Home Accident Surveillance System
HMSO	Her Majesty's Stationary Office
HSC	Health and Safety Commission
MMR	Mumps, Measles Rubella
MPEG	Moving Picture Expert Group
HSE	Health and Safety Executive
INSAG	International Nuclear safety Advisory Group
OSHA	Occupational Safety and Health Authority
OSH	Occupational Safety and Health
PASW	Predictive Analytics Software
RIDDOR	Reporting of Injuries and Dangerous Occurrence Regulations
RHS	Revitalising Health and Safety
ROSPA	Royal Society for the Prevention of Accidents
SME	Small and Medium Enterprise
SPSS	Statistical Package for Social Sciences

List of Abbreviations

SSO	Systematic Self Observation
SSS	Sensation Seeking Survey
UK	United Kingdom
USA	United States of America
USB	Universal Serial Bus
USEPA	United States Environmental Protection Agency
WWW	World Wide Web

Chapter 1 Falls from height

1.1 Introduction

The Health and Safety Commission (HSC, 2002) has identified falls from height as the most common cause of injuries and death to employees in the construction industry of Great Britain (GB). An analysis of their published statistics shows that over a five-year period between 1996 and 2000 falls from height accounted for 49% of fatalities, 34% of major injuries, and 12% of over-3-day injuries, mainly involving falls from roofs, ladders, and scaffolds. Falls from height have also been the most common kind of accident to the self-employed, accounting for 59% of fatalities 43% of major injuries and 20% of over-3-day injuries, over the same period.

Falls from height is also an international problem, and is the leading cause of deaths in construction worldwide. An analysis carried out by Cattledge, et al. (1996 cited in McDonald, 2002) on construction fatalities in the United States of America (USA) between 1980 and 1989 found that 49% of all occupational related fatalities were due to falls in the construction sector. McVittie, et al. (1997) compared occupational falls in the USA to those in Ontario Canada between 1988 and 1992, and found that 40% of all fatalities in Ontario were due to falls to a different level. A study of construction related fatalities in South Korea (Byung, 1998) between 1991 and 1994 showed that falls from heights accounted for 42% of all construction related fatalities. The picture from the European Union (EU) member states is not clear, as individual countries define and report workplace injuries in different ways, some including commuting accidents in their statistics. Eurostat (1996), published statistics for fatalities based on common definitions, using a standard rate of injuries per 100,000 workers. The EU average rate was 3.6 per 100,000 workers, the GB rate was 1.9, showing that the EU average fatalities to be twice that of GB. They clearly identified the highest rates of workplace fatalities to be in the construction sector and during 1996 the standard rate per 100,000 workers was; GB 5.6, Germany 8.6, Italy 17.6, France 20.8 and Spain 28.9. Their evidence also suggested that the injury rates from falls are similar to those of the rest of the world, at approximately 50%.

Myers (2003), the Health and Safety Executive (HSE) Chief Inspector for construction, identified falls from height as the single biggest cause of death, disability and injury in the construction industry, accounting for almost half of all deaths and nearly a third of major injuries in 2001/2002. Across all industries in Great Britain the HSE statistics reveal that falls from height accounted for 68 deaths, 5708 major injuries, and 8986 over-3-day injuries in 1999/2000 (Table 1.1).

Fall accident injury		UK Industry 1999 / 2000	Construction 1999 / 2000
Number of workers		27,542,500	1,962,500
Fatal	Number	68	42
	Rate per 100,000	0.3	2.1
Major	Number	5708	1779
	Rate per 100,000	21	91
Over 3-day	Number	8986	1495
	Rate per 100,000	33	76

Note: The accident data are those reported under the RIDDOR system

Table 1.1: Comparison of accident rates for falls

1.2 Height of fall

Bomel Consultants Limited (2003) in their report for the HSE on falls from height, which was carried out from a pan industry viewpoint, analysed data from employers and the self employed, via the Reporting of Injuries and Dangerous Occurrences Regulations (RIDDOR, 1995) over a five-year period between 1996 and 2000 inclusive. They identified that whether the fall results in fatality, major or over-3-day injury largely depends on the height of the fall. Bomel's analysis shows that nearly all fatalities result from a high level fall (above two metres), as opposed to a low level fall (below two metres), and it can be anticipated that high level falls will lead to a higher percentage of fatalities than low level falls. However, in an analysis of fall accidents, Snyder (1977) showed that people who fell from a low level landed on their heads 76% of the time, and people who fell from a high level landed on their feet 63% of the time. Therefore in relatively low falls, the head is more likely to be injured than in higher falls, with a greater risk of a serious injury (Table 1.2).

Industry	High falls				Low falls			
	Serious		Slight		Serious		Slight	
Agriculture	52	66%	27	34%	57	59%	40	41%
Construction	891	69%	405	31%	891	57%	670	43%
Manufacturing	447	63%	262	37%	514	39%	819	61%
Service Industries	383	57%	189	43%	492	39%	769	61%
Energy	23	68%	11	32%	37	44%	47	61%
Total	1796	64%	994	36%	1991	49%	2345	66%

Note: These figures only include accidents where the type of fall has been specified.
Taken from Clift (2004)

Table 1.2: Relationship between injury profile and distance fallen

The RIDDOR reported injuries are even more significant because there is evidence to show that they are severely under-reported. Research carried out as part of a Labour Force Survey for the Office for National Statistics (Institute of Employment Research, 2000) shows that the rate of falls from height is more than twice that indicated for employees and that the self-employed report less than 5% of non-fatal injuries. This problem is also evident in the USA where it was estimated from an analysis of labour statistics that between 33% and 69% of all non-fatal injuries were missed, representing a substantial under reporting (Leigh, 2004).

Clift (2004) in an evaluation of the performance and effectiveness of ladder stability devices concluded that *'falling off a ladder is by far the most significant agent of falls from height, resulting in construction accidents'*. Bomel (2003) from their study of construction accident statistics highlighted that portable ladders are involved in the largest number of accidents, being associated with over 4600 injuries resulting in an average of 8 fatalities and 530 major injuries per year, representing 11% and 47% respectively of falls from height. The Bomel (2003) report also identified that falls from ladders are almost equally divided between low and high falls, accounting for over 2500 and 2100 of falls respectively during the period 1996 to 2000. The total number of actual falls from ladders is unknown, however taking into consideration the known number of falls and those that are estimated to be under-reported; the number is probably closer to 2000 per year, representing a rate of approximately 40 per week in Great Britain.

1.3 Portable ladders

British Standard European Norm 131(BS EN, 1993) defines a ladder as a device incorporating steps or rungs on which a person may step to ascend or descend, and defines a portable ladder as a ladder which can be transported and set up by hand, without mechanical aid. There are basically two types; those that are self-supporting, and those that require support. Self-supporting types, normally called stepladders are two-piece, and are available in heights up to three metres incorporating up to 14 treads. Those that require support are known as leaning rung ladders and include both one-piece ladders, available for heights up to 10 metres, and extending ladders, having two or three sections arranged to slide parallel to one another, which can be hand or rope operated, and are suitable for heights up to 16 metres.

Clift (2004) from studies of available literature concluded that recommendations for the safe use of portable ladders were vague, and open to wide interpretation. The studies identified that for straight ladders, slipping at the base was the most common event preceding a fall, and that low angle of inclination was the most common contributory factor, thus confirming research previously carried out by Rice (1993, cited in Clift 2004). Clift identified that ladder falls were mainly due to reduced friction caused by the ladder not being erected at a suitable working angle, for example 75º, or a quarter of the height, one out four up ratio. Axelsson and Carter (1995) questioned 85 ladder accident victims in Sweden to obtain detailed information about factors contributing to their accident. Their report '*Measures to prevent portable ladder accidents in the construction industry'* agreed with previous research that for stepladders the most common event preceding a fall was the ladder tipping sideways, and for straight ladders the most common event preceding a fall was the ladder slipping at the base.

Clift (2004) concluded that '*user-related factors are by far the largest cause of accidents*' (Table 1.3) and that there were also a variety of factors implicated in the accidents attributed to manufacturing or design faults. It was also concluded that falling off a ladder is by far the most significant agent of falls from height resulting in construction accidents.

Causes associated with ladder falls	Frequency (rounded percentages)
Untied and un-secured ladder	33
No known cause	21
Over-reaching	13
Slipped/lost footing	8
Defective ladder	6
Knocked off	5
Overbalanced	5
Scaffold overturned	5
Dismantling	2
Age of victim	2

(Clift, 2004)

Table 1.3: User related factors in the causation of ladder accidents

Bomel (2003) concluded that *'despite the safety knowledge relating to ladders, the causes of falls tend to remain the same'* and the current advice or regulations do not appear to be preventing portable ladder accidents.

1.4 Perception of risk

Bomel (2003) developed a network to gain an insight into the underlying influences on falls from height and the work identified that one of the main factors that had a direct influence on falls was the risk perception of operatives. It was suggested that this was at least partly due to familiarity with the hazard and complacency towards the risk e.g. '*it won't happen to me'*. Inadequate risk perception was thought to contribute to accidents, in that people recognise the hazard but do not modify their behaviour accordingly, and have a greater perception of risk for work at high levels but an underestimation of risk at low levels. Clift (2004) identified that the perception of risk varies both with the individual, and with their level of expertise, and where a situation is familiar; the perception of risk is likely to be lessened. It has also been reported by Page (2000) that people are more willing to accept risks, and that some individuals actively seek out risk rather than avoid it, described by Zuckerman (1994) as '*thrill seekers'*.

Holmes, et al. (1999) identified that if the necessary safety measure is perceived to present too great a level of effort it will be ignored. The perception may be that the cost is the extra work effort required to implement the safety procedure. Johnson, et al. (1998) came to the same conclusion but further showed that workers would forgo personal safety if they felt speed and comfort were more important. Bomel (2003) concluded that awareness was the key factor, and although large companies take ownership and responsibility for safety, smaller companies and the self-employed do not put safety high on their agenda, if at all. Therefore, if the level of injuries associated with ladder falls is to be significantly reduced, and the industry is to meet its revitalising targets it is essential that personnel are made more aware of the risks, and the consequences of falling, especially at low levels.

1.5 Research

It is clearly established that in the construction industry, accidents caused by falls from height continue to be a major problem. Also established is the fact that many of the falls occur whilst using portable ladders and that an operative's perception of risk is a major contributing factor. Despite the high numbers of victims suffering the consequences of a fall from a ladder, there has been little research into the area of risk perception which may assist ladder users. The construction sector continues to have the highest incidence of ladder accidents, demonstrating that the existing safety measures are inadequate and that there is a need for research into this area in order to help understand and improve the situation.

This research therefore focuses on the of risk perception of portable ladder users before and after administration of a ladder-use training-aid, which was designed and developed by the author (Appendix E) with the aim of raising awareness of the risks involved with low-level ladder use. It uses three instruments for the data collection and analysis: a ladder-use survey, a sensation seeking survey and a risk perception survey (Appendices A, B and C). The ladder-use survey was developed by the author to help produce basic operative information by determining how portable ladders are being used on-site and also to test the participants perception of risk to given situations. The second instrument involved the use of Zuckerman's (1994) 'sensation seeking' test which was used to help determine the level of sensation seeking of the individuals. The third instrument also designed by the author, involved the use of a risk perception survey which followed the use of the training-aid.

1.6 Thesis outline

Chapter 2: Literature review - In making reference to literature several issues are considered. Firstly the research problem of risk perception is more fully defined by considering the characteristics of risk, the psychometric paradigm, risk communication. Secondly, the underlying influences and critical factors involved with falls from height are considered. Thirdly, behaviour change, safety culture, choice architecture, ladder training aids and current legislation related to falls from height are reviewed.

Chapter 3: Methodology - provides a description and justification for the research instrumentation, the determination of appropriate population and sample size and the description of pilot studies. It describes how the data was collected and analysed, how ethical issues were addressed and the limitations of the methodology.

Chapter 4: Results and Analysis – to aid clarity the results and analysis have been presented in the same order as administering of the questionnaires. The first section contains results from the ladder-use survey (stage one), the second contains the sensation seeking results (stage two), and the third stage contains results from the risk perception surveys. Predictive Analytics Software (PASW) is used to provide survey analysis for discussion, including comparative range, mean and datum scores. Regression analysis is used to test for relationships between sensation seeking and respondent demographics and pairs sample *t*-test used to test the null hypothesis of no relationship between risk items. Each output has been presented separately in chart format, (frequency tables are provided in Appendix D).

Chapter 5: Training-aid – provides a description of the design and use of the height awareness training-aid. It highlights the interactive format and use of case studies, questions, images, audio and video content to enhance the learning experience.

Chapter 6: Discussion – provides discussion of data contained within the results and analysis section, and comments upon levels of risk perception for different variables.

Chapter 7: Conclusions and further research – summaries the main findings and contributions from the thesis and identifies limitations and areas for future research.

Chapter 2 Literature review

2.1 Introduction

This review focuses on the risk perception of operatives using portable ladders in the United Kingdom construction industry. Initial research suggests that risk perception is part of a complex combination of factors which do not happen in isolation but are part of a wider system. The review therefore includes the underlying influences considered to have an effect upon risk perception and the training aids, legislation and strategies currently in place to help solve the falls from height problem.

2.2 Risk

Risk is a commonly used everyday word defined in the Oxford English Dictionary (2000) as the *'possibility of loss'*, which is rather simplistic, and although it is suggestive to a point, the definition is imprecise about how possibility and loss combine with each other to determine risk. The question of what people mean when they say something is '*risky*' has led to many attempts by researchers to identify the key dimensions of risk.

Since the initial studies of Starr (1969) there have been many definitions of the term which can be attributed to a wide variety of disciplines including, financial, health, environmental and security. Fischhoff, et al. (1981) defined risk as the '*existence of threats to life or health'*. In medicine, risk has been defined as the '*chance of some adverse outcome*' (Kleinbaulm, et al., 1982), such as *'death or contraction of a disease'*. In economic literature, *'opportunities whose returns are not guaranteed'* are described as risks (Camerer and Kunreuther, 1989). Although they are all using the same 'risk' expression they may have totally unrelated concepts in mind, which is reflected in the many different definitions of risk that appear throughout literature, for example:

- The possibility of either financial or physical damage (Starr and Whipple, 1980)
- The possibility of some adverse effect resulting from a hazard (Lowrence, 1976)
- The cost associated with the possibility of failure (Massmann and Freeze, 1987)
- The uncertain situation in which a number of possible outcomes might occur, one or more of which is undesirable (Merkhofer, 1987)
- A measure of the probability and severity of adverse effects (Yates, 1992)
- The possibility of suffering loss or injury (Babcock-Gove, 1981)
- The potential of unwanted negative consequences (Rowe, 1977)
- The chance of danger (Water, 2003)

In recent years there has been a change in emphasis for the meaning of the term risk. Dake (1992) examined the concept of risk from an historical perspective where risk was defined as '*the probability of an event occurring combined with an accounting for the losses or gains that the event would represent if it occurred'.* However, this idea, that risk is essentially a wager, which individuals take in hope of gaining something significant, or substantial, has effectively been lost in current thinking. Graubard (1990) summarised that risk today is conceived principally as danger and now carries largely negative connotations of loss or harm. This loss definition is however not universally accepted as Douglas (1990) states that '*risk is the probability of an event combined with the magnitude of the losses and gains that it will entail….*'

Merkhofer (1987) uses a definition that allows several outcomes not all of which are bad, and Adams (1995) suggests that 'risk is defined by most of those who seek to measure it as the product of the probability and utility of some future event'. Adams argued that 'the decisions that are made in the face of uncertainty involve weighing the potential rewards of an act against its potential adverse consequences'. As other researchers have extended the work of Starr (1969) by examining the various types of risk, the list of characteristics identified as important has continued to grow.

A psychological risk approach by individuals was highlighted in the work of Tversky and Kahneman (1974) who studied a person's cognitive processes applied to complex risk problems. Although the work has been used as a focus point by risk researchers it has been criticised by Douglas and Wildavsky (1982) for focussing on the individual whilst ignoring the importance of interaction between the individual and their environment. This has lead to the development of conceptual risk frameworks (Kasperson, et al., 1988) which have considered both the psychological and sociological perspectives in a multi-disciplinary approach in shaping a person's perception of risk. The relationship between an individual's beliefs, and attitudes in predicting risk behaviour was the subject of research by Fishbein and Ajzen (1975) who proposed a '*theory of reasoned action'*, in an attempt to predict individual behaviour. Unfortunately people's attitudes or perceptions about risk did not match their behaviour.

Risk in industry is defined by Ballard (1992) as the *'frequency of an event multiplied by the consequences of the event',* suggesting an expectation of failure. This suggests an acceptable level of risk and that events that happen often must have a low consequence or events involving serious consequence must be rare. Fischhoff, Watson and Hope (1984) argue that no single definition of risk can be correct since no definition can be suitable to all problems. They view the risk definition as *'expressing someone's views regarding the importance of different adverse effects in a particular situation'.* This is supported by Winterfeldt, et al. (1981) who view risk as an 'abstract construct that gains specific meaning only in the context of particular stimulus sets'.

One thing that is clear from the literature is that there is no all encompassing definition of risk; however what most definitions have in common is agreement that risk has two characteristics:

- Uncertainty - an event may or may not happen
- Loss - an event has unwanted consequences or losses

Any definition of risk is likely to carry an element of subjectivity, depending upon the nature of the risk and to what it is applied. Chicken and Posner's (1998) interpretation is: 'Risk = Hazard x Exposure'. They define hazard as *'the way in which a thing or situation can cause harm',* and exposure as *'the extent to which the* *likely recipient of the harm can be influenced by the hazard'*. Harm was taken to imply injury, damage, loss of performance and finances, whilst exposure encompasses notion of frequency and probability. Sandman (1998) defined risk as Risk = Hazard + Outrage, death rate was defined as the hazard and everything that the public considered part of risk was collectively labelled outrage.

2.2.1 A new definition of risk

A new definition has been proposed by Green (2000) which defines a hazard as '*anything with the potential to cause harm'*, and a risk as '*the likelihood of the hazard being realised and the degree of possible harm'*. Therefore, risk is 'the philosophy concerned with the understanding of the nature of harm associated with the hazard. Risk can be considered as a systematic way of dealing with hazards (Beck, 1986). If it is assumed that there is '*uncertainty associated with any prediction of a hazard being realised then there is only uncertainty because there is only ever a prediction of the likely occurrence'* (Beck, 1986). Therefore for a risk to exist there must be a hazard.

The perception of a hazard is *'entirely subjective',* what one person finds hazardous, another might not (Green 2000). It is the way in which we feel threatened by circumstances and in turn the opinion we develop by association with the threat or hazard. Green (2000) concluded that *'the perception of hazard is centred around previous experience, cultural values and to some extent the aspect of specialist training in an area or field of expertise to which the hazard relates'.*

2.2.2 Measuring risk

Smithson (1989) identified that one of the most common techniques for measuring risk is to allocate probabilities to undesirable events, as nearly all accounts of uncertainty refer to the concept and theory of probability as a benchmark. However there is strong debate whether it is in fact possible to calculate probability of a single event and Morgan and Henrion (1990) state that the probability is actually a property of a theoretical infinite sequence of trials rather than a single event. This misunderstanding can lead to errors such as extrapolating probabilities from small samples Morgan and Henrion (1990). The alternative view of probability is the personal view which defines probability in terms of personal belief and subjective judgements (Smithson, 1989). Probability is therefore rather limited as a measurement tool, because it is based on past events. Bernstein (1996) points out that data based in the past constitutes a sequence of events rather than a set of independent observations that are required in the laws of probability.

The use of probabilities for assessing risk suggests that it can be measured impartially. However Botterill and Mazur (2004) found that in some instances perceptions of risk do not appear to correlate with measurable probabilities and that other factors are clearly important. The calculation of probability therefore appears not to be a value free activity. Judgement is required to select relevant factors required to calculate risk involved, and then to determine the appropriate risk management strategy (Botterill and Mazur 2004).

Botteril and Mazur (2004) concluded that while there are considerable theoretical and technical limitations to using probability as a predictive tool, there are also substantive implications for basing assessments strictly along these lines. A more conventional technical meaning of the term risk can therefore be used referring to *'a combination of the probability, or frequency, of occurrence of a defined hazard and the magnitude of the consequences of the occurrence'*. How often is a particular potentially harmful event going to occur, and what are the consequences of this occurrence (Harding, 1998). A similar measurement method was used by Hansson (1989) who multiplied the probability of a risk occurrence by its severity which could then be used to compare risks. A weakness of this method is that it does not distinguish between risks that involve a large probability of minor consequences and those that involve a small probability of a major catastrophe (Beckwith, 1996).

2.2.3 Assessment of risk

Assessments of risk are increasingly being used by 'experts' to define a level of risk in the decision-making process. The siting of nuclear power plants and the use of mumps, measles and rubella (MMR) vaccination are two examples that evoke public concern, who ask '*what will happen if something goes wrong?'*.

The assessments of risk by 'experts' are increasingly being targeted as not being a science but being more related to art or 'hocus pocus' (Gregory, 1989). The very act of carrying out a risk assessment was observed by Konheim (1988) as validating concerns about the seriousness of the threat, and suggested that the term be changed in favour of 'health impact statement' or some other statement with less emotive connotations.

Beckwith (1996) reported that there is growing body of evidence (e.g. Freudenburg, 1988; Freudenburg and Pastor, 1992; Hyman and Stifel, 1988; National research council, 1989) which suggests that research may be flawed as assessments of risk may be subject to judgemental and other types of validity errors, which include:

- Failure to predict the cumulative impact of individual minor problems
- Drawing conclusions from small samples
- A tendency to see meaning even when events are random
- A tendency to fit ambiguous evidence into predispositions
- Excluding low probability events from the analysis
- Insufficient attention paid to assumptions made from small sample sizes
- Failure to identify interrelated components

Beckwith (1996) identified that while risk assessments have a place in risk decision making, it is increasingly difficult to argue that they should be the sole basis for decision making. Rushefsky (1982) rejected the risk assessment process arguing that because the first stage focuses on the measurement of risk and the second on the process of evaluation this creates an objective / subjective dichotomy. His rejection of the process was based on the measurement of risk being flawed because it was not scientifically subjective. Lowrence (1976) defines the information processed during the accomplishment of a task in terms of the following two components:

- Hazard perception – the information required for executing the task
- Risk assessment – the information needed to keep existing risks under control

Lowrence concluded that hazard perception is crucial to co-ordinate body movement to keep dangers under control, whereas conscious risk assessment plays only a minor role, if any. For instance working at the top of a six metre high leaning ladder cutting holes into a brick wall, the operative has to simultaneously keep a balance on the ladder and automatically co-ordinate body-hand movements.

2.3 Risk communication

If the risk message is to be received and acted upon by stakeholders then it must be clearly communicated. The method by which it is communicated will be dependent upon the type of target audience, which can be described as either people associated with organisations, or members of the general public. The format and extent of the risk communication will be dependent upon the degree and level of risk, and can be defined as '*an exchange of information through actions and words that incorporate and respect the perceptions of people, and is intended to help people make more informed decisions about threats to their health or safety*' (Ropelk, 2008). Findings in the field of psychology have established that the perception of risk is a dual process, based not only on technical facts but on people's feelings, instincts, and culture, and may vary depending on their experience, gender and social status (Khripunov, 2006).

2.3.1 Organisational risk communication

There is a statutory requirement for organisations to carry out and communicate the results of formal risk assessments to anyone who might be affected by their activities. Risk assessments identify significant hazards and provide control methods designed to reduce hazards to their lowest level. Risk communication is an interactive process of exchange of information between stakeholders, and its aim is to make the process, outcomes, significance and limitations of the assessment clearly understood. Risk communication is most effective when it is undertaken in a systematic way and involves all stakeholders. It starts with discussion and agreement of the 'what, whom and how' strategy by managers and risk assessors, and a two way process of communication continues throughout the entire process. Communication is most effective if end-users are consulted throughout the risk assessment process, which can be achieved by encouraging participation both during information gathering and when carrying-out control measures.

The results of risk assessments are communicated to all stakeholders, and also made available to any interested parties, so that risk priorities and any specified control measures can be understood and followed. There is no set format for the presentation of the risk assessment results however; they are normally presented in table to aid understanding. Table 2.1 provides a sample risk assessment for falls from height, showing how the information is typically presented.

2.3.2 The Young report

Evidence from the Health and Safety Executive (2010) confirms that the application of risk assessments by carefully examining the workplace for significant hazards, and applying control measures to eliminate, reduce or minimise risks, is effective in reducing accidents. However, the process has been criticised by all industry sectors as being too bureaucratic, placing an unnecessary burden on organisations, especially small and self-employed enterprises. It was suggested by Young (2010) that part of the responsibility lies with the European Union Directive of 1989, which made risk assessments compulsory across all types and sizes of organisations. It was further suggested that the rigour necessary for carrying out risk assessments for high-risk workplaces was unnecessarily transferred to low-risk workplaces. David Cameron, in a forward to the Young Report (2010) confirmed the position by stating that '*legislation designed to protect people from major hazards has been extended inappropriately to cover every walk of life, no matter how low risk*'. The health and safety emphasis has shifted away from the test for 'reasonably practicable' required under the Health and Safety at Work Etc Act 1974, to trying to eliminate all risk, which is impracticable.

The aim of the Lord Young (2010) report was to free businesses from unnecessary bureaucratic burden by applying proportionate systems, and to reinstates common sense back into the health and safety system. Part of the report focussed on risk assessments for low-hazard workplaces as one of its priorities, and recommended to simplify the risk assessment procedure for low-hazard workplaces. The report proposed the use of online risk assessments for workplaces such as offices and shops, and also exempting the self-employed in low-hazard businesses. It was proposed that the on-line user completed a series of 'tick box' questions, before being provided with a risk assessment containing a series of required risk control actions. An online interactive risk assessment was subsequently developed by the Health and Safety Executive for office-based environments, that allow the risk assessment to be done easily and quickly, avoiding unnecessary paperwork and bureaucracy (Hackitt, 2010).

In a response to Lord Young's report the Institute for Occupational Health and Safety (IOSH) urged the government to reconsider this approach, as it is likely to foster a short-sighted and mechanical response from many businesses with an unthinking 'tick box' mentality (IOSH, 2010). Underhill (2010) expressed concern as to how effective the forms would be and compared the process to handing someone the Highway Code and expecting them to know how to drive, emphasising that *'some won't have the necessary expertise to judge whether the actions they list in their online forms will work properly in practice'.* Furthermore, it was highlighted by Underhill (2010) that there is no clear definition of 'low-hazard' and that Young's report sometimes confuses 'low-hazard' with 'small businesses'. Considering that the United Kingdom construction sector is dominated by small businesses, this could place high-hazard activities in a low-hazard category.

Hackitt (2010) from the Institute for Occupational Health and Safety expressed concern that the '*Young Report doesn't go far enough*' and that health has been largely ignored. It was considered that the report missed the opportunity to focus on education which could *'transform how the next generation of workers sees health and safety and sensible risk-taking'.*

Company name: ABC Contract bricklayers **Date of risk assessment:** 16.01.2010

Hazard?	Who might be harmed?	Existing control measures?	Further control measures	Action by who?	Action by when?	Done
Falling from height Serious or fatal injury resulting from fall	Bricklaying operatives Site operatives Supervisors Inspectors	Agree scaffolding requirements at contract stage, including: ▪ Site manager to check that the correct scaffold is provided ▪ Appropriate load rating and provision of loading bays ▪ Workers instructed not to interfere with or misuse scaffold ▪ Ladders in good condition, placed on firm surface and adequately secured (lashed) ▪ Handrails to be used for work on internal walls.	Supervisor to regularly liaise with to site manager to arrange scaffold alterations	Site Manager	20.03.10	20.03.10
			Scaffold inspected regularly to meet statutory regulations	Supervisor	10.04.10	

Table 2.1: Example Risk Assessment

2.3.3 Public risk communication

The 'public' is not a single entity, they perceive risks in different ways, and are influenced by different 'fright factors', with some risks triggering more alarm than others (House of Commons, 2010). The risks that kill people and the risks that alarm people are often completely different (Covello and Sandman, 2001). Their perception of risk is influenced by the perceived magnitude of the consequences and ignorance about the nature of a hazard. For example, risks involving nuclear energy evoke a high fright factor, whilst risks involving road accidents evoke a low risk factor. Effective risk communication is therefore vital in the process of achieving a common public perception of risk, and the most important principle that underpins public risk communication is inclusiveness. The most appropriate approach should therefore be open and transparent, understanding and engaging and based on an ongoing dialogue (Bouder, 2009). It should be a two-way process of information exchange that includes multiple types of information with multiple purposes (Khripunov, 2006).

There is no legislation regarding how risk information should be communicated, however the following seven rules of communication are widely accepted as being good practice for communicating with the public.

Rules of Risk Communication (Modified from Covello and Sandman, 2001)

- *Involvement of the public* - the ultimate goal of the communication strategy is to produce an informed public, not to defuse public concerns or replace actions
- *Listening to the public* – if people feel or perceive that they are not being heard then they cannot be expected to listen, effective risk communication is a two-way activity. People often care more about trust, credibility, competence, fairness and empathy than about statistics or details
- *Honesty, and openness* – the first goal of risk communication is to establish trust and credibility, as once lost they are almost impossible to regain
- *Working with credible sources* – all risk information should be co-ordinated as it can help with the credibility of the communication. Few things make risk

communication more difficult than conflicts or public disagreements with other credible sources

- *Needs of the media* - the media are prime transmitters of information on risks, and play a critical role in determining outcomes. However, they are usually more interested in politics than in risk, in simplicity than in complexity, and in danger than in safety, and can ultimately present the wrong message
- *Clarity* - technical language and jargon are useful for specialists but are barriers to successful communication with the public
- *Planning* - different goals, audiences, and media require different risk communication strategies. Risk communication will be successful only if carefully planned

2.3.4 Public Outrage

It is common for technical experts to believe that everyone understands risk the same way they do usually as the probability of an event occurring and the possible consequences of that event (Byrd, 2005). However, the public view risk differently and base risks on the hazards they pose, referred to by Sandman (2009) as 'outrage factors', and defined as cultural perceptions or values regarding a hazard (Hardy 2010). A number of outrage factors that affect how the public perceives a risk have been identified by researchers (Nebel and Wright, 1993; Sandman, 2009; Hardy, 2010), some of the key outrage factors are described as:

Outrage factors – (Modified from Nebel and Wright, 1993).

- *Voluntariness* - risks from activities considered to be imposed (e.g. working at height) are judged to be greater than risks from activities that are seen to be voluntary (e.g. rock climbing).
- *Controllability* - risks from activities viewed as under the control of others (e.g. a passenger in a vehicle) are judged to be greater than those from activities that are under the control of the individual (e.g. driving a vehicle)
- *Familiarity* - risks from activities viewed as unfamiliar (e.g. radiation leaks) are judged to be greater than risks from activities viewed as familiar (e.g. using power tools)

- *Catastrophic potential* - risks from activities viewed as having the potential to cause a number of deaths (e.g. major gas explosion) are judged to be greater than risks from activities that cause a single death (e.g. fall from a roof)
- *Understanding* - poorly understood risks (e.g. effects of breathing in asbestos fibres) are judged to be greater than risks that are well understood (e.g. electrocution)
- *Dread* - risks from activities that evoke fear or anxiety (e.g. exposure to toxic substances) are judged to be greater than risks from activities that do not arouse such feelings or emotions (e.g. cuts or abrasions)

Knowledge of outrage factors and how they influence the public's perception of risk has led Sandman (2009) to conclude that, to the expert, hazard equals probability times magnitude, while to the public, risk equals hazard plus outrage (Byrd, 2005).

2.3.5 Obstacles to risk communication

An inappropriate approach to risk communication can often be an obstacle to communication (Covello and Sandman, 2001). Members of the general public often approach risk communication in an adversarial manner, whereas scientists approach it with the aim of educating people. The difficulty in risk communication is that '*a scientist defines risk in terms of populations, whilst a lay person defines risk in personal terms*' (Cabinet Office, 2009). These linguistic differences confuse the issues of trust between the stakeholders and may hinder effective communication. Covello and Sandman (2001) identified four further potential obstacles to risk communication that should be taken into consideration:

Obstacles to risk communication – (Modified from Covello and Sandman, 2001)

- *Risk data* - complex and incomplete risk assessment data may contain gaps in knowledge making it difficult, if not impossible, to reach definitive conclusions about cause and effect
- *Distrust* – may be caused due to disagreements between experts, insensitivity to the requirements for public participation, information distortion, exaggeration or secrecy

- *News media* - are critical to the delivery of risk information to the general public as many media articles about risk contain substantial omissions, present inaccurate information or are inclined towards articles that are dramatic, distorted or negative
- *Psychological and social factors* - influence how people process information about risk, including:
    - *Heuristics* - mental short cuts
    - *Apathy* - not interested in learning about a risk
    - *Overconfidence* - may lead to ignoring or dismissing risk information
    - *Understanding* - difficulty in understanding information that is probabilistic in nature, or relates to unfamiliar activities or technologies
    - *Desire* - for scientific certainty
    - *Reluctance* - to change strongly held beliefs, and willingness to ignore evidence that contradicts them

Risk communication that understands public outrage factors, follows appropriate communication rules, and avoids obstacles to communication between stakeholders, should lead to suitable solutions. In addition, effective risk communication can be summed up as having genuine concern and caring for a community (Byrd 2005).

2.4 Risk and hazard perception

The literature review identified a large body of research undertaken on the perception of risk from specialists in different disciplines and covering a wide variety of situations and subjects. However, surprisingly only a small part of the research focussed on risk perception of people working at height, and very little related to portable ladder use. The review has therefore used a broad approach and included factors influencing risk perception generally.

2.4.1 Risk perception

Researchers in the field of risk perception seek to determine what people mean when they say something is risky and what factors contribute to that perception. The term risk perception has been described in many different ways depending on the perspective used by the researcher, and a lack of agreement continues to exist over how it should be defined. Early risk perception definitions were proposed by psychologists such as Fischhoff, et al. (1978) and Slovic (1987) who built on earlier work by Starr (1969) and used psychological factors in the development of cognitive aspects of a person's risk perception. A general definition presented by Wogalter, et al. (1999) is that '*risk perception is a broad notion of safety awareness, and the overall awareness and knowledge regarding hazards, likelihoods, and potential outcomes of a situation or set of circumstances that could cause potential harm*'. The psychologists developed hazard taxonomies based on a 'psychometric paradigm' to produce maps of risk attitudes that could be used to help understand and predict people's responses to different types of risk. Other researchers have extended the research of Slovic and Fischhoff by examining other aspects of risk and the 'risk maps' are continuing to grow. The psychological risk research, has however been criticised by those that promote a 'cultural' theory of risk, for focussing on the individual while ignoring the importance of the individual and their social environment. A 'cultural' definition of risk perception proposed by Mearns and Flin (1995) is '*a person's beliefs, attitudes, judgements and feelings about hazards, danger and risk-taking, within the wider context of social and cultural values*'. Mearns and Flin (1995) also stated that '*it is not risks that are perceived, but hazards which lead to feelings of danger or safety*'.

The work of Brehmer (1987) presented a different viewpoint, by stating that '*there is no risk perception*', Brehmer argued that it is impossible to perceive risk since there is nothing 'out there' which can be called 'risk' and which can be sensed. This was supported by Sjoberg (1979) who proposed that risk is all about thoughts, beliefs and constructs, and Boholm (1996) stated that '*a person's own estimate of risk may be very different from an 'objective' estimate, as the objective risk is independent to the individual's knowledge*'.

A number of different theories and methods have been used to measure risk perception either objectively or subjectively such as the psychometric paradigm, cluster analysis, multi-dimensional scaling, self administered questionnaires, comparative risk analysis and the fearful/not fearful measurement scale (Leonard and Hill, 1989; Marris, et al., 1998 and Sjoberg, 2000a). In recent years a multi-dimensional approach has been taken to risk research, which has attempted to reconcile the various psychological and sociological perspectives. This has lead to the development of conceptual risk models, not only based on individual factors but on social and environmental influences which act upon individuals, the most well known being the 'social amplification of risk' (Kasperson, et al., 1988). The aim of the models is to structure data on an individual's risk perceptions taking into account both contextual and cultural influences.

Sjoberg et al. (2004) identified that several decades of work have been devoted to psychological studies on the understanding of perceived risk, and that two distinct theories currently dominate the field of risk perception. One is the '*psychometric paradigm'*, rooted within the disciplines of psychology and decision sciences, and the other derives from 'cultural theory', developed by sociologists and anthropologists (Sjoberg, et al., 2004). In order to quantify that different people have different hazard perceptions Clift (2004) carried out research using relative injury rates for everyday items, taken from home accident surveillance system (HASS) statistics, indicating the relative likelihood of an injury requiring hospital attendance. Concealed within the data were hospitalisation figures for ladders and stepladders (Table 2.2).

Item	Hospital attendance figures for Injuries (HASS)	Correct number of ranking scores for 52 participants
Indoor stairs	230,200	7
Splinter / grit / rust	27,557	6
Knife	22,108	8
Banister	15,233	6
Stepladder / ladder	13,222	4
Rug / mat	8,574	3
Lawn mower	6,347	8
Hammer	4,472	7
Power drill	2,578	5
Vehicle jack	937	3
Pliers	237	8

(Clift, 2004).

Table 2.2: Relative injury rates for everyday items

52 participants (age range 18 to 71 years) ranked the accidents according to the level of risk perceived. The scores were generally poor and it was concluded that '*individuals are poor at assessing relative levels of hazard relative to familiar objects*', indicating that they rely on initiative to determine hazard items.

Clift (2004) also used scales devised for the road safety arena to analyse the subject's perception of dying due to a variety of causes. Ladders were included to see how well individuals could judge the true level of risk, and the chances of winning the lottery was also included as a rogue variable as the likelihood of which is believed to be well known. Only a small number of participants (five) correctly placed ladders in their ranking order (Table 2.3).

Event	Probability	Rank	Correctly ranked Scores
Dying of cancer	1 in 360	1	18
Dying in a road accident	1 in 15 700	2	18
Dying in a rock climbing accident	1 in 250 000	3	5
Dying due to a ladder accident	1 in 1 000 000	4	5
Dying whilst white water canoeing	1 in 2 000 000	5	14
Dying on a passenger aircraft	1 in 10 000 000	6	8
Winning the jackpot in the lottery	1 in 14 000 000	7	8
Dying from a lightning strike	1 in 15 000 000	8	15
Dying on a fairground ride	1 in 250 000 000	9	3

(Clift, 2004).

Table 2.3: Risk perception rating

Clift concluded that his results reinforced the understanding that individuals are poor at estimating level of risk, and identified that if a user is aware of the risk they better manage their safety strategy, so poor quantification of risk is a safety dis-benefit.

2.4.2 Psychometric paradigm

Early psychological research by Starr (1969) weighed technological risks against benefits in order to determine 'how safe is safe enough'. It was pioneering in this area and Starr argued that the public acceptance of activities is most strongly related to the voluntariness of exposure to the risk source, its benefits and the number of people exposed to the risk. The argument was based on what was termed 'revealed preferences' i.e. the actual behaviour of people, and assumed a balance between risks and benefits, e.g. more risky activities produced greater benefits in compensation.

Slovic (1992) criticised Starr's approach on theoretical and methodological grounds and proposed an 'expressed preference' approach, which used questionnaires to ask people directly about perceptions of risk (Fischhoff, et al., 1978). The major difference between the two approaches was that Starr's analysis dealt with public behaviour whereas the work of Slovic dealt with attitudes.

According to the paradigm, risk can be understood as a function of general properties of the 'risk object' (Sjoberg, 1996), and there are certain hallmarks in the objects that make people rate them as risky or not risky. Fischhoff, et al. (1978) suggested nine general properties of activities or technologies important for the subjective risk judgement, these are:

- Voluntariness of risk
- Immediacy of effect
- Knowledge about the risk; (by the person exposed to the risk)
- Scientific knowledge
- Control over the risk
- Newness (new and novel, or old and familiar)
- Chronic / catastrophic (chronic – kill people one at a time, catastrophic – kill a large number of people all at once)
- Common dread
- Severity of consequences

The degree to which these factors are related to potentially hazardous activities or technologies determines peoples risk judgements. The nine properties were used by Fischhoff, et al. (1978) during psychometric questionnaires which required respondents to rate each of thirty risk items on a seven point scale (Table 2.4) Fischhoff, et al. found that the risk level was considered more acceptable by those respondents who had considered the benefits than those who had previously dwelt on risks, indicating a relationship between perceived benefit and acceptable level of risk.

Rating scale	Question
Voluntariness of risk. 1 = voluntary 7 = involuntary	Do people get into these risky situations voluntarily? If for a single item some of the risks are voluntary undertaken and some are not, mark an appropriate spot towards the centre of the scale.
Immediacy of effect. 1 = immediate 7 = delayed	To what extent is the risk of death immediate – or is death likely to occur at some time later.
Knowledge of risk. 1 = known precisely 7 = not known precisely	To what extent are the risks known precisely by the persons who are exposed to those risks.
Scientific knowledge. 1 = known precisely 7 = not known precisely	To what extent are the risks known to science.
Control over risk 1 = uncontrollable 7 = controllable	If you are exposed to the risk of each activity or technology, to what extent can you, by personal skill or diligence, avoid death while engaging in the activity?
Newness. 1 = new 7 = old	Are the risks new novel ones or old familiar ones.
Chronic-catastrophic. 1 = chronic 7 = catastrophic	Is this a risk that kills people one at a time (chronic) or a risk that kills large numbers of people at once (catastrophic)?
Common dread. 1 = common 7 = dread	Is this a risk that people have learned to live with and can think about reasonably calmly, or is it one that people have great dread for-on the level of gut reaction?
Severity of consequences. 1 = certain not to be fatal 7 = certain to be fatal	When the risk from the activity is realised in the form of mishap or illness, how likely is it that the consequence will be fatal?

(Fischhoff, et al. 1978).

Table 2.4: Properties of activities

The respondents also believed that more risk was acceptable for more beneficial activities (Fischhoff, 1978). The risk dimensions were found to be highly inter-correlated, leading to a conclusion that they could be reduced to two dimensions: the first are technology risks – the difference between high and low technology activities, and the second are severity risks – reflecting the certainty of death. The results of these studies indicate that not only is perceived risk both quantifiable and predictable, but the concept of risk means different things to different people.

The approach has been criticised by other researchers (Krass and Slovic, 1988; Bishop and Syme 1992; Mullet, et al., 1993) for not considering other potential factors that may be involved, and subsequently researchers have identified 'dread' and 'familiarity' as two more higher order factors (Slovic, 1987).

The dread dimension is characterised by the general way people think about risk in terms of their feelings. *'What's worse, being eaten by a shark or dying of a heart attack'*, both kill but the dreadful death of being eaten often evokes more concern (Slovic and Ropier, 2003). This helps to explain why death is perceived differently for different situations.

The familiarity dimension is characterised by a tendency of overconfidence when a person faces risks every day (Kasperson, cited in Joffe, 1999). When things are unfamiliar to a person they are more likely to be perceived as dangerous (Bronstein, 1987). This is evident in the construction industry with hazards that can be hard to detect, such as dust, noise and vapours which can have harmful effects that may not be obvious for several years (Waddick, n.d.). Overconfidence may also lead to lower perception of risk because individuals who are certain of their decision and rely on their personal competence may not be aware of the potential for error (Bermudez, 1999). Zimalong's (1985, cited in Fleming and Buchan, 2002) study of construction workers found that operatives that perceived themselves to be most in control of a task tend to underestimate their risks. As a consequence, when rating risks, a competent person feels they are less vulnerable than others, especially those who may be less competent (Waddick, n.d.).

Krass and Slovic (1988 cited in Beckwith, 1996) conducted a further study to assess the relationship among the various risk characteristics and factor structures of a set of railway hazard scenarios. They concluded that 78% of the characteristics could be represented by two factors. The first characteristics included voluntariness, control and knowledge and the second of catastrophic potential, newness and equity. The effects of dread were split between the two factors and did not play a strong role in the study. As in earlier studies the characteristics of catastrophic potential and knowledge were found in both major components, similarly, overall risk was highly correlated with the characteristic catastrophic potential and dread.

To summarise, the psychometric paradigm encompasses a theoretical framework that assumes risk to be subjectively defined by individuals who may be influenced by a wide array of factors, and with appropriate design of survey instruments many of these factors can be quantified (Slovic, 1992).

2.4.3 Risk characteristics

The list of risk characteristics continues to grow as researchers consider different aspects that influence people's risk perception. Otway and Von Winterfeldt, (1992, cited in Beckwith, 1996) identified a further seventeen characteristics from psychological literature. A selection have been reproduced in Table 2.5, those considered to have the greatest influence are presented below.

Characteristic	Perception
Understanding	Risks that are associated with poorly understood exposure mechanisms or processes create greater concern than those with apparently well understood exposure mechanisms or processes.
Delayed effects	Risks that are associated with somatic effects that are delayed in time (e.g. cancer) create more concern than those whose effects are immediate.
Uncertainty	People are more concerned about risks that are scientifically unknown or uncertain than those which are relatively known to science.
Violation	Risks that are perceived involuntary create more concern than risk perceived voluntary.
Victim identity	Risks to identifiable victims generate more concern than risks to statistical victims.
Media attention	People are more concerned about risks that receive media attention than those that receive little media attention.
Accident history	Activities associated with major accidents create more concern than those with no track record of accidents.
Benefits	Activities perceived as having unclear benefits generate more concern than activities perceived to have clear benefits.
Reversibility	Activities with irreversible negative effects create more concern than those characterised by reversible negative effects.
Evidence	Risk based on human evidence create more concern than those based on evidence from animal studies.
Personal stake	Activities believed to place an individual personally and directly at risk create more concern than those not believed to do so.

(Otway and Von Winterfeldt, 1992).

Table 2.5: Risk characteristics

Control

When people feel in control over a process that determines the risk facing them, that risk will probably not appear as great as in the case when they have no control over it (Andries, et al., 1996; Weyman and Kelly, 1999). Harrell (1990) suggested that a link between control over work and perceived risk may be due to people with higher control being able to avoid hazards or having freedom to be more cautious when doing certain tasks. In contrast operatives with low control may have to do the work more quickly because their pace of work is dictated by others, for example in the construction sector where earnings are based upon incentive schemes. Weyman and Kelly (1999) suggested that people in high control perceive the risk to be under their control which caused them to rank the risk lower.

In addition people have a level of risk with which they feel comfortable and will adjust the riskiness of their behaviour in the presence of safety measures. Adams (1995 cited in Clift, 2004) calls this tendency the individuals '*risk thermostat*' and uses it to explain why people tend to drive faster when they have airbags or child restraints fitted in their car.

Choice

A risk that we choose to take seems less hazardous than one imposed upon us by another person. For example a person working on a ladder that is not secured against falling, may perceive it as hazardous if another person works in the same manner, if it may be hazardous to them. A person is generally less concerned about the risk if they have a choice, as this influences their perception.

Personal impact

The risk can seem greater if we ourselves, or someone close to us are the victims, as individuals who have experienced accidents themselves or witnessed accidents involving injury increase their perception of the risks associated with an activity (Johnson and Tversky, 1983). For example a person who has fallen from height and been injured has an increased perception of the situation, as the fall has had a personal impact on their future actions. The closer we are to the risk, the greater will be our perception of it, however it is not clear how long lasting the effects might be. Also people tend to think that an event is more likely if they can recall an incident of its occurrence (Sunstein, 1999), therefore '*discussions of a low probability hazard may increase its memorability and hence it's perceived riskiness, regardless of what the evidence indicates*' (Slovic, 1992).

Trust

Researchers have found a difference in the perceived risks between experts and members of the public (Sjoberg, 1999). In a frequently cited study, the United States Environmental Protection Agency (USEPA, 1987) compared expert's rankings of important environmental risks with public risk perception. They found little agreement between the two sets of rankings. A follow up three years later gave virtually the same results (Roberts, 1990 cited in Sjoberg, 1999). The researchers concluded that the more confidence we have in people responsible for our safety, the less fear we will feel, and the less we trust people the greater will be our level of concern.

Awareness

The more aware we are of a risk, the better we perceive it and the more concerned we are. For example, giving more attention to the consequences of falls from height may raise a person's awareness and cause greater concern. The awareness can be high or low depending on the attention given to them.

Experience

Several studies supported the idea that the greater a person's experience of a hazard the lower the perception of risk, identified as the *'theory of reinforcement'* (Karnes, et al., 1986), and that exposure to high risk events which do not result in harm will lessen an individual's perception of the risk associated with the event. (Zimolong, 1985; Karnes, et al., 1986). A study of the risk perception of colliery workers found that experienced workers were less aware of the hazards whilst inexperienced workers rated their activities more risky (Rushworth, et al. 1986; Weyman and Kelly, 1999). Also the more time a person spends in a job or activity the more familiar they become with the risks in their work environment and they tend to underestimate the risks from the tasks they perform regularly because they become habituated to the risks and complacent about the precautions required (Ittleson, 1978; Fleming and Buchan, 2002). From their review of literature on risk familiarity Weyman and Kelly (1999) suggested there is a tendency for people to underestimate familiar risks and to overestimate unfamiliar risks. This was supported by Clift (2004) who identified that the perception of risk varies both with the individual, and with their level of expertise, and where a situation is familiar; the perception of risk is likely to be lessened.

Cost – benefit

If there is a perceived benefit in a specific behaviour or choice, the risk associated with it will seem smaller as people are more likely to see less risk in situations where they see benefits from the activity (Ross and Anderson, 1980). This could be experienced by construction workers who work a bonus (incentive) system as 'time is money' and a risk may be ignored if affects a workers financial reward.

Effort

Holmes, et al. (1999) identified that if the necessary safety measure is perceived to present too great a level of effort it will be ignored. The perception may be that the cost is the extra work effort required to implement the safety procedure. Johnson, et al. (1998) came to the same conclusion but further showed that workers would forgo personal safety if they felt speed and comfort were more important.

Risk taking trait

The literature proposes the personal trait of risk takers and risk avoiders which influence attitudes towards risk and level of risk people will tolerate (Young, 1996; Synes, et al., 1992; Fleming and Buchan, 2002). The most likely link being that people with the risk taker trait perceive risks as lower than people who are risk averse. It has been reported by Page (2000, cited in Clift 2004) that people are more willing to accept risks, and that some individuals actively seek out risk rather than avoid it.

Sensation seeking

Sensation seeking is a recognised trait that is widely accepted as having an influence on risk taking behaviour. The trait is defined by Zuckerman (1994) as '*the seeking of varied, novel, complex and intense sensations and experiences, and the willingness to take risks to achieve such sensations*'. Zuckerman developed a test to help determine the level of sensation seeking of individuals. It consists of a series of questions, where the respondents are required to answer honestly their feelings in relation to their likes, and dislikes, of two variables, of which there are no right or wrong answers, e.g.

1. a A sensible person avoids activities that are dangerous.
   b I sometimes like to do things that are a little frightening.

2. a I often wish I could be a mountain climber.
   b I can't understand people who risk their necks climbing mountains.

The results of the test are relative, i.e. the values on their own do not have merit. The benefit lies in the comparative scores between individuals in a given population. Using the score, it is possible to correlate personality traits with behavioural traits, for example it could be used as a precursor to risk taking and hence accidents.

The measure of sensation seeking is an important behavioural variable to quantify, as it allows the performance of a participant to be understood in terms of norms of behaviour, which then places the individual in a rank of likelihood to take risks. Clift (2004) used the Zuckerman scale as part of the research into the performance and effectiveness of ladder stability devices, to help correlate personality traits with behavioural traits. A weak negative correlation was observed between the ages of participants (sample size 52) and their scores when plotted on a scatter diagram. This agreed with previous research by Zuckerman (1994) in that the older the participant the more likely are to have a low sensation score. This suggests that the older users will behave in a less risky fashion. It was also observed that the sensation seeking score was similar for males and females.

Gender

Generally speaking, men perceive risks lower than women (Finucane, et al., 2000) as women feel more insecure with regard to an industrial threat. One reason for this may be related to vulnerability, as studies have shown that women *'generally perceive themselves more vulnerable than men'* (Vlek and Stallen 1979; Fischer, et al., 1991) and have *'more dread of hazards'* (Savage, 1993). Leonard, et al. (1990) examined the perception of risk to oneself versus others and found that as a group, only the males under 30 years old ranked risks lower for themselves than others, suggesting that this group though that they were least vulnerable and held the view *'it couldn't happen to me'*. Unlike later research by Zuckerman (1994) and Clift (2004) they found a significant overall difference for sex, but no difference in terms of age.

2.4.4 Cultural theory

Rayner (1992) has criticised the psychometric approach for not having a strong enough theoretical base and for this reason researchers have turned to 'cultural theory' which is the second theory currently dominating the field of risk perception, as offering an alternative approach. The theory has been developed by sociologists and anthropologists, who propose a typology labelled as hierarchists, individualists, egalitarians and fatalists (Thompson, et al., 1990). What is unclear however is whether cultural theory is attempting to classify individuals or groups within society, as perhaps only an organisation can be described as hierarchical (Langford, et al., 1997).

Cultural theorists have pointed out that risk perception cannot be studied in isolation as it goes beyond the individual, and is a social and cultural construct (Douglas, 1978; Weinstein, 1989; Boholm, 1996). Spangler (1984) suggested that personal experience and memory influence the way people perceive risks, and that factors such as our education, family, and occupational background are fundamental in the perception of risk. Covello (1989) extended the theory further and suggested that societies select particular risks for attention and that risks are therefore '*exaggerated or minimised according to the social, cultural, and moral acceptability of the underlying activities*'. Culture is therefore embedded in a person's 'way of life' which has been defined by Thompson, et al. (1990) as '*a combination of social relation and cultural bias*'. How much to accept is therefore a function of a person's cultural adherence and social learning. Despite reservation about the classification of cultural theory the psychometric and cultural approaches can offer complimentary information on how individuals construct their perception of risk (Marris and Langford 1996).

2.4.5 Safety behaviour

Research carried out by McDonald (2002) into the safety behaviour of operatives on construction sites in Northern Ireland identified that they had a 'poor understanding of how individual attitudes and behaviour are related to safety' in the construction industry. Research focussed on investigating the behaviours, perceptions and attitudes associated with accidents on construction sites. A cross-sectional design was observed from the results based on a comparison of a representative sample of 18 construction sites. The sample included large and small sites, involving between twenty and two hundred operatives mainly on new build housing, located in metropolitan and regional areas in Northern Ireland, however they did not include very small sites or sites in rural areas. The research strategy adopted was to investigate the perception of risk associated with certain target behaviours and situations, and concentrated on falls from height in response to the high incidence of recorded accident statistics. A total of 244 surveys were completed across the eighteen sites, representing 20% of operatives. 38.5% of the sample (94 operatives) were employed by main contractors, while 61.5% (150 operatives) were employed by sub contractors. The average age of workers was 31 years, with 25% of the workers being under 23, and 50% younger than 29 years, highlighting the relative youth of the population.

Most of the workers had good experience of working in the industry, 25% of the operatives sampled had worked for an average of 11 years, 25% reported working for less than 1 year and 50% for less than two years, highlighting the lack of experience. To further establish experience, the operatives were asked the frequency at which they worked on ladders, 98% of the operatives reported using ladders sometimes or regularly. Only operatives who used ladders were allowed to answer questions on the access specific sections.

The operatives were interviewed following a strict interview protocol. Each participant was asked to give their own perception of risk, frequency and preferred behaviour in the face of risk for each of the situations presented. The survey items were designed to address working at height, and included an equal emphasis on, working on scaffolds, working on roofs and using ladders. Three situations were presented under the title of 'using ladders':

- Using a ladder not tied or secured
- Using a ladder broken or somehow defective
- Using a ladder that extended less than one metre above the landing place

For each of the situations, the operative was requested to analyse them on three levels. They had to:

- Offer an evaluation of their perceived level of risk (low, medium or high) for each situation
- State the frequency (rare, usual or frequent) at which these situations occur
- Predict their probable behaviour (report it, fix it, stop working, continue working) if the situation occurred on site today

The great majority of workers reported that they would respond constructively to risky situations, either reporting the defect (61%), fixing it (37%) or stopping work (depending on the situation). The preferred way to deal with risky situations is to report them, however between 20% and 30% would just continue working in the case of a ladder being too short. In general, working on ladders was perceived as high risk, the operatives perceived using a defective ladder as one of the most risky situations. Using short ladders for accessing upper levels was the situation perceived as the least risky, evaluated as medium risk. However the researcher did not establish the operatives understanding of the term risk prior to the survey, which could have had a bearing on the results. An interesting finding concerned perception of risk by 35% of operatives on each site. These workers reported low perception of risk to:

- Using ladders not tied or secured
- Using ladders too short for the landing place

The findings for these critical high-risk situations outline that the majority of operatives do not have a misperception of the risks associated to these situations. When operatives were asked how they would behave in relation to those situations, their answers indicate that their preferred behaviour depends more on the actual situation than the perceived level of risk.

The research team reported that there is a small minority who may not perceive risks accurately and a larger minority who say they are prepared to continue working in risky situations. Workers do not generally see difficulty in being aware of the hazards, or their familiarity or demands of their work as significantly contributing to safety. Thus, most operatives generally perceive construction sites to be dangerous places, however developing and maintaining awareness of risk is not perceived to be a significant problem. In general the situations concerning working with ladders were perceived as high risk, the major exception being short ladders, which were perceived as medium risk.

McDonald and Haymak, (2002) concluded that workers would respond constructively to risky situations, though a significant minority would just continue working, and that at its broadest level, the main implication is that the system is not working. The high proportion of relatively inexperienced workers gives rise to concern about their effective appraisal and response to risk. As far as possible, training should not only seek to foster awareness of hazard and risk, but it should strengthen knowledge and skills in managing risky situations effectively.

2.5 Behavioural change

Behaviour can be defined as an action by an individual that is observable by others (Geller, 2006), and refers to any intervention that affects the frequency or type of behaviour carried out. The primary aim of behaviour change is to turn a behaviour into normal practice and then into a stage that it becomes automatic (Knott, et al., 2007).

2.5.1 Stages of behaviour change

Worker behaviour change is crucial to the effectiveness of any safety intervention, and can be achieved by either targeting an individual directly, or targeting the social or physical aspects of their work environment (Lunt, et al., 2008). Prochaska and DiClemente, (1986) developed a transtheoretical model (TTM) to help promote positive behaviour change. The model focussed on the decision making of individuals, and described how people modify their behaviour. It involved progress through a series of stages of change, based on cognitive and behaviour activities until individual behaviour become automatic and part of normal routine (Prochaska and DiClemente, 1986).

The five stages of behaviour change – (Modified from Prochaska and DiClemente, 1986)

- *Pre-contemplation* –the stage in which people are not intending to take action in the foreseeable future, usually measured as the next six months, and they may be unaware of the need to change
- *Contemplation* –the stage in which people are intending to change in the next six months. While they are usually aware of the pros of changing, their cons are about equal to their Pros
- *Preparation* –the stage in which people are intending to take action in the immediate future, usually measured as the next month, and they have typically taken some significant action in the past year
- *Action* –the stage in which people have made specific overt modifications in their life-styles within the past six months, and positive change has occurred
- *Maintenance* –the stage in which people are working to prevent relapse but do not apply change processes as frequently as do people in action. They are less tempted to relapse and increasingly more confident that they can continue their change

2.5.2 Process of change

The process of change involves independent activities that people need to apply, or be engaged in to progress through the behaviour stages. Darnton (2008) identifies five stages as experiential processes used primarily for early stage transitions, and five stages as behavioural processes used primarily for later stage transitions.

Experiential Processes (including safety examples).

- *Consciousness raising* (Increasing awareness) – I recall information given to me on how to avoid falls from height
- *Dramatic relief* (Emotional arousal) – I react emotionally to explicit warnings about fatal falls from height
- *Environmental re-evaluation* (Environmental opportunities) – I consider the view that correct working procedures serve as a role model to others
- *Social liberation* (Social reappraisal) – I find society changing in ways that make safety a more important element of work
- *Self re-evaluation* (Self reappraisal) – My negative approach to working safely at height makes me feel disappointed in myself

Behavioural processes (including examples).

- *Stimulus Control* (Re-engineering) – I am continually reminded of the risks of falling from height
- *Helping Relationship* (Supporting) –I have someone to talk to about the risks of falling from height
- *Counter Conditioning* (Substituting) – I am assertive in response to negative peer pressure to take shortcuts when working at height
- *Reinforcement Management* (Rewarding) – I am self rewarded for working safely and not having accidents when working at height
- *Self Liberation* (Committing) – I make commitments to follow safe working practices when working at height

2.5.3 Influence and intervention strategies

The processes of change provide guides for intervention strategies, since the processes are independent variables that people need to apply, or be engaged in to move from stage to stage (Prochaska, et al., 1998). In terms of safety, Stober (2009) stressed that there is a need to be aware of which behaviour stage workers are in to be able to apply the correct safety system. The stages of change were therefore focussed on safety behaviour and systems used to engage individuals in positive safety behaviour.

Behavioural Stages and example influence strategies- (Modified from Stober, 2009)

- *Pre-contemplation* – workers may feel that they have performed the work safely for many years and do not see the need for change. They are resistant, defensive and unaware, and are influenced by raising awareness of safety issues
- *Contemplation* – workers are beginning to think about the safety process and weigh up the pros and cons of their actions. They are influenced by training and opportunities to discuss their beliefs and attitudes
- *Preparation* – workers become determined to learn how to keep themselves safe. They display readiness for change, and are influenced by harnessing their own thinking and tapping into intrinsic motivation
- *Action* – workers can pinpoint the changes they want to make and start to make them. They are consciously practicing safety but their actions are not yet automatic. They must overcome old habits to form new habits of safe behaviour. They can be influenced with reminders, feedback, recognition and ongoing regular discussions
- *Maintenance* – the change becomes automatic to workers and becomes part of their normal routine. Their safety behaviour becomes a habit, and their safety attitude becomes consistent. The positive attitudes and behaviours should be reinforced
- *Relapse* – a normal part of the change process, which needs to be reaffirmed

For most people behaviour change occurs gradually over time, '*with the person progressing from being unaware or unwilling to make a change (pre-contemplation),* *to considering a change (contemplation), to deciding and preparing to make a change (preparation)'.* This is followed by definitive action (action), and attempts to maintain the new behaviour over time (maintenance) (Zimmerman, et al., 2000).

Behavioural models do not affect how people behave but are useful for identifying where a person is in the change process so that interventions can be designed to meet their needs. Interventions that are not tailored to the readiness of the individual or are progressed too quickly are less likely to successfully change behaviour (Zimmerman, et al., 2000). Behavioural models cannot account for all of the complexities of behaviour or determine how people behave, however they can help identify some of the factors that influence behavioural outcomes (Darnton, 2008). The models can be used to help design an intervention strategy, and in turn the interventions can be evaluated against the end behaviour itself.

Most behavioural models relate to an individual level, and are used to help understand behaviour by identifying factors which influence them; however the models are limited in terms of the information they provide for designing specific intervention strategies. Theory based guidance can be used to develop intervention mapping systems, which use needs assessments to generate problem based plans and matrices. Bartholomew, et al. (1998) developed a theoretical approach to change based on Lewin's (1951) change theory, which was characterised by theory through practice, and learning by doing. Emphasis was placed on piloting and evaluation followed by building learning back into the process. Darnton (2008) built on the theory through a practice approach and produced a range of principles synthesised from theory based guidance that took into account the need for flexibility during the development process.

Principles for developing interventions (Modified from Darnton, 2008).

- *Identify the worker groups and the target behaviour* – break the behaviour down into its component parts
- *Identify relevant behavioural models* – draw up a shortlist of influencing factors
- *Select the key influencing factors* – use the factors to help design objectives

- *Identify effective intervention techniques* – select those that have worked previously
- *Engage the workforce for the intervention* – to help understanding the intervention from their perspective
- *Develop a prototype intervention* – based on the learning from the workers
- *Pilot the intervention* – and monitor continuously
- *Evaluate* – the impacts and processes
- *Feedback* – learning from the evaluation fed back into the process

The principles should be understood as a cyclical process with learning from monitoring and evaluation feeding back into the development of the intervention. The cyclical process helps to prevent inflexible interventions as the behaviour change is managed by building learning back in to the process. Lunt et al, (2008) also emphasised that workers should be properly supported during the behavioural change process, as creating change within an individual requires a process of monitoring and management.

Worker support of the change process (Modified from Lunt, et al., 2008)

- The immediate and wider physical work environment supports change
- Workers are equipped with the right skills so that they believe they have the necessary capabilities for affecting change.
- Distracters, that force unconscious error such as stress, fatigue and noise are minimised
- Behaviours to be changed are isolated
- Goals are set that are jointly agreed
- Plans are specified for how those goals are to be achieved
- If used, meaningful incentives are set that reward the occurrence of safe behaviour rather than absence of unsafe behaviour.

It was concluded from the literature that interventions need to be centred on the worker and comprise techniques that actively engage the worker in the subject matter to ensure its relevance. By doing so the end product shifts from only raised awareness to more serious considerations of how behavioural change tangibly reduces workplace risks.

There are limits to what information can be gained from behavioural models as they are deliberately simplistic whereas behaviour is complex; therefore using models alone is insufficient to bring about behavioural change (Darnton, 2008). An understanding of the process of change must be applied as models don't tend to differentiate between different workers, and need to be adapted to suit different circumstances. Also factors don't necessarily precede behaviour as workers may be compelled to change their behaviour first, which then leads to change (Darnton, 2008). Consequently if behavioural models are to be used effectively it is essential that they are used appropriately as tools in the design of interventions.

2.5.4 Barriers to behaviour change

There are many barriers to effective behavioural change which include lack of motivation, lack of resources and biased perception of information, which are generally embedded within individuals, organisations and target populations. Lunt, et al. (2008) in a report on behaviour change within the construction sector, identified workforce transience, safety culture, production pressures, site complexity, management styles, and a separation from design from build as specific barriers to construction sector behavioural change. The report concluded that the construction sector has a particularly disparate workforce and that there are many disincentives for being transparent about safe work-practices. If behavioural change is to be effective in terms of health and safety then attention needs to be focussed on modifying consequences and strategies that reinforce change over time. In other words behaviour change requires integration with the wider performance management system (Lunt, et al., 2008).

Lunt, et al. (2008) also identified that behaviour change in construction would be challenging due to the complexities of the sector, and it was identified that a common framework should be used to strike a balance between being evidence based and user centred change, engaging the workers and providing scope for accommodating the nuances of given construction projects.

2.6 Choice architecture

Choice architecture refers to the environment in which an individual makes choices, and changing the way options are presented can make it much more likely that a choice becomes the default preference (Rainford, 2011). The nudge theory of choice intervention aims to change the environment in which individuals choose, influencing their behaviour in ways that they do not notice. Thaler and Sunstein (2008) defined 'nudge' as *'...any aspect of choice architecture that alters people's behaviour and 'nudges' them to behave in a predictable way...'*. Choice architecture 'nudges' can help sub-conscious decision-making so that individuals make the 'safe' choice (Lunt, and Staves 2011), for example by the use of colour coding on hazardous equipment or by graphics depicting a correct work technique.

2.6.1 Nudge theory

Human failure is widely accepted by research as falling into two main processes; the first is a reflective deliberate process that an individual is aware of doing. The second is an automatic non-deliberative process, that an individual is not aware of doing (Lunt and Staves 2011). Nudge focuses on the automatic non-deliberative processes, designed to increase safety behaviour by allowing individuals to make decisions that they consider to be their own. Nudge techniques are used to improve safe behaviour of construction site operatives' by improving their situational awareness, for example, by using:

- Posters depicting memorable safety images
- Safety messages on notice boards
- Colour coding of walkways, services and hazardous substances
- Safety training information

As human behaviour tends to follow a course of least resistance, nudges should make the 'right thing to do' also the course of least resistance, which should translate into a positive impact in terms of their safety behaviour. However, nudges alone may not be enough to change behaviour, as behaviour is the product of many of interrelated factors, including genetics, thoughts, feelings, environment and social interaction, (Lunt and Staves 2011).

2.6.2 Nudge, Think, Shove

Lunt and Staves (2008) identified that whilst 'nudge' can be effective in changing safety behaviour they are short-lived, and that their benefits only last for the duration for which an individual is exposed to them. Long lasting improvements in health and safety are more likely if an integrated approach to change is taken, using a combination of 'nudge', 'think' and 'shove' approaches (DEA, 2011):

- *Nudge* - focused on automatic processes and is effective for specific, limited shifts in behaviour, such as hazards associated with working at height
- *Think* - effective at building support and legitimacy for transformational changes such as training programmes for working at height
- *Shove* - a legislative approach focuses on restricting, by law, the choices that an individual person can make in relation to a range of different potential behaviours, such as the Work at Height Regulations.

During 'think' approaches more behaviour-change techniques can be used that could include using risk communication, raising awareness, goal-setting and safety planning practices. 'Think' approaches can therefore compliment 'nudge' and be a more effective than 'shove', often creating the conditions under which 'nudge' is effective (Lunt and Staves 2011). It is therefore possible to build a safety framework that uses elements of all three approaches to improve situational awareness for all construction site operatives. Nudges are more applicable to one-off behaviours than more complex chains of actions, for example nudging a construction site operative to wear a fall arrest harness is easier than nudging safe working practices during the erection of a working platform.

2.6.3 Limitations to nudge theory

A report on behaviour change published by the House of Lords (DEA 2011) found that non-regulatory measures used in isolation are less likely to be effective, and that 'nudging' people will have limited impact if carried out in isolation. Rainford (2011) identified that individual risk behaviour was complicated and encompassed a wide range of factors including emotional drivers and optimism. Rainford (2011) also raised questions regarding the idea that the *'human brain can be sliced into two* *categorically different systems, namely an unconscious, intuitive system and a conscious deliberate system'* because 'nudge theory' lies not in the separation but in the integration neurological processes.

2.6.4 Self-attribution bias

A self-attribution bias is a tendency for people to attribute their success to their own abilities, or personal factors and blame failures on bad luck or to situations beyond their control. It is a common human tendency to take credit for success but to deny responsibility for failure (Miller and Ross, 1975). The effect prevents individuals from recognising their mistakes and hence prevents them from learning from their mistakes.

Research by Barber and Odean (2000) found that people subject to one behavioural flaw are also likely to be subject to other behavioural flaws, and self-serving bias was found to be strongly linked to a person's over-confidence. For example, construction operatives working at height are reluctant or unwilling to wear fall arrest harness as a form of personal protective equipment, as they are over-confident in their ability to work safely. However, victims of serious injury resulting from falls from height can be observed to have a self-attributive bias, as they tend to attribute their accident to external factors beyond their control (Ayim and Simo, 2006). The majority of people consider themselves superior in most day-today activities; which is particularly dangerous as it leads to over-estimation of one's knowledge and under-estimation of potential risk (Della, 2009).

If an over-confidence, self-attribution bias persists over a long period of time without some form of behaviour intervention, an individual may gain an 'illusion of control', which is a *'tendency for people to overestimate their ability and feel that they control outcomes that they demonstrably have no influence over'* (Thompson, 1999). The 'illusion of control' may reduce an operatives risk perception and situational awareness in hazardous work at height situations, especially if the operative is familiar with the work place.

2.6.5 Heuristics in decision making

Heuristics are general decision making strategies that people use as mental short cuts to reduce the cognitive burden associated with decision making (Shah and Oppenheimer, 2008).

There are no rules or guidelines on how to make decisions when facing complex problems; however heuristics involve strategies in which decisions are made quickly and with relative ease (Shah and Oppenheimer, 2008). Examples of heuristics are using an educated guess, using common sense, or applying a 'rule of thumb'. Heuristics diminish the work of retrieving and storing information in memory; streamlining the decision making process by reducing the amount of integrated information necessary in making a decision (Shah and Oppenheimer, 2008). They are strategies that help people make correct decisions, make judgments, and solve problems; however they are sometimes the reasons why people make the wrong decisions due to cognitive biases.

Types of heuristics

Many types of heuristics have been developed to explain the decision making process; essentially, individuals work to reduce the effort they need to expend in making decisions and heuristics offer individuals a general guide to follow (Nokes, Dole and Hacker, 2007). There are many types of heuristics that have been applied to risk communication research but three are important and commonly used; affect, availability, and anchoring-and-adjustment.

Affect heuristic

The affect heuristic proposed by Slovic (2002) is a heuristic in which current affect influences decisions; it is a 'rule of thumb' instead of a deliberative decision. It is one of the ways in which people show bias in making a decision, which may cause them to take action that is contrary to logic or self-interest (Slovic, et al., 2002). It is a feeling, for example surprise or fear occurring rapidly and involuntarily in response to a stimulus, and has an effect on the decision making process. Affect, can therefore be taken into account for risk communication, as the use of a word or image may evoke a strong emotional response and alter a person's perception of risk (Slovic, et al., 2004).

Availability heuristic

The availability heuristic is a phenomenon in which people predict the frequency of an event, based on how easily an example can be brought to mind, as memory plays a major role in decision making (Tversky and Kahneman, 1982). People make judgments based on how easy it is to think of examples, using the notion that 'if you can think of it, it must be important' (Esgate, 2004). According to this heuristic, people retrieve information that is most readily available in making a decision (Redelmeier, 2005), and use examples of a hazard that can be brought to mind as a cue for estimating risk perception.

Slovic, et al, (2004) suggested that the availability heuristic might work because remembered images are tagged with affect, proposing that the availability and affect heuristics are closely connected, and that strong emotional experiences with hazards may be important for increasing perceived risk.

Anchoring and adjustment

The anchoring and adjustment heuristic is the decision making heuristic in situations where some estimate of value is needed (Epley and Gilovich, 2006). A person starts with a first approximation (anchor) and then makes incremental adjustments based on additional information (Kahneman and Tversky, 1972). This heuristic is like the availability heuristic because it's sometimes based on previous knowledge. In terms of risk perception individuals will often start with one piece of known information and then adjust it to create an estimate of an unknown risk.

2.6.6 Factors that influence decision making

Understanding how individuals arrive at their decisions is an area of cognitive heuristics, which are ways in which our brains are in autopilot as a result of our biology or our past experience or learning (Fried, 2010). Researchers have identified several factors that influence the decision making process which include but are not limited to, age, past experiences and cognitive biases.

Age

As cognitive functions decline as a result of old age, decision making performance also declines, with older people making significantly worse decisions than younger people (Finucane, et al., 2005). Older people rely more on suboptimal decision rules which are quickly produced, rather than an optimal ones that take longer. They experience a greater performance reduction when faced with a greater number of options, and there is evidence to support the notion that older adults prefer fewer choices than younger adults (Reed, Mikels and Simon, 2008). In addition, older people may be more overconfident regarding their ability to make decisions, which inhibits their ability to apply strategies (de Bruin, Parker and Fischhoff 2007).

Past experiences

Juliusson, Karlsson, and Garling (2005) concluded that individuals past experiences influence their future decisions, and that it is an important influencing factor. When something positive results from a decision, people are more likely to decide in a similar way when in similar circumstances, and conversely are more likely to avoid repeating previous mistakes (Dietrich, 2010). Siegrist and Gutscher, (2005) identified that past experience was an important factor influencing how hazards are perceived, which would be beneficial when estimating levels of risk perception in work place situations.

Cognitive biases

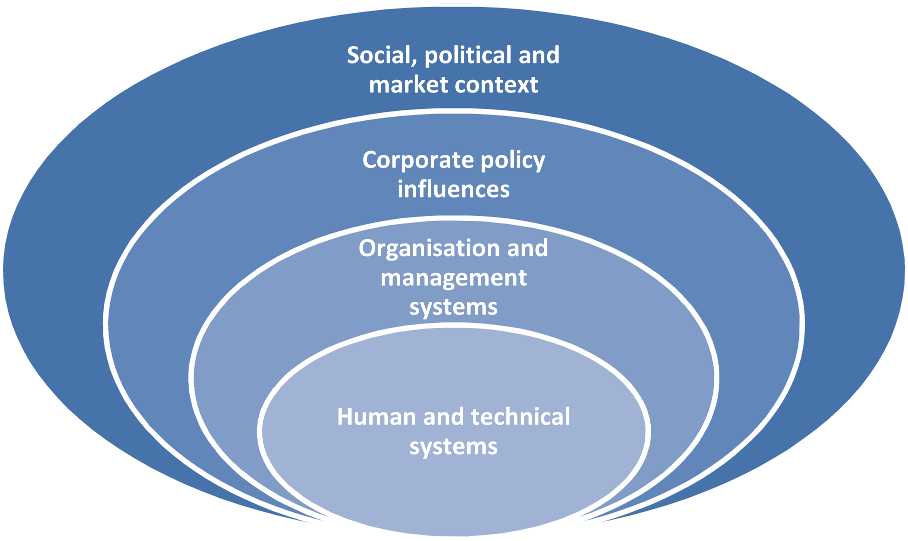
Cognitive bias is a general term that is used to describe many distortions in the mind that lead to perceptual distortion, inaccurate judgment, or illogical interpretation (Kahneman and Tversky, 1972). Typical biases include:

- *Confirmation bias* – observing what they expect in observe
- *Hindsight bias* – a tendency to explain an event as inevitable once it has happened
- *Belief bias* – too much dependence on prior knowledge
- *Omission bias* – omitting information that was perceived as risky

(Marsh and Hanlon, 2007; Nestler and Von Collani, 2008; Stanovich and West, 2008) In decision making, cognitive biases influence people by causing them to over rely on previous knowledge, while dismissing information or observations that are perceived as uncertain, without looking at the bigger picture (Shah and Oppenheimer, 2008).

2.7 Underlying influences on falls from height

Bomel (2001) developed a network to gain an insight into the underlying influences on falls from height in the construction industry. The study used a baseline of accidents resulting from falls from height, taking into account under-reporting, from RIDDOR accident data for the period 1996/97 to 2000/01 together with HSE investigations data and information from experience and open literature. The method was to consider the human activities in construction in the context of the site organisation, corporate approach of principal parties and environmental factors, such as the regulator influencing the industry. They used the information to develop a network to structure and quantify the influences that could contribute to falls from height in the construction industry. The network is a model representing the various factors that influence the occurrence of a particular accident. Bomel highlighted that accidents are caused by a complex combination of events; they do not happen in isolation, but are part of a wider system of casual factors, which can be identified as a nested system that influence the performance of people and hardware in hazardous situations (Figure 2.1).



(Bomel, 2003. p.125)

Figure 2.1: Nested system of influences

This confirmed the research of Pearce (1986) who identified that '*a typical accident in the built environment is a process and not a single isolated event*'. Bomel's nested system comprised of a set of generic influences (Table 2.6) which were based on theory and experience to cover principle aspects of human and organisational behaviour, whilst accounting for hardware and external factors which could contribute to accident causation.

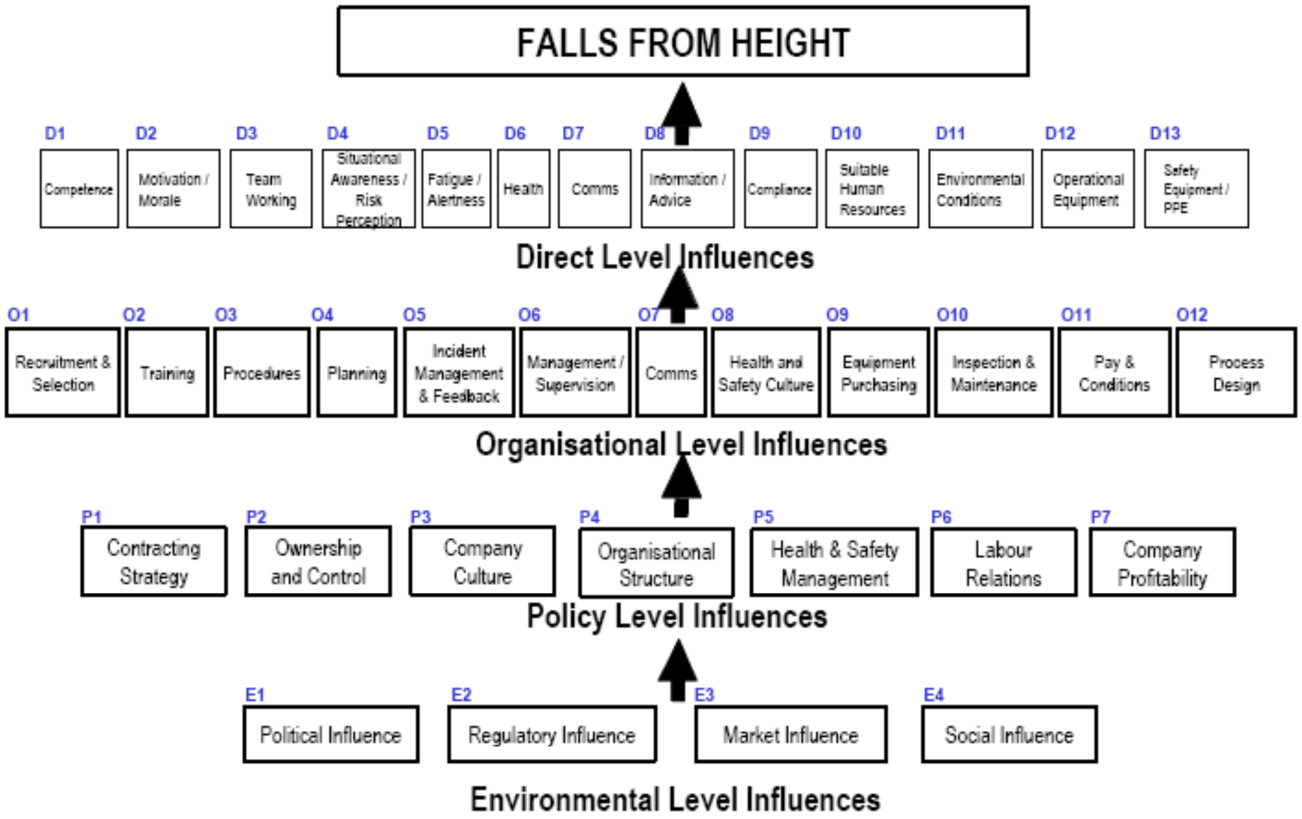
Influence level	Definition
Direct level	Applies to site operatives and technicians, i.e. the people actually carrying out the construction work
Organisational level	Applies to site organisation and local management
Policy level	Applies to both the client and construction company management
Environmental level	Incorporates both national and local government procurement strategy as well as government as guardians of worker and public safety

(Bomel, 2003.)

Table 2.6: Generic influences

Importantly the technique distinguished the quality of practice in a particular area (rating) from its significance (weighting) in determining other factors. It was developed by defining the accident and identifying the hierarchy of influences upon the accident. Workshops helped identify the main cause of falls, which were identified within the influence network as, environmental, policy, organisational, and direct level factors. The model (Figure 2.2) identified that one of the main factors that had a direct influence on falls was the situational awareness and risk perception of workers. It was suggested that this was at least partly due *'to familiarity with the hazard and complacency towards the risk'*. Inadequate risk perception was thought to contribute to accidents, in that *'people recognise the hazard but do not modify their behaviour accordingly, and have a greater perception of risk for work at high levels but an underestimation of risk at low levels'*(Bomel 2001).

The strength of Bomel's (2001) research is that it used data from a wide section of the construction industry, and therefore produced a network that was representative of the industry. Research carried out by Bomel (2003) for the Health and Safety Executive into the underlying influences on, and control of falls from height, used the influence network to provide a quantified model of the influences affecting falls from height. The research strategy adopted was to consult with key stakeholders through workshops to obtain a consensus view on the key issues relating to falls from height and the measures available to prevent and control those risks.



(Bomel, 2003)

Figure 2.2: Influence network

Due to the nature of construction work the workshops focussed on both new build construction and existing structures. Representatives were taken from: self-employed structural work, the Health and Safety Executive, civil and structural engineering personnel. The new build workshop focussed on the construction of single and multi-storey buildings, bridges and industrial structures in structural steel, concrete and timber. The existing structures covered inspection, repair, maintenance, refurbishment and demolition.

The attendees were briefed on the approach to be taken and the definitions to be used prior to the workshops (Table 2.7) and concentrated on the following objectives:

- Identification of the factors that influence falls from height
- Rating the factors in terms of current practice
- Weighting the influences of each of the factors on other factors
- Identifying possible risk control measures

Factors	**Underlying influences**
Direct level	Competence, situational awareness, risk perception and compliance were identified as being amongst the most significant factors.
Organisational level	The primary influences on falls from height were identified as training, management and supervision, followed by planning, communications and safety culture.
Policy level	Company culture and health and safety management are the most significant factors followed by contracting strategy via the client.
Environmental level	Regulatory and market influences are far more significant than political or social influences.

(Bomel, 2003)

Table 2.7: Underlying influences

A major weakness with Bomels research was that there were no representatives from small or micro organisations; no input from jobbing builders, and no experienced builders within either group. The input was from representatives all based at the higher levels of construction organisations, which have an effect on the overall conclusions.

2.7.1 Critical factors influencing falls from height

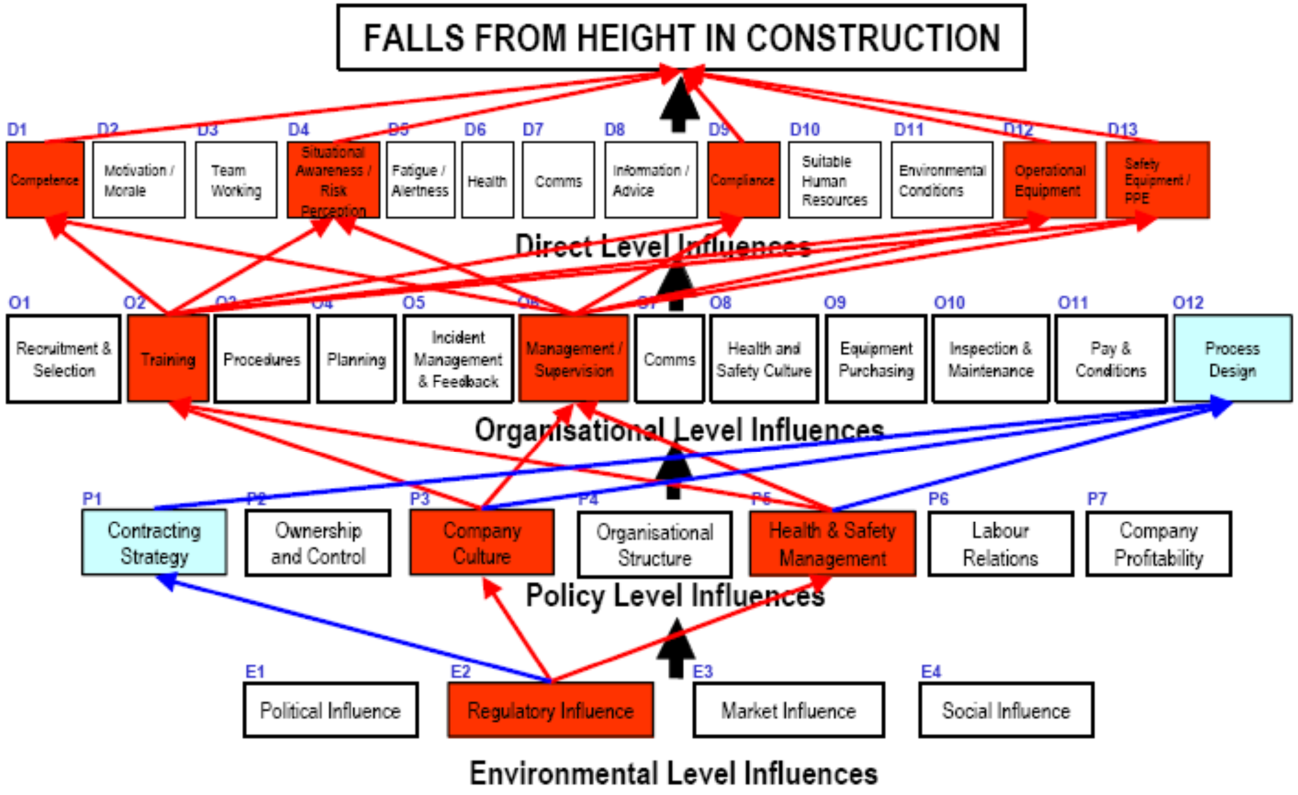
The quantitative analysis of the influence network involved the calculation of a risk index for falls from height using rating and weighting values assigned to each activity. This was then used to explore the influences bearing on the current risk level and to ascertain the potential for improvement. The ratings were increased in a systematic way in order to assess the effects that these increases had on the overall risk index. The process was then used to highlight the critical factors that may have the most potential to reduce the overall risk and to plot paths of influence through the network:

1. Competence, risk perception, situational awareness and compliance on site
2. Operational equipment and safety equipment / Personal protective equipment
3. Process design

The workshops identified three main factors having the most potential influence through the network (Figure 2.3). Bomel (2003) identified five underlying causes in falls from height which appeared to be most common across industry:

1. Attitude
2. Risk perception and situational awareness,
3. Risk awareness
4. Safety culture
5. Safety training

It follows that if these underlying causes can be matched with risk control measures then reductions in the risk of falls from height could be made across the industry.



(Bomel, 2003, p 164)

Figure 2.3: Critical factors influencing falls from height in construction

Attitude

Much of the discussion related to the underlying attitude associated with the accidents which appears to be 'it won't happen to me'. Several hypotheses for this attitude were put forward including:

- *Complacency* – I've been doing the job for twenty years and have never had an accident so why should I change now
- *Inexperience*- new to the work activity
- *Production culture* – work pressures forcing people to cut corners
- *A lack of appreciation* – of the scale of the risk
- *Basic human nature* – to get things done quickly and easily
- *Macho culture*

In reality it is likely to be a combination of these factors which encourages people to take unnecessary risks while working at height. At the basic level the two underlying factors that were identified that needed to be addressed were:

- Eliminate hazards through improved process design
- Encourage safe behaviour while working at height, thereby improving compliance

This approach looks to alter the 'it won't happen to me attitude' by making people realise that it could happen to them as improving compliance is strongly linked to risk perception.

Risk perception and situational awareness

Research carried out by McDonald and Hrymak (2002) into safety behaviour in the Irish construction sector highlighted that that risk perception was very important in terms of reducing the risk of falls from height. This was supported by Bomel (2003) who added that situational awareness was also an important factor, and summarised that *'people can generally appreciate the hazards but are not good at quantifying the risks'* and in terms of improving risk perception, it was acknowledged that this is a difficult area. Bomel (2003) made the point that unless people see negative consequences for unsafe behaviour then they will continue to break rules because they feel *'they can get away with it'*. It was proposed that the nature of working at height means the hazards and risks are not appreciated as much as other similar hazards. This being the case it is perhaps necessary to present hazards and risks in a different light. This may include comparing the risk level to a domestic situation which people would never put themselves into, showing graphic illustrations of the severe consequences. If people are more aware of the risks then they are more likely to follow the rules for working at height without strict policing.

The difficulty with risk perception was brought into sharp contrast by Bomels research when he reported that a particular group of workers had been willing to put themselves at more risk in order to wear more comfortable personal protective equipment even though it was less safe. The workers were prepared to sign a declaration that they would not bring claims against the company if they had an accident. This appears to relate to the attitude that 'it won't happen to me'. The feeling emerged that the workers may be competent, know the hazards and the rules and have the right equipment but still take unnecessary risks while working at height due to poor risk perception (Bomel, 2003).

Bomel (2003) research identified that people are aware of the hazards when working at height but not the extent of the risks. The attitude that *'it always happens to somebody else'* was identified as common in work at height, and that people will always take risks during work that would normally be considered unacceptable. Bomel (2003) identified that people *'have a different idea of what constitutes risk when they are working',* and that one reason for this seems to arise from *'overconfidence and familiarity with the hazards'*. Bomel also identified that as a consequence of this *'there may be more risk of a low fall because the risks do not register as being significant'*. Awareness needs to be raised of the risks associated with low level falls given that there are so many of them.

In terms of improving risk perception, it was acknowledged by Bomel (2003) that this is a difficult area but there were a number of suggestions. Of great importance is that managers and supervisors lead by example and do not take risks that they do not want their operatives to take. This was thought to be the first step in developing a culture where people take less risk. The point was made that unless people see negative consequences for unsafe behaviour then they will continue to break rules because they feel 'they can get away with it.' It was proposed that the nature of working at height means the hazards and risks are not appreciated as much as other similar hazards. This being the case it is perhaps necessary to present hazards and risks in a different light. On the basis of the discussions and analysis of results Bomel (2003) proposed the following potential risk control measures:

- Action to raise the situational awareness and improve risk perception
- Improving the safety culture of the industry (both individuals and organisations)
- Providing a better trained workforce

In terms of raising situational awareness / risk perception a number of possibilities were put forward in the workshops:

- Presenting the risks, hazards and consequences of falls from height in a way which attracts workers attention
- Supervisors leading by example
- Introducing risk taking and the consequences into the education system to encourage an overall societal change

This suggests that a multi prong approach is required, addressing risk perception among both current and future workers.

Risk awareness

Bomel (2003) concluded that risk awareness was the key factor in the reduction of falls, and although large companies take ownership and responsibility for safety, smaller companies and the self-employed do not put safety high on their agenda, if at all. Therefore, if the level of injuries associated with ladder falls is to be significantly reduced it is essential that personnel are made more aware of the risks. Accurate risk perception is therefore essential in order to facilitate an employee's duty of care to themselves, which means that appropriate risk communication is vital.

Aranda (n.d) agreed with Bomel's conclusion by identifying safety communication as one of three '*emotional constructs'* highlighted by participants during research into hazard perception. The research, unlike Bomel's, used experienced construction operatives, bricklayers, carpenters, plumbers etc. who participated as part of their normal working day, rather than managers.

Bomel's (2003) extensive study recognised the need to take action to raise situational awareness and to improve the risk perception of workers and proposed better planning and appropriate method statements, such that the work process is thought through beforehand and the risks managed in the most appropriate way. They emphasised the role of the regulator in that it underpins many of the potential risk controls, and highlighted that the HSE has a major role to play including further information, advice and best practice along with greater prescription and tougher enforcement. They proposed improving the safety culture of the construction industry, both in terms of individuals and organisations, as the current culture is felt to underpin many of the current problems.

Safety culture

Safety culture is described by Zhang, et al. (2002) as *'the value and priority placed on safety by everyone in every group, at every level of an organisation'*. It refers to the extent to which individuals and groups will commit to personal responsibility for safety. Within the construction sector risk taking is often the culture that exists, reinforced at the operational level by a traditional emphasis on meeting production goals rather than safety. Therefore decisions on taking or rejecting risks are affected in part by the safety culture of the organisation. The concept of safety culture is discussed more fully in section 2.8 of this literature review.

Safety training

Bomel (2003) concluded that on an operational level, one of the primary influences on falls from height was training, and that a potential risk control measure for the construction industry was to provide a better trained workforce. Bomel suggested that because of the high turnover rates of the workforce and the difficulty of ensuring competence of working at height the uptake of schemes such as the Construction Skills Certificate Scheme (CSCS) would be beneficial. Bomel's research was supported by the findings of Loughborough University (1977) who suggested that *'Passport to work'* safety training systems had been very effectively used on large construction projects to reduce the incidence of accidents. The CSC Scheme requires workers to hold a valid safety knowledge certificate before they can work on a construction site. To obtain certification the worker needs to pass a health and safety examination and prove work competency via possession of relevant qualifications or verified by industry experience. The principle behind the scheme is that through competency assessment and enforcement it should be possible to improve site safety. However, there is no published information that directly links the CSCS to safety performance (Trethewy, 2003).

Hinze, et al. (2002) conducted a study to determine what elements of safety programmes of large construction organisations were responsible for a reduced rate of falls in comparison to small construction organisations. A survey of twenty five large organisations showed that the rate of falls decreased as the cost of construction projects increased, and it was suggested that safety training was likely to be one of the key elements responsible. The large organisations tended to plan for a high turnover of workers and put into place finance for appropriate training programs. This was not evident with small construction companies who did not build safety training into their work perhaps because they may be priced out of the market or go out of business.

McDonald and Hrymak (2002) carried out research into safety behaviour of a representative sample of eighteen construction sites in Ireland, by using site observations and operative questionnaires. The research established that very little time was devoted to health and safety training across all sites. Almost 40% of operatives received no safety training from the main contractor. For a further 50% their safety training comprised of an induction course, lasting between ten minutes and one and a half hours. For the majority of operatives the main way in which they achieve knowledge of the risks is through their experience of the work itself, even where the main contractor provided induction training it was perceived as a formality with little expectation that it would influence knowledge or behaviour.

Bomel (2003) reported that contrary to some opinions, training was probably not a practical means of improving safety in terms of working at height, and that awareness was the key factor opposed to training. It was also highlighted by McDonald and Hrymak (2002) that training does not lead to competence, defined as a person that has: 'sufficient training and experience or knowledge' (The Management of Health and Safety Regulations, 1999) and it is vital to have the right blend of experience and training as it is easy to check for training but less so for competence.

2.8 Safety culture

The immediate causes of accidents in construction are often identified as human error or technical failure but the investigations and analysis of the circumstances surrounding major accidents such as, Chernobyl nuclear disaster, Kings Cross fire, and sinking of the Herald of Free Enterprise have, according to Yule (2003), *'revealed issues beyond the immediate causes'.* These issues relate to wider considerations of the organisation as a whole. A quotation from the International Nuclear Safety Advisory Group (INSAG) (1991) enquiry report for the Chernobyl incident illustrates the point:

'...their belief in safety was a mirage, their systems inadequate, and operator errors commonplace...from the top to the bottom, the body corporate was infected with the disease of sloppiness'.

It has become clear that basic faults in organisational structure and procedures may predispose an organisation to an accident. This background environment is being increasingly described in terms of safety culture (Institute of Electrical Engineers, 2004).

When reviewing the safety literature it becomes apparent that there is no exact definition of the term safety culture, as disagreement exists between researchers as to how safety culture should be defined. The term seems to have arisen out of the Chernobyl disaster report where errors of the operating procedures were seen as being evidence of a poor 'safety culture' at the plant (Fleming, 1999).

The definition suggested by the Health and Safety Commission (2002) is:

'The safety culture of an organisation is the product of the individual and group values, attitudes, competencies and patterns of behaviour that determine the commitment to, and the style and proficiency of an organisation's health and safety programmes'.

The HSE, (1993b) advisory committee on the safety of nuclear installations suggests that;

'*Organizations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety and by confidence in the efficacy of preventive measures*'.

The Confederation of British Industry (CBI) (1990) uses a more simplistic definition as '*the way we do things around here*', which seems to sum up how organisations work.

A recurring theme within the literature is that safety culture has two general components; the first is the safety framework of an organisation (culture), which is the responsibility of the organisation management, and the second is the perception of workers at all levels responding to the framework (climate). However there is some confusion amongst researchers and practitioners as the terms are often used interchangeably. In an attempt to clarify the concepts, Zhang, et al. (2002) proposed hybrid definitions following a comprehensive review of literature, and has defined the terms as:

- *Safety culture* -The enduring value and priority placed on worker and public safety by everyone in every group at every level of an organisation
- *Safety climate* -The temporal state measure of safety culture, subject to commonalities among individual perceptions of the organisation

Most 'safety culture' research has focused on measuring workers 'safety attitudes' within an organisation, with positive attitudes being considered to be the most important aspect of a good safety culture. Fleming and Buchan (2002) highlighted a study carried out by Mearns, et al. (1997) in the UK offshore oil industry, which assessed attitudes to safety among 722 workers on ten offshore installations. They used focus groups, followed up by individual questionnaires to obtain worker views on safety. They found major differences in the views of different groups of workers, who had different perceptions, beliefs and attitudes with respect to safety, which were linked to their safety behaviour and to prior accident involvement.

There have been attempts to integrate the two concepts to reduce confusion. Guldenmund (2000) proposed that they could be understood in terms of a sphere with three layers. At the centre are the basic assumptions held by an organisation. The middle layer highlights attitudes, training, procedures and formal communications. The outer layer contains the outcomes of safety such as accidents and incidents.

Loughborough University (1977) in partnership with the Offshore Safety Division of the HSE combined the different approaches during the development of their 'Measurement Toolkit' for safety climate. They used a multiple perspective model to show three different aspects of the organisational culture (Figure 2.4), and used the model to formulate their research emphasising that safety culture can be measured in a variety of ways.

(Loughborough University, 1977)

Figure 2.4: Measurement of culture

2.8.1 Positive safety culture indicators

Gadd (2002) describes a positive safety culture of an organisation as '*the product of individual and group values, attitudes, perceptions, competences and patterns of behaviour that determine commitment to, and the style of an organisations health and safety management*'. The Advisory Committee on the Safety of Nuclear Installations (1993) describes positive safety culture to be characterised by '*communications founded on mutual trust, by shared perceptions of the importance of safety and by the efficacy of preventative measures*'. A positive safety culture is about improving safety attitudes in people, but it is also about safety management that uses a holistic, whole of organisation approach. Gadd (2002) from a review of literature on safety culture has identified the factors that appear to characterise organisations with a positive safety culture (Table 2.8). The opposite is the case in a negative safety culture, where the commitment of some workers is negatively affected by the cynicism of others, even though they are subject to the same policies and procedures.

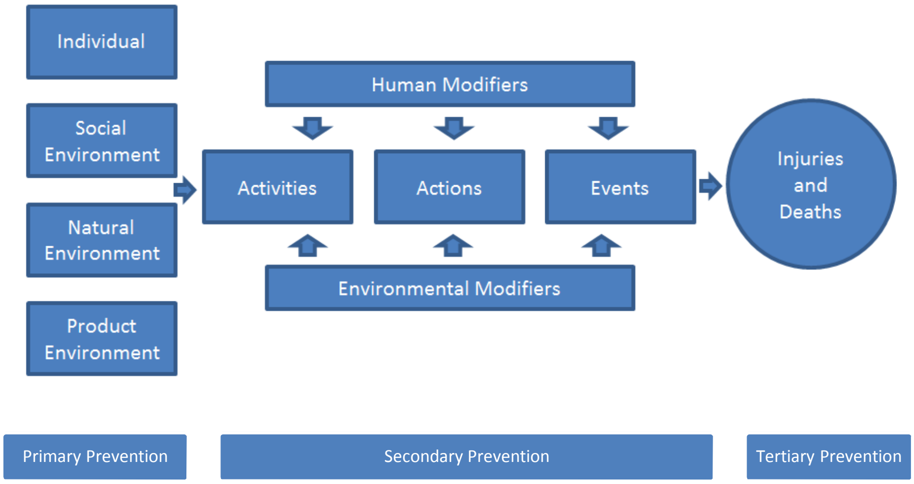
Managers	Indicators
Planning work effectively	Avoiding production pressures on workers leading to 'cutting corners', or turning a blind eye because of pressure.
Active monitoring	Conducting safety tours
Reactive monitoring	Investigation of accidents, near misses or occupational diseases.
Participation on health and safety committees	Considering e.g. Environmental factors and workplace layout Influences on performance – fatigue, training and experience
Communicating	Keeping people informed of health and safety issues.

(Gadd, 2002)

Table 2.8: Positive safety culture indicators

Aranda's (n.d) research agreed with part of Gadds findings by identifying management communication as one of three '*emotional constructs'* highlighted by participants during research into hazard perception. The research used experienced construction operatives, bricklayers, carpenters, plumbers etc. from a working construction site. A modified accident process model was produced previously developed by Kelly (1959) to present his results, which he identified in three groups:

the place, the people and the organisation (Figure 2.5), which stressed all have an effect on the safety culture of the organisation.

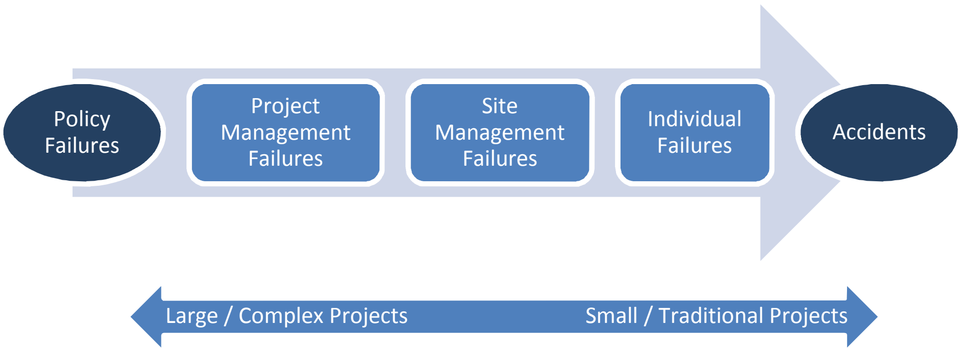


(Modified from Aranda n.d. p 13)

Figure 2.5: Accident process model

2.8.2 A model of accident causation

Whittington et al. (1992) carried out research into the management, organisational and human factors in the construction industry with the objective to examine the extent to which safety performance in the industry may be undermined by factors beyond the control of the individual worker. The study involved a detailed analysis of 30 serious accidents, together with interviews and postal surveys with safety managers and clients. A model was proposed (Figure 2.6) for considering the influence of management and organisational factors on the behaviour of an individual worker. This addressed the root cause of the behaviour previously identified by Gronenweg, et al. (1991) who pointed out that conventional thinking about accidents often remains at the 'event area', with accident investigations focussing on the unsafe acts and immediate related triggers. Accidents are then regarded as events appearing suddenly and out of nothing and the human component is characterised as involving ignorance, stupidity or deliberate negligence. Whittington, et al. (1992) suggested that it fails to recognise that different forms of error exist which have underlying causes, which may be out of the individual's control, such as time pressures. The model assumes that the starting point is the stage at which the prime responsibility for safety is managed.



(Whittington, et al., 1992. p 29)

Figure 2.6: Influence of factors on individual behaviour

Whittington, et al. (1992) emphasised that failure for the large / complex projects are likely to result from failures at the policy levels and that accidents at the small traditional projects are more likely to result from failures at site management or individual level. The following example of a person who fell through a roof was used to illustrate the point (Table 2.9).

Level	Failure
Policy Failure	No company procedure to cover work on fragile roofs.
Project Management Failure	Failure to employ specialist contractor.
Site management failure	Failure to ensure individual was appropriately trained. Failure to identify roof was fragile. Failure to establish a safe system of work.
Individual failure	Certain level of risk taking and probable inattention whilst carrying out task.

(Whittington et al. 1992)

Table 2.9: Accident causation

2.8.3 The nature of the industry

Many researchers and practitioners are utilising the construct of safety culture to help improve construction workplace safety. However, the transitory nature of work within the construction sector frequently hinders an organisation's attempts to develop and maintain a good safety culture. Risk taking is seen as endemic, and indeed the culture which often exists at the operational level has traditionally reinforced this by placing considerable more emphasis on meeting production goals rather than safety as a large proportion of the work is completed by subcontractors, the majority of whom will shift regularly between projects and primary contractors (Biggs, et al., 2005). The nature of the working culture is strong and seen by many as the most significant influence undermining safety on site; and a culture which has historically valued initiative and flexibility is likely to be resistant to change Whittington, et al. (1992).

Little (2002) carried out research into the interfaces between various parties involved in a construction project. Workshops were held between clients and contractors involved in high risk projects; however no participants were from small or micro organisations. The work identified that at any point in a project there can be a new influx of people onto the site at both managerial and operative level who have little previous knowledge of the project. The workshops recognised that in order that the 'safety baton' is effectively transferred to these people, it is important that safety is introduced as an integral part of the project management procedures from the beginning. Furthermore, even when a proficient safety culture is present, the knowledge about how to develop and maintain this culture is often lost when the project ends and the workers disband (Trethewy, 2003).

Little research has specifically tested for the mechanisms by which safety climate influences safety outcome. To meet this need Mohamed (2002) used structural equation modelling to investigate the independent factors that accounted for safety climate in the Australian construction industry. The modelling identified four independent constructs determining safety climate: management, safety, risk and competence (Table 2.10). Higher values on the management, safety, and competence constructs were associated with a better safety climate, for risk, greater work hazards were associated with a poorer safety climate.

Factor	Incorporating
Management	Communication, commitment, supervisory environment, supportive environment.
Safety	Safety rules and procedures of the organisation.
Risk	Appraisal of the work hazards they faced and their personal risk appreciation.
Competence	Level of skills, knowledge and ability of workers.

(Mohamed, 2002)

Table 2.10: Independent factors that account for safety climate

Guldenmund (2000) identified from literature that safety culture is determined by the commitment, leadership and communication styles of management together with the participation, training, behaviour and attitudes of individual workers. For instance, a safety climate study in a large retail organisation by DeJoy, et al. (2004) found that environmental conditions, safety policies/programmes, and organisational support play a strong role in determining safety climate (Table 2.11).

Safety climate	Related conditions
Environmental conditions	E.g. noise, heat, chemicals, hazardous tools and equipment.
Safety related policies / programmes	Referred to the existence of directives indicating the value an organisation's management placed on safety.
General organisational climate	Individual's perception of various aspects of their organisation, including areas such as leadership, communication, organisational support, participation and innovation.

(DeJoy, et al., 2004)

Table 2.11: Perceived safety climate

To summarise, the immediate causes of accidents in construction are often identified as human error or technical failure however it has become clear that basic faults in organisational structure and procedures may predispose an organisation to an accident, this background environment is being increasingly described in terms of safety culture. Organisations with a positive safety culture are characterised by communications founded on mutual trust and by shared perceptions of the importance of safety. However risk taking is seen as endemic in the construction industry and the culture which often exists has traditionally reinforced this by placing considerable more emphasis on meeting production goals rather than safety. Also the transitory nature of work within the construction sector frequently hinders an organisation's attempts to develop and maintain a good safety culture as it is lost when the project ends and the workers disband.

The complex combinations of cultural, psychological and behavioural factors that influence the risk perception of ladder users are not fully understood. It is not clear where to focus attention to help improve the situation, and the solution currently seems to be focussed on the training of ladder users. The following section therefore provides a review of the ladder use training aids currently available within the UK.

2.9 Review of ladder training aids

The review has concentrated on information currently available within the UK. Although a worldwide search has been carried out it has been restricted to information published in written English, and has focussed on the United States of America, Canada, Australia, New Zealand and Northern Ireland. Information from the European Union was also reviewed although guidance referred the reader back to information produced by the member states. The review has also concentrated on the hazards connected with falls from ladders rather than the hazards associated with safe working practices that could contribute to a person falling.

It has not been possible to trace when the first ladder training aid was made available for construction employees. Early guidance normally formed part of prescriptive regulations, for example the Construction Regulations (Royal Society for the Prevention of Accidents, 1966), related codes of practice and associated guidance. There has been a steady flow of guidance following the inception of the HSE in 1974, who have regularly published ladder guidance for employees. This information however largely 'waited on the shelf' not fully utilised until the early 1990s, (Lawrence, et al., 1996) when a new impetus was placed on health and safety by the HSE following directives from the European Union. New UK legislation that followed in the form of the Construction (Health, Safety and Welfare) Regulations (HMSO, 1996) placed specific emphasis on the avoidance of falls from height which included the use of all types of portable ladders.

The new emphasis on reducing the incidence of accidents associated with falls from ladders has prompted more information to be made available for ladder users. The Department of Trade and Industry published a handbook (DTI, 1993) that gathered together expert advice and guidance on the safe use of ladders. It listed the do's and don'ts of selection, erection, using and storing of portable leaning ladders, however the information was not specific to the construction sector but gave general guidance that could be applied to all industries. The majority of other information sources are in the form of checklists of actions to be carried out, and a wide variety of types are available including: manuals, bulletins, guidelines, handbooks, leaflets, advice, training modules, study units, information sheets and booklets.

The HSE believes that all ladder users need adequate information and training to be able to use ladders and stepladders safely and that adequate supervision is needed so that safe practices continue to be used (HSE, 2005). The most recently published information by the HSE gives separate guidance to employers and employees and is available as three separate guides:

- Safe use of ladders and stepladders – An employer's guide
- A toolbox talk on leaning ladder and stepladder safety - employees guide
- Top tips for ladder and stepladder safety – employees pocket guide

The employer's guide (HSE, 2005) concentrates on good working practice and uses both correct and incorrect examples to highlight specific ladder use. It states clearly the minimum requirements for aspects of normal portable ladder use and provides checklists for minimum requirements. It reinforces the need to ensure that the ladder is the most suitable access equipment.

The guidance is to help employers know:

- When a ladder is the most suitable equipment
- When it is a safe place to use a ladder or stepladder
- When the ladder or stepladder is safe to be used

It is not specific to the construction sector and the information is generic in nature. The guidance currently directed towards employees is in the form of a toolbox talk (HSE, 2005) which contains similar information to that contained in the employer's guidance; however the emphasis is on improving the competence of the employee by concentrating on, hazards, pre-checks, positioning and safe use of the equipment. It provides a framework to guide the learner through step by step stages of correct ladder use using questions and answers as the learning method for this non practical session. The pocket guide (HSE, 2005) provides the ladder user with a very basic checklist for use of the equipment, in an easy to follow bullet point format which is intended to be carried by the user.

Written guidance from around the world tends to be government led (Table 2.12).

Country	Relevant Organisations
Australia	Department for Administration and Information Services.
Canada	Centre for Occupational Health and Safety (COHS).
European Union	European Agency for Safety and Health and Work.
Ireland	Health and Safety Authority (HAS).
USA	Department of Labor, Occupational Safety and Health.
New Zealand	Department of Labour Occupational Safety and Health.

Table 2.12: World ladder use guidance

The information is very similar in nature to that of the UK (Table 2.13) providing the same information to ladder users, albeit in slightly varying formats. It tends to follow a common approach and is produced in a relatively standard format. Some publishers deal with the choice, inspection, maintenance and storage of the ladders in some detail and others concentrate on the use of the ladder. The format seems to depend on whether it is designed as a guide for the user or as information for the employer.

Title	Published	Description
Safe use of ladders and stepladders. An employer's guide INDG402 C3000	UK Health and Safety Executive 2005	The leaflet contains notes on good practice which are not compulsory but which the reader may find helpful in considering what they need to do when using ladders and step ladders. The leaflet explains when a ladder is the most suitable access equipment, if it is safe to use and the users know how to use them safely. It is a general leaflet and is not specific to construction. The information is supported with good graphics of do's and don'ts.
Top tips for ladder and stepladder safety	UK Health and Safety Executive 2005	A pocket card giving notes on good practice which are not compulsory but which the user may find helpful in considering what needs to be done. It is a general guide and is not specific to construction.
Safe use of ladders and stepladders. An employer's guide	UK Health and Safety Executive 2005	The checklist covers ladder preparation, climbing and points to remember when using portable ladders for the service industry. It is a general guide and is not specific to construction.
Working Safely at Height	EU European Agency for Safety and Health at Work 2004	The guidance includes aspects of working from ladders and covers choice, maintenance and coordination. The article is construction specific and provides a checklist on the prevention of falls from height.
General access scaffolds and ladders. information sheet no. 49 (revision)	UK Health and Safety Executive 2003	The information sheet provides a basic checklist on the safe use of ladders and stepladders specific to the construction industry.
Stairways and Ladders 3124 - 12R	USA Department of Labor Occupational Safety and Health Administration OSHA 2003	The information booklet provides a general overview of the OSHA rules for the use of ladders. It provides comprehensive checklists for the use of ladders and stepladders and the training requirements needed to comply with the regulations. It is a general booklet and is not specific to construction.
Ladder Safety A 5-Minute training Aid HS02-029A (09-02)	USA Texas Workers Compensation Commission 2002	A thirteen point checklist of tips to keep in mind when using ladders. It is a general training aid and is not specific to construction.
Stepladder safety OSH 3700.16	New Zealand Department of Labour	The bulletin describes the choice and maintenance of stepladders. It gives essential safe working practices to consider when using a stepladder. It is not specific to

Title	Published	Description
	Occupational Safety and Health 2001	construction.
Ladder safety rules	USA Department of Labor Occupational Safety and Health Administration OSHA 2000	The guide is designed as a quick and easy reference for employers and employees on the requirements of the OSHA regulations and some learned common sense rules for the safe use of ladders. It provides the information in the form of checklists for: ladder inspection, setup, climbing and standing, proper use, care and storage. It is a general guide not specific to construction.
Safeguards GS 57 Ladders	Australia Department for Administrative and information services. 2000	Basic information provided to offer guidance on ladder legislation. It provides rules for the use of portable ladders in the form of checklists supported by basic graphics and an inspection checklist. It is general guidance and is not specific to construction.
Portable ladders /Stepladders	Northern Ireland The regional Health and Safety Authority Health and Safety Executive 2000	The guidance gives simple but essential safety steps to help the user control the risks when using ladders and stepladders. They are presented in the form of a checklist and include a helpful graphic of correct ladder use. It is a general guide and is not specific to construction.
Portable ladders Safety guide no: 4053	Australia Minister of Commerce New South Wales Work Cover 1999	The guide gives brief points to be observed when using portable ladders and includes supporting at the base, set up angle and use of the ladder. It includes stepladders and multipurpose ladders. It is a general guide and is not specific to construction.
The ladder users handbook	UK Department of Trade and Industry 1999	The handbook gathers together expert advice and guidance on the safe use of ladders. It lists the do's and don'ts of selection, erection, using and storing of portable leaning ladders. It is a general guide and is not specific to construction.
Ladder - Safety Hazards OSH Answers	Canada Canadian centre for Occupational Health and Safety National Occupational Health and Safety Resource 1998	The guide uses lists to inform the reader how to choose, set up and use a portable ladder safely. It also gives a check list of what to avoid when climbing portable ladders. It is a general guide and is not specific to construction.

Title	Published	Description
Safe Ladder Use Construction Bulletin Number 3	USA Department of Labor Occupational Safety and Health Administration OSHA 1998	A construction specific bulletin outlining the maintenance, transportation and inspection of ladders before use. Also contains a very basic yes/no user checklist.

Table 2.13: Summary of ladder safety guides

There is also a wealth of other sources who offer free advice and information, and who publish guidance on the use of ladders. Many organisations across the UK produce guidance suited to their company, especially national organisations, Local Authorities, colleges and universities.

The guidance almost exclusively follow the same layout pattern and start with the choice of ladder and its inspection, and then list how to set-up and use the ladder safely. The majority use some form of checklist to reinforce the main points and many include additional references where more specific information can be located. Once again they are very similar in their content and many reproduce part of the information that is provided free by the HSE. Irrespective of the country, government, body or organisation that publishes ladder safety information the message tends to remain the same. The structure of the guidance follows a logical progression from the initial selection process through the inspection and set up to the safe use of the equipment. Virtually all of the guidance contains checklists of recommended ladder use. However very few publications contain any form of image to help reinforce the safety message. Images that are provided are generally in sketch are cartoon format that may convey a humorous, rather than a serious message to the user.

Information provided for ladder users is generally generic in nature, aimed at an industry wide audience and does not take into consideration the specific problems associated with the construction sector. Construction has a higher potential for accidents than more static environments such as factories, offices etc. as the ladders are used extensively in outside environments where they are subject to the elements and are used for rigorous activities. Although the safety information has been made available from a wide variety of sources the message has generally remained the same, and there is very little ladder use information that is construction specific.

The UK seems to compare well with other EU and worldwide countries in terms of the information provided for the safe use of ladders. Employers, aware of the need to ensure that all personnel have the correct level of training for work at heights have set up national training programmes such as the Construction Skills Certificate Scheme (CSCS) operated by the Construction Industry Training Board (CITB) and the Safety Passport Scheme operated by the Client Contractor National Safety Group (CCNSG) to try to ensure that the correct information is conveyed to construction workers. The new schemes have been supported by the major contractors group and there is a requirement for all personnel to carry a CSCS card or Safety Passport card.

There is an abundance of safety information available on ladder safety, in the form of checklists, safety cards, and leaflets; however they often remain unread (Lawrence, et al., 1996). The operatives are either not getting the message, don't understand it, or are choosing to ignore it, and taking a chance. The fact is that a ladder is one of the simplest and most easy-to-use pieces of equipment in the industry, and statistics suggest that their abuse and misuse is a rule rather than an exception. There are still horror stories to be told of the cavalier attitude of some site operatives, with a comment such as "it will only take a minute" (Singleton, 2004). Lawrence, et al. (1996) concluded that there was a definite need to raise awareness of the safety messages.

To summarise, there has been a steady flow of training aids published around the world for the safe use of ladders, which place emphasis on improving ladder-use competence by concentrating on hazards, pre-checks, positioning and safe use of equipment. The most recent published by the HSE is aimed at the employee and is in the form of a toolbox talk and pocket guide. However research suggests that the information often remains unread and operatives are either not getting the message, don't understand it, or are choosing to ignore it and taking a chance. Information provided is generally generic in nature and does not take into consideration the specific problems associated with the construction sector.

2.10 Review of regulations

A review of current Health and Safety Regulations was carried out to determine which regulations were applicable to the use of portable ladders. The following includes the relevant clauses from UK and European Union regulations (Table 2.14).

Name	Regulation
The Health and Safety at Work, Etc Act 1974	*Section 2 – General duties* This places a general duty on employers to ensure, so far as is reasonably practicable the health, safety and welfare of all employees and anyone who might be affected by work activities. It requires that employers provide safe access and egress, a safe system of work and equipment that is safe and suitable for the job
Provision and Use of Work Equipment Regulations 1998	The regulations require risks to people's health and safety, from equipment that they use at work, to be prevented and controlled. The regulations apply to all work equipment used where the HSW Act applies and is generally intended to ensure that work equipment does not result in an accident regardless of its age, condition or origins. Ladders are covered under this regulation and are defined as work equipment. *Regulation 4 – Suitability* Every employer shall ensure that work equipment is so constructed as to be suitable for the purpose for which it is used or provided. This means that the employer should ensure the equipment is used according to the manufacturer's instructions. The employer should also take into account the working conditions and the risks to the health and safety of the individual using the equipment. *Regulation 5 - Maintenance* An employer should ensure that the work equipment is maintained in a safe condition for use so that people's health and safety are not at risk. The frequency of maintenance should take into account the intensity of use, the operating environment, and the variety of operations undertaken. *Regulation 6 - Inspection* The extent of the inspection required will depend on the potential risks from the work equipment. Inspection should be carried out by a competent person and include, where appropriate, visual checks, functional checks and testing. As ladders are involved in a high number of accidents each year they can be viewed as posing a significant risk. *Regulation 8 - Information and instruction* Every employer shall ensure that all persons who use work equipment have available to them adequate health and safety information and, where appropriate, written instructions pertaining to the use of the work equipment. *Regulation 9 - Training* Every employer shall ensure that all persons who use work equipment have received adequate training for purposes of health and safety,

Name	Regulation
The Workplace (HSW) Regulations 1992	The regulations apply to a wide range of workplaces, however they do not apply where the only activity being undertaken are building operations. *Regulation 13 – Falls* This covers falls and requires that suitable and sufficient measures shall be taken so far as is reasonably practicable to prevent a person falling.
The Construction (Health, Safety and Welfare) Regulations 1996	The CHSW Regulations are aimed at protecting the health, safety and welfare of everyone who carries out construction work. They also give protection to other people who may be affected by the work. The main duty-holders under the Regulations are employers, the self-employed and those who control the way in which construction work is carried out. Employees have duties to carry out their own work in a safe way. *Regulation 5 - Safe place of work* This Regulation places a general duty to ensure a safe place of work and safe means of access to and from that place of work. It applies to all construction work, and all work at height and requires that 'reasonably practicable' steps should be taken to provide for safety and to ensure risks to health are minimised. *Regulation 6 - Precautions against falls* The guidance note to regulation 6 states that an employer must take steps to prevent people falling, and states that "*precautions must be taken to prevent falls from any height where injury might result*". This has impacted on the use of ladders and stepladders, in that, where practicable and especially where work is not of a short duration, working platforms should be used. The Regulation states that a ladder should not be used as a means of access to or from, a place of work unless it is reasonable to do so having regard to: The nature of the work being carried out and its duration. The risks to the safety to any person arising from the use of the ladder. *Regulations 28, 29 and 30 -Training and inspection* Before any work at height is carried out the place of work must be inspected, by an experienced competent person, who must be satisfied that the work can be done safely. Work at height activities are only to be carried out by, or under the supervision of an experienced competent person. *Schedule 5 -requirements for ladders* The schedule gives minimum requirements for ladders to comply with regulation 6 in terms of suitable and sufficient strength, positioning and erection and securing of ladders to be used as a means of access
The Management of Health and Safety at Work Regulations 1999	*Regulation 3 - Risk assessment* This regulation requires all employers and the self-employed to make suitable and sufficient assessment of risks to anyone affected by their work. This will enable them to identify measures that need to be taken to control the identified risks.

Name	Regulation
The European Directive 92/57/EEC	*Part B Specific minimum requirements for on-site workstations* Clause 4 requires that "Ladders must be sufficiently strong and correctly maintained. They must be correctly used, in appropriate places and in accordance with their intended purpose". However ladders do not appear in the control hierarchy and it can be seen that there is little unity across national borders, with respect to specific regulations concerning the use of ladders.

Table 2.14: Ladder Regulations

The Construction (Health, Safety and Welfare) Regulations (1996) emphasises that a ladder shall not be used unless it is reasonable to do so. Sopp (2003) reported that should an employer be taken to court as a result of a fall from a ladder, it would have to be show that it was reasonable to allow work to be completed from a ladder because, it was of short duration or the work could be performed with one hand, and the worker had received suitable training in erecting a ladder and using it safely.

It was emphasized that work that can be performed with one hand on a ladder is extremely limited. It could involve simple maintenance work where tools or materials are secured to a ladder by hooks or to the body by a suitable belt. Painting with a brush needing only one hand could be possible, as paint could be held in a painters kettle secured to a ladder rung. Perhaps masticing to seal gaps could be performed with one hand. However, where there is any doubt as to whether a worker will resort to using two hands, or where work clearly requires the use of both hands then a working platform must be used. Sopp (2003) highlighted that there may be risks to not only the person using the ladder and the person footing it but to passers-by and members of the public. This may involve placing warning signs and zoning off the area to protect people from falling materials or even the collapse of the ladder.

2.10.1 International regulations

Clift (2004) in a research report evaluating the performance and effectiveness of ladder stability devices reproduced a review of international standards applicable to ladders and stepladders taken from part of a larger survey produced by the Victorian Workcover Authority, USA on the causal factors implicated in accidents involving ladders. The following is an extract from Clift's report (Table 2.15).

Name	Regulation
United States The OSHA Regulations Part 1926	The OSHA Regulations Part 1926 Safety and Health Regulations for Construction – Ladders (1926.1053b) provides in great prescriptive detail for the use of fixed and portable ladders. The regulations do not establish a hierarchy of control; employers are permitted to select fall protection measures compatible with the type of work being undertaken. The section dealing with ladders (1053 (a) and (b)) do not indicate that ladders are to be avoided if safer alternatives are practicable.
Canada The Ontario Occupational Health and Safety Act	The Ontario Occupational Health and Safety Act, Construction Projects O. Reg. 213/91 regulate ladders under Part 2 General Construction. These provisions prescribe requirements for the design, manufacture and maintenance of ladders. They also give details on how a ladder is to be positioned and secured and used.
New Zealand The Health and Safety in Employment Act 1992 and Regulations 1995	The Occupational Safety and Health Service of the Department of Labour, New Zealand has developed Guidelines for the Prevention of Falls (January 2000) to assist duty-holders in meeting the requirements of the Health and Safety in Employment Act 1992 and Regulations 1995. The guidelines are primarily aimed at the construction industry, but they also have application to a wide range of work situations where workers are placed in a position from which falls are possible". A generic hierarchy of control is adopted: elimination, isolation or minimisation (the least preferred option). Control measures to prevent falls are not set out under this hierarchy, so it is not possible to discern whether ladders are included in, or excluded from, the hierarchy. Guidelines for ladders fall under the heading Temporary Non-Fixed Access and Platforms. Ladders are required to comply with the relevant New Zealand Standards.

Table 2.15: International Ladder Regulations

2.11 Ladder use regulations and guidelines

Legislation places greater emphasis on the use of safer alternatives to ladders, and specific requirements are required for the work to be risk assessed, organised, and planned, and take account of the distance and consequences of a fall (HSC, 2010). Whether the regulations will have any impact on the small and micro organisations is questionable, as safety knowledge at this level of the industry tends to be rather limited and the requirements of legislation are not generally known.

Current safety legislation places emphasis on the requirement that a ladder should not be used unless it is reasonable to do so, having regard to the nature of the work, its duration and the risks to the user. Employers must ensure a safe means of access to and from a place of work, and that all 'reasonably practicable' steps are taken to ensure risks from falls are minimised (Employers must take steps to prevent people falling by ensuring that ladders are in good condition, adequately maintained and inspected by a competent person. Employees should receive appropriate information, training and supervision to allow them to use ladders safely.

The use of portable ladders is currently controlled under a number of statutory regulations, most prominently within the Work at Height Regulations (2005). The regulations require that work at height is eliminated where possible, and where it is not possible then a risk assessment be carried out (Management of Health and Safety at Work Regulations, 1999) to determine the most reasonably practicable work method. Where work is carried out at height, every employer shall take suitable and sufficient measures to prevent, so far as is reasonably practicable, any person falling a distance liable to cause personal injury (WAHR, 2005). Ladders should only be used where the use of more suitable work equipment is not justified because of the low risk and short duration of use, or because of existing features on site which cannot be altered. The use of a ladder should be last resort in the hierarchy of control, however if ladders are used the following must be considered:

- Use of the ladder
- Type of ladder
- Positioning of the ladder
- Securing of ladder
- Duration of the work
- Prevention of and consequences of falls
- Wear and tear of the equipment
- Frequency of use
- Abilities of users
- Site conditions
- External factors, such as the weather
- Ladder design

2.11.1 Ladder design induced error

The basic principles on which ladders are designed and constructed are relatively simple, and are rated according to their safe working loads. Ladders marked with BS EN131 are given a maximum static vertical load rating, and ladders marked with

BS2037 are given a duty rating. They are designed for different purposes and different environments and are graded to indicate their correct level of use, as either:

- Class 1 (Industrial) Maximum static vertical load 175Kg - Duty rating 130kg
- Class 3 (Domestic) Maximum static vertical load 125Kg - Duty rating 95kg

Ladders are designed for the 'average' person, and can be used for a wide range of activities, it is therefore essential that the correct grade of ladder is selected and used in accordance with the manufactures instructions. Research carried out by McIntyre (1979) into the mechanics of ladder climbing, found that the design of ladders in terms of ladder width and rung spacing were factors beyond the control of the user that could be attributed to accidents. Results showed that taller ladder users climbed and descended ladders differently to shorter ladder users, which was dependant on their gait. Taller users spent less time in contact with the ladder rung in comparison with shorter users, and for short users increased rung spacing was accompanied by increases in applied force to the ladder and increased sway and bounce of the ladder. McIntyre (1979) concluded that ladders which have either narrow or wide rung spacing increased the likelihood of ladder users of a larger or smaller than average size being involved in a ladder accident. Furthermore a study by Juptner (1976) found that the shape of ladder rungs affected how a ladder was used and that rungs with curved sides had a significant impact on use.

The display of safety instruction labels on a ladder is a simple design feature to help ensure that ladders are used correctly. However, they must be positioned in a prominent position so that they can easily be seen, and acted upon by the ladder user (Woodson and Cohen, 2005) otherwise they could be considered as a design error.

It should also be noted that the grading of ladders may not be fully understood by the user, which may lead to a domestic grade ladder being used in an industrial setting, or ladders being used for whatever purpose is deemed necessary, irrespective if they are suited to a particular task. Manufacturers of ladders must not only consider the normal use of a ladder, but must also consider and make allowance for 'reasonable foreseeable misuse' of ladders (Navarro and Clift, 2002). This means that ladder manufactures cannot simply apply warnings to ladders advising of their correct use, when it is apparent that they will be used as required, but must design for reasonable foreseeable misuse.

2.11.2 Ladder design intervention

There are a number of devices available on the UK market that claim to increase the stability of portable ladders, which can be broadly classified as:

- *Ladder tie-off devices* – intended to provide additional stability by tying the styles of a leaning ladder to an anchor fastened to a permanent structure
- *Top mount devices* - intended to be permanently, or semi permanently attached to the top of the ladder to provide a more stable contact with a surface
- *Base mounted devices* – intended to be permanently, or semi permanently attached to the feet of the ladder to improve grip with the ground by increasing the base area of the ladder
- *Replacement feet*- intended to be permanently, or semi permanently attached to the feet of the ladder to improve grip with the ground and take the form of spikes, suction cups, articulated feet and replacement end caps
- *Large tripods* – converts the ladder from a leaning ladder into a freestanding ladder by the addition of a sub-frame which extends and props the ladder in its elevated position
- *Steps and platforms* - intended to be temporarily fitted to the ladder to increase the comfort and usability.
- *Slope compensation devices* - intended to be temporarily fitted to the feet of the ladder to allow adjustment for uneven surfaces

Clift (2004) from research on ladder stability devices concluded that many of the devices currently available are designed in accordance with intuition rather than mechanics or engineering, and that some devices achieve nothing at all. To be effective an intervention device should prevent failure in all four of the following identified modes:

- Top contact failure mode

- Top slip failure mode
- Flip failure mode
- Base slip failure mode

It was further concluded by Clift (2004) that if a device is to be considered as providing a case for enhanced stability then it should prevent failure in at least one of the failure modes. It should also be considered that if individuals using the devices in the belief that they have enhanced stability when they have not, then they will be placing themselves in greater risk from falls.

If portable ladders are deemed to be both reasonable and practicable for use as work equipment, then they will continue to be used for work at height. It will not possible to design out all types of error especially rung spacing, unless they are only used by operatives of average height, and the use of design interventions will still be necessary despite their low effectiveness, especially for use on uneven ground. However, it will be possible to alleviate the problem of using the wrong grade of ladder, by manufacturing only class 1 industrial ladders for all uses.

2.12 Engaging the workforce

The Constructors Liaison Group (CLG) placed emphasis on the use of safety representatives from the workforce and trade unions to engage the workforce in safeguarding their health and safety on site. Emphasis has been placed on introducing safety committees, and health and safety training for employees, to improve worker involvement in health and safety issues. Site inductions have become commonplace and now expected by employees before starting work. Much of the training for working at height is delivered during these sessions. The main problem however is that unless a small/medium enterprise (SME) is working on a major contractor site they may not be involved in the induction system and therefore not be engaged in the safety programme.

2.12.1 Improving Competence

The industry is aiming for a fully qualified and competent workforce, which is currently being implemented through the CSCS and CITB who are working to ensure everyone engaged in construction activities has a recognised minimum safety standard. All construction employees need a CSCS card which they obtain after proving their vocational competence and passing a health and safety test. The test is repeated every five years and unless the candidates are successful the card is withdrawn, effectively preventing them from working. A weakness of the CSCS testing is that it fails to address the falls from height problem. Of the thirty five questions asked in the test only three are related to falls from height. The three questions on falls are selected from a bank of thirty one falls questions of which only eight are related to ladders. Therefore because the questions are randomly chosen it is possible to pass the test and imply competence without answering a falls from height or ladder related question. This is also the case with the Client Contractor National Safety Group (CCNSG) Safety Passport, which has only five falls from height questions from a possible one hundred and no questions at all related specifically to falls from ladders. As only seventy percent is required to pass the programme it is possible to be awarded the passport with little knowledge of the falls problem and competence being attributed wrongly to the candidate.

2.13 Worker engagement

Employee engagement plays an important role in safety behaviour and risk communication strategies in the workplace, as engaged workers will display ‘organisational citizenship’ in their commitment to the organisation and its values. Employee engagement is a willingness to help colleagues; it goes beyond job satisfaction, and is something the employee has to offer that cannot be required as part of an employment contract (CIPD, 2009). There is no agreed definition for employee engagement however, Gatenby, et al, (2009) use the following definition: *‘Engagement is about creating opportunities for employees to connect with their colleagues, managers and wider organisation. It is also about creating an environment where employees are motivated to want to connect with their work and really care about doing a good job’.* Engagement is a two way process where organisations work to engage the employee, who has a choice about the level of engagement to offer the employer (Macleod, 2009). It is collaborative process where the employer supports the employee, and in turn the attitude and behaviour of the employee supports the employer. The benefits to the organisation may not be clearly measurable but may include: higher productivity, improved branding, lower accident rates, improved customer relations and reduced sickness rates. The employee might feel pride and loyalty (attitude), or 'go the extra mile' to finish a piece of work (behaviour) (Macleod, 2009).

Consulting with employees on health and safety issues is essential in creating and maintaining a safe and healthy working environment. The Health and Safety (Consultation with Employees) Regulations 1999, implemented the Framework Health & Safety Directive 1989 which required employers to inform and consult with their employees and allow them to take part in discussions on health and safety matters (Welch, 2010). In particular, the Regulations require consultation with regard to:

Consulting employees on health and safety, (Modified from HSE, 2010).

- The introduction of measures which may affect health and safety
- Competent people to help comply with health and safety laws
- Information for employees on the risks, measures to reduce risks and what to do if they are exposed to risks
- Planning and organisation of health and safety training
- The health and safety consequences of introducing new technology

By consulting with employees an employer motivates staff and makes them aware of health and safety issues. Businesses can become more efficient and reduce the number of accidents and work-related illnesses, experiencing benefits for the organisation, for example:

Involving workers in health and safety, (Modified from HSE, 2008).

- *Safer workplaces* – employee input is used to identify hazards, assess risks and develop control measures
- *Better health and safety decisions* – based on the experience of employees who have extensive knowledge of their own job
- *Implementation of decisions* – employees have been actively involved
- *Greater co-operation and trust* – employers and employees talk and listen to each other
- *Joint problem-solving*

Communication is central to worker engagement and it is essential that procedures are in place for informing and consulting with employees (Macleod, 2009). The Information and Consultation of Employees (ICE) Regulations 2005 implemented the European Information and Consultation Directive 2002, with the aim of promoting dialogue between management and the workforce. The regulations provide a statutory framework giving employees the right to be informed and consulted by their employers on a range of key business issues (Hall, 2008). A key aspect of the legislation is that it will allow a high degree of flexibility of organisation-specific negotiation and help to establish long-term employee relations (Harper, 2007).

2.13.1 Barriers to worker engagement

The construction sector has many characteristics that act as barriers to the effectiveness of worker engagement; it extensively uses sub-contractors on ‘multi-employer’ sites, which have the potential to cause confusion and conflict. The nature of the work environment and hazards are constantly changing, and the workforce is generally peripatetic (Cameron, et al 2006). If worker engagement is to be successful the sector must find ways to involve all workers in a common ‘engagement goal’, to build trust, respect, co-operation and joint problem solving and every worker must contribute to the improvement of health and safety.

2.13.2 Construction (Design and Management) Regulations 2007

The aim of the Construction (Design and Management) Regulations (CDM) is to improve health and safety in the UK construction industry. The regulations place duties on the general management of a construction project to *"co-ordinate all activities in a manner which ensures, so far as is reasonably practicable, the health and safety of persons carrying out the construction work; and those affected by the construction work"* (CDM 2007). A duty placed on a principal contractor is to engage and communicate with workers so as to ensure their health and safety. Regulation 24 of the regulations requires the principal contractor to:

Communication with workers – (Modified from the CDM Regulations, 2007)

- Make arrangements with workers to co-operate in promoting and developing measures to ensure health, safety and welfare on the project
- Consult workers on health, safety or welfare matters connected with the project
- Ensure that workers can inspect information which relates to the health, safety or welfare planning and management of the project

Worker engagement and consultation involves the principal contractor communicating with the workforce when making health and safety decisions, as the workforce have first-hand experience of the project and are often the first to identify potential problems (ACoP 2007). Consultation involves a two way process that builds trust and involves a joint commitment to solving problems, principal contractors should employ a range means to ensure that the process is effective, including:

Consultation processes - (Adapted from the CDM Regulations ACoP)

- Engaging with worker representatives
- Establishing health and safety committees
- Conducting regular consultation meetings
- Setting up clearly defined communication channels
- Conducting site inductions, daily briefings, toolbox talks, meetings etc
- Carrying out site managers' walkabouts
- Involving workers in carrying out site-specific risk assessments
- Encouraging workers to report problems

- Encouraging workers to provide ideas for innovations to raise standards
- Ensuring that feedback is provided to the workforce on issues raised
- Monitoring the effectiveness of consultation processes

Arrangements for consultation with the workforce should be tailored to individual project requirements, as the nature of the risks involved for large scale projects will be different from those on medium or small scale projects.

Despite the requirement for consultation, Bomel (2010) reported that there was still a problem with a peripatetic subcontracted work force. Regular site meetings were not working effectively as subcontractors were not engaging with the process in terms of identifying potential health and safety issues. Bomel's pilot study (2010) identified that meetings *"…still tend to be a one way thing, with us telling them what they're doing wrong"*. The evidence suggests that the philosophy of the CDM Regulations in terms of engaging the workforce is not working effectively, and that the workforce needs to be educated in how to communicate if to meet the aim of the improving health and safety in the UK construction industry.

2.14 Workforce diversity

Workforce diversity refers to the concept of engaging the differences between people, for example, age, gender, background, disability, ethnicity, ability, race, etc. so that they work together within an organisation to create a more adaptable and productive work environment. Diversity creates a more socially acceptable workforce that encourages people to become engaged in the construction process. However, diversity performance within the UK construction industry is generally poor as the industry tends to target a traditional workforce of young male workers into its site skill base (Peters and Katalytik, 2011). The sector is characterised by a fragmented transient workforce and heavy physical workloads, which has failed to appeal to, recruit or retain women, ethnic minority groups or disabled workers (de Graft-Johnson, et al., 2009). It could be argued that the failings are justified as it would be difficult, if not impractical to utilise a fully diverse workforce due to the nature of construction work, for example working at height. However, if the sector is to meet the legal requirements of the Equality Act and remain competitive it will need to diversify to meet future skills shortages, which means targeting non-traditional groups of workers (Loosemore, Dainty and Lingard, 2003). Although the sector has failed to attract a large section of the workforce it has gone some way to diversify in terms of the continued inclusion of some operatives with low educational achievement, and the recent utilisation of migrant workers. This diversity approach has implications in terms of providing suitable health and safety information and training, as it needs to be communicated so that workers can easily understand and benefit from it (McInnes, 1999). In terms of risk perception the most effective method is by visual communication tools that use images (Timmermans, 2005), as they have the benefit in that they can be easily understood and do not require translation.

2.14.1 Visual tools

Visual communication uses images, graphs and charts as well as signs and symbols to communicate health and safety information to the workforce. They are effective because visual tools have greater power than the written word to inform, educate or persuade (Lester, 2006) especially if the worker can't read properly, or can't read English. For example, a poster that shows images of step-by-step procedures for erecting and securing a portable ladder will be more effective than written instructions, and can assist in informing a worker of safe practices to be followed, reducing the risk of an accident. However the visual tools need to be carefully designed as the interpretation of images is subjective, and may convey different meanings to different people. For example, if viewed from a personal perspective the response depends on the viewer's thoughts and values, which might sometimes conflict with cultural or ethical values, which can be seen in other ways (Lester, 2006).

The majority of people (83%) learn most effectively through visual means, as images are more evocative than words and have the advantage over textual content in that they focus attention on the salient points, and create a clear view of the subject matter allowing connections and relationships to be made (JISC, 2011). By absorbing information in a format that makes sense to them e.g. a hazard image on a health and safety poster, people will increase their understanding and recollection of risk concepts, which will affect their perception, and subsequent behaviour (Timmermans, 2005). Images can be used effectively as substitutes for words or to produce non-verbal information, which will benefit construction operatives with low educational achievement and migrant workers with poor English communication skills.

2.15 Chapter summary

From the literature review it is evident that very little is known about risk perception of users of portable ladders in the UK construction industry. There is a very small amount of research relating to risk perception of ladder users and even less on users within the construction sector, which is curious given the capacity for improvement this could make. In general, researchers have concentrated on workplace risk perception and the research is general in nature with little specific work evident for the construction sector or for ladder use generally. The main methods of research have been focus groups with participants taken from higher level management or professional bodies, and very little use has been made of research involving site operatives to gather information. The research has identified that inadequate risk perception is a critical factor that influences the performance of workers, and that a person's attitude, risk awareness, training and culture are the underlying causes to accidents most common across the construction sector. A lack of site operative involvement is seen as a major weakness in the research as information is not being obtained from the people who are directly involved at operational level. If a training aid is to be successful in raising the perception of risk then it is essential to carry out research based at site operative level.

Chapter 3 Methodology

3.1 Introduction

The review of literature has highlighted that falls from height is the most common cause of injuries and death to employees in the construction industry of Great Britain (HSC, 2002), and falling off a portable ladder is by far the most significant agent resulting in construction accidents (Clift, 2004). The perception of risk by portable ladder users has been identified as a critical component in falls from height accidents (Bomel, 2003). Although there is a wide body of research within the literature on risk perception (Fischhoff, et al., 1978; Slovic, 1987; Leonard, et al., 1989; Sjoberg, 1996; Marris, et al., 1998; Zuckerman, 1994; Mearns and Flin, 1995; Wogalter, et al., 1999; Sjoberg, 2000; Clift, 2004), surprisingly only a small part of the research focuses on people working at height, and very little is related to portable ladder use. If the level of injuries associated with portable ladder falls is to be significantly reduced then operatives need to be more risk aware and accurate risk perception needs to be effectively communicated. The research described in this thesis was undertaken to address this issue.

This chapter provides the aim, objectives and hypothesis for the research and explains the procedures, methods and techniques used to collect the primary data. It provides a justification for the use of questionnaires as the means of gathering data, describes the carrying out of pilot studies, determination of the survey population and suitable sample size. It also describes how the data was collected and analysed, how ethical issues were addressed and the limitations of the methodology design.

3.2 Aim, Objectives and Hypothesis

3.2.1 Aim

To analyse the risk perception of operatives using portable ladders in the construction industry, and to develop and test a ladder use training-aid.

3.2.2 Objectives

1. To identify and review construction sector falls from height statistical data
2. To identify and review relevant risk perception, sensation seeking and falls from height literature
3. To survey construction operatives to determine their level of risk perception, their level of sensation seeking and ladder use experience
4. To develop and test a training aid, designed to improve the risk perception of portable ladder users
5. To analyse the results and provide basic user profiles

3.2.3 Hypothesis

The use of a training aid can improve a construction operative's risk perception when using portable ladders.

3.3 Methodology justification

The study of risk perception is about a person's belief regarding the likelihood and probability of harm being caused from a future event, and therefore requires a research methodology that involves sampling of respondents. Risk perception is not merely a function of likelihood and probability but other factors such as a person's beliefs, concerns, worries or attitudes, and is more closely related to social rather than cognitive psychology (Sjoberg, 2000a), however it can be investigated in the same way as the other factors which use a variety of measurement techniques mainly based on a psychological perspective.

The most common methodologies that can be used have been presented in Table 7.1 (Appendix D), together with their associated data analysis strategies and application to the risk perception research. The following three research methods were selected as being most suitable for use within this research, and were considered further prior to the adoption of the most appropriate method.

1. Interviews
2. Participant self-observation
3. Survey Questionnaire

3.3.1 Interviews

The qualitative interview method of research, typically involves a face-to-face meeting in which a researcher asks an individual a series of questions. They are particularly useful for getting in-depth information about a participants experiences (McNamara, 1999), and could be an effective method of obtaining risk perception data from participants. However the interview method can be subject to many biases and there is no guarantee that the interviewer does not inadvertently affect the results that they get (Sjoberg, 2000a). For example, by slanting the questions differently, or prompting the respondents to construct scenarios that do not provide an accurate risk response; or sensitive questions not asked in an appropriate manner. Interviewer fraud is also a real possibility and care must be taken to ensure that the results are not adjusted or fabricated during the process (Aaker and Day, 1990). Interviewing a relatively small number of respondents to get an idea of risk perception in a population is recognised by social scientists as potentially misleading, and is best avoided (Sjoberg, 2000b). The interview process can however provide a positive experience to the respondent as the interviewer can guide the process and correct any misunderstandings as they arise (Suchman and Jordan, 1990) which should provide more accurate results.

Interviews are a valid method of collecting risk perception responses and would meet the requirements of the research proposition. However they are very time consuming and resource intensive, especially for the large number of participants required to provide significant results for the research. The interview method was therefore considered not to be the most appropriate method of obtaining the data.

3.3.2 Participant systematic self-observation

The systematic self-observation (SSO) method of research typically involves a participant measuring their own risk perceptions in the workplace, and could be an effective method of obtaining risk perception data from participants. This method has the advantage over other research methods in that the observer and participant is the same person (Rodriguez and Ryave, 2002), minimising problems associated with poor communication, timing, availability etc. However the method requires special attention to the training of participants to be able to self-observe, record risk perceptions correctly and to provide high-quality self-observation data.

Self-observations are a valid method of collecting risk perception responses and would meet the requirements of the research proposition. However they would very time consuming and resource intensive; especially for the training of participants involved in a large survey, and were not considered to be the most appropriate method of obtaining the data.

3.3.3 Survey questionnaire

A quantitative research approach using questionnaires is an effective method of obtaining risk perception data from participants. Questionnaires have the advantage over interviews and focus groups in that they directly assess an individual's perception, they can be completed anonymously and can be re-administered to assess changes in individuals experiences and thinking over time.

Questionnaires typically involve respondents answering a list of written questions, with or without the aid of the researcher. There is no preset format for the questions however scales are typically used, say from 0 (no risk) to 10 (high risk), and have been found to be very useful (Sjoberg, 2000a). Category interval rating scales have also been used however they have the potential to be misleading if one category interval is greater than another. To ensure the accuracy of risk perception responses generated from respondents it is essential that careful consideration is given to the design of the questionnaire, and that emphasis is placed on the correct style, number of categories and total number of questions.

There is some criticism of scales being used to measure risk perception, based on the argument that a rating of 6 on the scale could easily have been rated as a 5 or a 7. However the criticism has been disregarded by Sjoberg (2000b) arguing that this could result in a move away from quantitative methods altogether, generating more qualitative details and information instead of singling out a few dominating and important themes focused on by the quantitative methods.

Survey questionnaires are a valid method of collecting risk perception responses and would meet the requirements of the research proposition. Their administration would need careful consideration to help avoid the problems of non-completion if a postal questionnaire was used, and the problem of resources and time if a structured interview method was used. However, they were considered to be the most appropriate method of obtaining the data.

3.4 Structured survey questionnaires

The research was designed to be a within-subjects study using quantitative surveys in the form of paper based structured questionnaires to focus on an operatives risk perception when using portable ladders in the construction industry. Risk perception and falls from height survey items were adapted from previous research to formulate some of the items to meet the requirements of the research aim. The wording within the questionnaires was kept short and simple to provide clarity, help understanding and maximise reliable responses. Factors highlighted in the literature review were used to focus the survey questions, for example age and ladder use experience, and were included to allow analysis of secondary factors that may have an effect on an individual's risk rating ability.

Three instruments were used for the data collection in this research: a ladder-use survey, a sensation seeking survey and a risk perception survey (Appendices A, B and C respectively). A ladder-use survey was developed by the author to produce basic operative profiles by determining how portable ladders are being used on site, and also to test the participants perception of risk to given ladder-use situations. The second instrument involved the use of Zuckerman's (1994) 'sensation seeking' test which was used to help determine the level of sensation seeking of the individuals which could affect the perception of risk. The third instrument also designed by the author, involved the use of a risk perception survey to measure any difference in risk perception following the use of a ladder-use training-aid. Photographic images were provided to clarify the items, and maximise understanding.

3.4.1 Ladder-use survey

The ladder use survey consisted of a questionnaire containing 37 items. 23 directly related to risk perception, seven for the use of ladders and seven for demographic information (Ladder use survey - Appendix A).

Risk perception items

The participants were asked a series of questions directly related to their general risk perception, which included the agents associated with the most construction deaths, the likelihood of dying, the hazards associated with the most injuries, and agents associated with falls from height. The questions required responses to be placed in rank order and were analysed according to the following specific published data:

- *Agents associated with falls from height*
  Data taken from the Health and Safety Commission, National Statistics 2000/01, for the number of fatal injuries to workers by kind of accident, Table 7.2 (Appendix D - Ladder use survey item 27, Appendix A)
- *The likelihood of dying*
  Data taken from the Department of Trade and Industry, Home Accident Surveillance System Annual Report Data 1998, Table 7.3 (Appendix D- Ladder use survey item 28, Appendix A)
- *The hazards associated with the most injuries*
  Data taken from the Health and Safety Executive Research Report 205, Table 7.4 Appendix D - Ladder use survey item 29, Appendix A)
- *The most construction deaths*
  Data taken from Health and Safety Commission, National Statistics 2000/01, for the number of high and low fall accidents over a five year period, Table 7.5 Appendix D - Ladder use survey item 30, Appendix A)

A series of photographic images showing a random series of ladder use situations were used for responses specifically related to ladder use risk perception (Figure 3.1). Respondents scored each item in relation to the level of the risk involved using a ten point scale, where 1 represented low risk and 10 represented a high risk. A brief description of the ladder use situation used for the risk items, including height in metres, has been produced in Table 7.6 (Appendix D).

Extension ladder	Step ladder
	
4 metres high	0.8 metres high

Ladder use survey - Appendix A

Figure 3.1: Example ladder-use situations

Use of ladders

The participants were asked questions directly related to their experience of portable ladders. The questions covered the frequency of ladder use, training that had taken place, and fall from ladder experience (Ladder use survey items 1 – 7, Appendix A).

Demographic information

Demographic information in relation to age, occupation, health and safety qualifications, employer type/size, and number of years experience in the industry was also obtained for the user profile (Ladder use survey items 31 – 37, Appendix A).

3.4.2 Sensation seeking survey

This survey was included specifically to help make judgements regarding an individual sensation seeking behaviour. The survey questionnaire was adapted from Zuckerman’s (1994) ‘sensation seeking’ test. It consisted of 40 items where the respondents were required to answer honestly their feelings in relation to their likes, and dislikes, of two variables, of which there were no right or wrong answers (Table 3.1), (Sensation seeking survey - Appendix B).

Question N°		Statement
1	A	A sensible person avoids activities that are dangerous.
	B	I sometimes like to do things that are a little frightening.
2	A	I often wish I could be a mountain climber.
	B	I can't understand people who risk their necks climbing mountains

(Zuckerman, 1994). Sensation seeking survey – Appendix B

Table 3.1: Example sensation seeking questions

3.4.3 Risk perception survey

The post-training risk perception survey was designed to measure any change in a participant's risk perception following the use of a training-aid. To help maintain clarity and understanding it followed the same format and layout as the risk perception questions contained within the ladder-use questionnaire. It consisted of six photographic images showing ladder use situations which were selected from the risk perception items of the ladder-use survey, (Risk perception survey - Appendix C).

3.5 Pilot studies

A pilot study was carried out prior to administering of the ladder-use and risk perception surveys, with the objective of checking the reliability and validity of the questionnaires. The respondents chosen to take part in the pilot stages were taken from the same population as the main surveys and included a cohort of twenty operatives attending construction training programmes at a college of further education. The number chosen to participate in the pilot phase was arbitrary and did not specifically relate to the main study. The number of participants was considered to be suitable and sufficient to provide the required feedback in relation to the survey design. The respondents represented a broad cross-section of UK construction organisations in terms of size and work activity, and included representative samples in terms of age and training programme attended. Respondents who participated in the pilot stages were identified and subsequently omitted from the main surveys to maintain validity of the final results. The questionnaires were administered to the pilot study participants using the same planned method and format as the main surveys, with the aim of testing the approach and to identify any details that need to be addressed before the main data collection. The results from the surveys were not used as part of the main survey and were discarded following the pilot stages.

The pilot study was carried out in stages, the first stage involved completion of the ladder-use questionnaire, containing a series of tasks to rate the level of risk involved in ladder-use situations. The survey was carried out in the same conditions designed for the main study, and there was no time limit set for completion, however the time taken by each respondent was noted, and ranged between fifteen and thirty two minutes. A group feedback session was conducted immediately following completion of the survey, and respondents were asked to provide feedback on all sections of the questionnaire. The process identified several weaknesses in terms of wording, grammar, images, numbering and clarity. It was necessary to adjust the wording of the instructions and questions to avoid confusion and aid understanding, and some ladder use images were replaced to further reflect the diverse uses and misuses of portable ladders. An aspect of duplication of images was also introduced to help test for consistency between the responses.

The second stage of the pilot study involved completion of the risk perception survey which was conducted using the same cohort of respondents and same conditions as the stage one pilot. It was considered important for consistency to carry out the survey using similar timescales between surveys to those planned for the main surveys, and a duration of four days was therefore considered appropriate and used. The feedback from respondents identified several weaknesses in terms of clarity and understanding, and some ladder use images were identified and subsequently replaced for alternatives from the ladder-use survey.

The administration of both questionnaires worked as planned, requiring only minor changes regarding how the written and verbal instructions for completion were communicated. However, problems were experienced due to shine through of double sided printing within the questionnaires establishing the need for single sided printing for the main surveys. Both surveys received positive feedback with regards to the use of images for the risk perception items, which were identified as being essential for understanding. The results from both surveys were input in Predictive Analytics Software (PASW) to test that all data could be successfully recorded and that appropriate reports could be obtained. Some minor modification was necessary to the numbering system of the ladder-use survey to ensure omissions were avoided, and accuracy maintained.

It was not considered necessary to carry out a pilot study for the Zuckerman's sensation seeking questionnaire as it was already well established in the research community.

3.6 Training-aid

The training aid (described in Chapter 5) was administered to groups of participants following the completion of the ladder-use and sensation seeking surveys. Computers equipped with an electronic visual display that can detect the presence and location of a touch within the display area (touch-screen technology) were used. This had the advantage of enabling the user to interact directly with what was displayed, rather than indirectly with a cursor controlled by a mouse or touchpad. The touch-screen removed much of the uncertainty, fear, and anxiety initially expressed by non computer users, especially older users, and also prevented users from accessing or altering the computer settings during the presentation.

The training aid went through several stages of development to ensure that it was fit for purpose and met its aim of improving an operative's risk perception. Three pilot stages were carried out using groups of up to five construction operatives who tested the training aids functionality and operation. Group feedback sessions following the testing of the aid highlighted potential issues or problems, which were used to help improve the content, sequence and operation ensuring that it was user friendly and worked effectively.

The duration of the training was designed to be 15 minutes, however no specific time limit was imposed on the participants and they were allowed to access the presentation within a one hour window. This helped to remove any potential pressure on the users, and ensured that they had sufficient opportunity to fully complete the learning.

A checklist of participants (names and reference numbers) who completed the training aid was maintained by the researcher to feed into the next risk perception survey stage which followed the training. (Training-aid, Appendix E).

3.7 Population

Following the decision to use structured questionnaires as the best method for gathering data, and recognising the fact that the response rate for questionnaires is normally very low, the author investigated the possibility of using suitable respondents from a college of further education. It was envisaged that the normal problems associated with poor questionnaire response rate could be eliminated if some element of control could be maintained. The author worked as a construction programme director at a college, and was given full access to approximately 700 personnel attending construction related programmes. The population for the surveys was subsequently taken from respondents attending construction related training programmes (Table 3.2) at a further education college located within Northumberland, North East England. The participants represented a broad cross-section of the construction industry, with regards to age, experience and work type, and included participants from micro, small, medium and large enterprises, employing between 2-9, 10-49, 50-249 and 250 or more people respectively (European Commission, 2003), as well as the self-employed. Participants from building, civil engineering, services, and maintenance sectors were targeted as potential portable ladder users to ensure that the surveys were focussed at a representative sample.

Training programme	Description
Safety Passport Client Contractor National Safety Group (CCNSG)	A two-day basic health and safety programme, designed for construction/engineering operatives and consisting of ten health and safety modules, including safe working practices. Updating is required every three years.
Construction safety awareness	A one-day basic health and safety programme, consisting of six health and safety modules, including working at height. Updating 'as required' by individual organisations, but not exceeding three years.
National Vocational Qualification (NVQ) level 2 and 3, and Construction Skills Certificate Scheme (CSCS)	A three-year programme, incorporating one health and safety unit, which involves preparing the following construction operatives for the industry's touch screen health and safety test. Bricklayers, Painters and Decorators, Plumbers, Electrical fitters, Gas appliance fitters, Carpenters and joiners, Dry liners, Plasterers, Wall and floor tillers, Ceiling fixers
Construction National Certificate (NC) level 3 and 4	A two-year programme, incorporating one health and safety unit, which involves preparing construction technicians for the industry's touch screen health and safety test.
Specialist training programmes	One day programmes incorporating health and safety, designed for specific training in the following areas: Tower scaffolding, Roof maintenance, Wall tie replacement, Building maintenance.

Table 3.2: Training programmes

Participants from the National Vocational Qualifications and National Certificate programmes attended year long programmes, whereas Safety Passport / Awareness and specialist training programmes were short courses delivered typically within a seven day attendance programme. The training programmes would allow participants to be revisited, allowing the validity of the training-aid to be tested at various stages of its design. This would have the advantage of minimising any serious differences in incidental factors such as experience or personality. The research did not target respondents from specific training programmes, and participation was dependent upon programme patterns of attendance, cohort numbers, age, experience etc.

All potential respondents were fully informed, both verbally and in writing of the reasons for the research and that they were not obliged to complete questionnaires. They were further informed that if they did take part their responses would be treated in strict confidence and that it would not be possible for anyone to identify them from the information they provided. To ensure anonymity the participants were issued with a unique referenced number to be used on all surveys, and confidential data was held in the authors secure, password protected files within a remote data base. Respondents were assured at each stage of the process that information provided would be kept confidential and that the questionnaires would be destroyed following completion and verification of the research.

3.7.1 Sample size

The standard Altman's Normogram diagram-formula (Altman, 1982) was used to determine how many participants were appropriate for the study. It uses a relatively simple approach; reducing problems associated with complex calculations and is accepted as normal practice. The Normogram uses four integrated factors i.e. power, significance level (fixed by research convention), minimum worthwhile difference and standard deviation to determine the sample size. The power sets a statistically significant difference for the survey and is normally taken between 80 – 90% (0.8 – 0.9), and a significance level of between 1 - 5% (0.01 - 0.05) is used. The minimum worthwhile difference and standard deviation were determined using statistical data for falls from height taken over a ten year period between 1991/92 and 2000/01 (HSC 2001), (Table 3.3). As the data set was taken from HSE published statistics it contained all of the parameters for the research population, and therefore sigma was used to determine the population standard deviation, using the following formula.

$$\sigma = \sqrt{\frac{\Sigma x^2 - \mu^2}{N}}$$

Where:

σ = population standard deviation

$\sum x^2$ = sum number of falls squared

μ^2 = mean number of falls squared

N = number of items

The total number of fall related accidents was 28547 with a mean of 2854.7 for the ten year period. This figure included fatal, major and over three day accidents and included falls up to and including two metres, over two metres and height not known.

The standard difference was tested using powers of 0.8, 0.85 and 0.9 and worthwhile differences ranging from 4 to 10% (Table 3.4).

A worthwhile difference of 5% and a power of 0.85 were considered reliable for the survey and a sample size of 400 was taken from the Altman's Normogram, (Figure 3.2)

No.	Year	Number of falls (x)	x^2
1	1991/92	3786	14333796
2	1992/93	3116	9709456
3	1993/94	2857	8162449
4	1994/95	2898	8398404
5	1995/96	2216	4910656
6	1996/97	2545	6477025
7	1997/98	2913	8485569
8	1998/99	3043	9259849
9	1999/00	3145	9891025
10	2000/01	2028	4112784
N=10	∑	**28547**	**83741013**
	Mean (μ)	**2854.7**	
	Mean^2 (μ^2)	**8149312**	

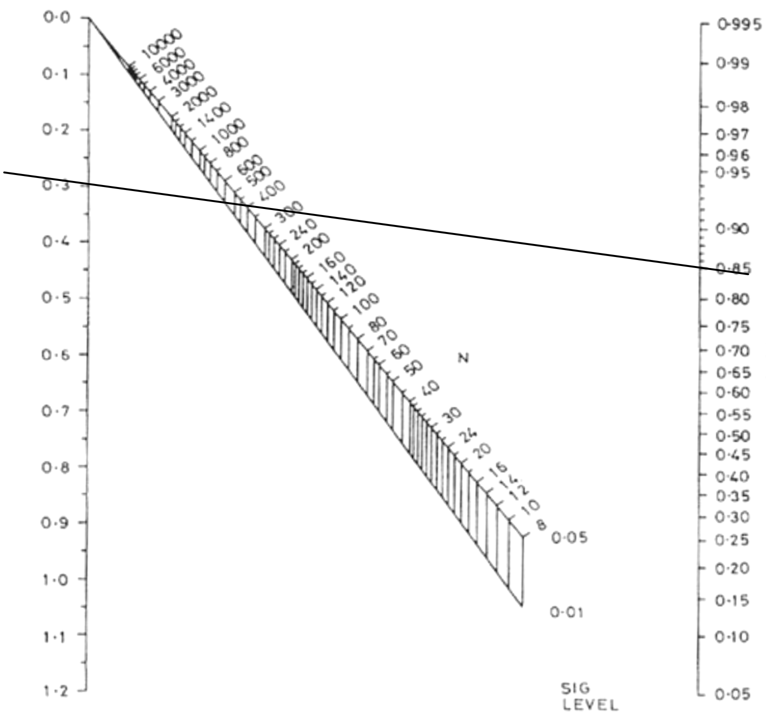
Table 3.3: Falls from height

$$\sigma = \sqrt{\frac{\Sigma x^2 - \mu^2}{N}} = 474$$

$$\text{Standard Difference} = \frac{\text{Minimum worthwhile difference}}{\text{Standard Deviation}} = 0.301$$

Worthwhile difference %	Mean % (rounded figures)	Standard difference	Power		
			0.8	**0.85**	**0.9**
4	114	0.241	500	600	700
5	142	0.301	350	400	450
6	171	0.361	240	280	350
7	199	0.421	180	200	240
8	228	0.482	135	150	170
9	256	0.542	110	120	140
10	285	0.602	85	100	110

Table 3.4: Sample size



(Altman, 1982)

The left hand axis shows the standard difference (taken as 0.301), and the right hand axis shows the power of the study (taken as 0.85). A straight line drawn between the two values gives a sample number of 400 taken for a significant level of 0.05 (upper value).

Figure 3.2: Altman's Normogram

3.8 Data collection

Three paper based surveys were used for data collection:

1. Ladder use questionnaire (Appendix A)
2. Sensation seeking questionnaire (Appendix B)
3. Risk perception questionnaire (Appendix C)

The surveys were carried out in three stages; the aim of the first two stages was to establish the participant's level of risk perception on entry, before any training had taken place. The third stage measured any change in the level of participants risk perception following use of the training aid.

The surveys were administered sequentially to groups of participant's, ranging in size from eight to twenty four depending upon their mode of attendance on their training programme. They followed 'face to face' briefing sessions conducted by the author, where the reasons, purpose, use and confidentiality of responses were explained. The method of completion was also fully explained, together with the definition of the terms risk, hazard and danger, which according to Young, et al. (1990) are often confused. Help was available throughout the survey, to provide further clarification and/or explanation, and those participants who had difficulty reading were read the questions at the end of the session by the researcher to allow their responses to be recorded. The briefing sessions provided the benefits normally associated with interview data collection, as the process was guided and misunderstandings corrected as they arose. The administration of the surveys by the author had the advantage in that control was maintained over the questionnaire completion, which helped ensure a high response rate and thereby greater validity of results.

The time interval between administering of the pre-training and post-training questionnaires varied between groups, depending upon their type of college programme and mode of attendance, and was typically achieved within a four day timeframe. This minimised the threat to the validity of the study in the form of bias, particularly due to any external learning that may have taken place during the testing period.

Upon completion of each section of the research the respondents were thanked for their responses, and if appropriate informed that they would be contacted at a later date to take part in the next phase of the study. They were also offered access to a copy of the results when the study was complete if they were interested.

3.8.1 Ethical issues

Five ethical issues have been identified by McNamara (1994) to be considered when conducting survey research. The concerns deal with voluntary participation, no harm to respondents, anonymity and confidentiality, identifying purpose and analysis and reporting. Each will be addressed individually with explanations to help eliminate or control concerns.

Voluntary participation.

Participation in the survey needs to be completely voluntary. However participation can sometimes conflict with the need to have a high response rate as low response rates can introduce response bias (McNamara, 1994). In order to encourage a high response rate for this study, the researcher explained the reasons for the study to the potential respondents who were given time to complete the questionnaires as part of their learning programme. Furthermore the statement 'you are not obliged to complete the questionnaire but your help in my research would be greatly appreciated' is clearly printed in the opening introduction to the questionnaire. This had a positive effect and very few responded negatively, giving a high overall response rate for the survey.

Harm to respondents

The second ethical guide is to avoid harm to respondents which could include embarrassment or feeling uncomfortable about questions. This study did not include any sensitive questions that could cause harm. Harm that could arise in data analysis or results is discussed under confidentiality.

Identity, anonymity and confidentiality

The third ethical guide is to protect respondent's identity. This can be achieved by exercising anonymity and confidentiality. If the respondent cannot be identified on the basis of a response then the survey is anonymous, it is confidential when a response can be identified with the respondent but the researcher promises not to disclose the individual's identity. This survey clearly states that 'your responses will be treated in strict confidence and it will not be possible for anyone to identify you from the information that you give'. This statement was further reinforced during the briefing session by the researcher.

Purpose

The fourth ethical guide is to inform the prospective respondent's of the purpose of the survey. This survey clearly stated in the opening statement of the questionnaire 'I want to find out about how people use ladders' which was further elaborated on during the briefing session with regards to the emphasis on safety.

Analysis and reporting

The fifth ethical guide is to accurately report the results of the survey to the professional community and to ensure that the researcher assumes responsibility to report problems and weaknesses as well as positive results of the study.

3.8.2 Validity

An instrument is valid if it measures what it is intended to measure and accurately achieves the purpose for which it was designed (Patten, 2004). When writing the survey items three principles, identified by Patten (2004), were addressed to improve the content validity, 1) Use a broad sample, 2) emphasise important material, and 3) write questions to measure the appropriate skill. The validity was further reinforced by a focus group of three health and safety practitioners who provided comments and feedback on the survey items, which were amended and rewritten on several occasions prior to testing on a pilot sample. The research was planned to be a within-subjects design and it was envisaged that the participants will be able to be pre-tested early in their programme, and post-tested before the completion of their programme.

3.9 Data analysis

The results from the ladder-use, sensation seeking and risk perception surveys were analysed using a combination of cross-tabulation and regression analysis, to test the hypothesis that the use of a training aid can improve a construction operative's risk perception when using portable ladders.

3.9.1 Ladder-use analysis

Results for the ladder-use survey items involving general risk situations were analysed, to determine if there was any relationship between the participant's age, experience, qualifications or training and their perception of risk when using portable ladders. Results were input into predictive analysis software (PASW) and used to obtain cross-tabulation information for questionnaire items. Bar charts were produced to aid analysis using a Microsoft Excel software package. The following items were cross-tabulated for analysis of relationships:

Items involved with the most falls from height

- Falls from ladders – Age in years
- Falls from height – Years worked in the construction industry
- Falls from ladders – Years worked in the construction industry
- Falls from height – Years worked with ladders
- Items involved with falls from height – Years worked in the construction industry

Events linked to the probability of dying

- Dying due to a ladder accident – Age in years
- Ladder/step ladder accidents – Years worked with ladders

Items involved with the most injuries

- Items involved with accidents – Age in years
- Ladders involved with accidents – Age in years

Items involved in the most construction deaths

- Years worked in the construction industry
- Health and safety qualifications
- Ladder and step ladder training – falls from height

Regression analysis was used to test for correlation between age and years experience in the construction industry with age being the dependant variable. Correlation was used to test the null hypothesis that there was no relationship between age and experience.

Risk rating analysis

A risk rating 'datum' score was established for each item to be used within the analysis. As no scores were available from previous research or publications they were obtained from the author and two health and safety experts who agreed to provide risk ratings for the purpose of the research, as follows:

- The author – a senior lecturer with 40 years experience of practical ladder use, and 15 years experience of carrying out falls from height risk assessments within the construction sector
- A Senior Lecturer –20 years experience in health and safety research based at a University in Newcastle-upon-Tyne
- A Health and Safety Inspector – 10 years experience based at Newcastle-Upon-Tyne

A full range of datum scores from 1 to 10 was not used due to limitations in available images, however it was not considered necessary to obtain valid responses for the research. The scores from the three sets of expert risk ratings were averaged and the nearest full number used as the datum score within the analysis (Table 3.5).

Nº	Ladder type	Score 1	Score 2	Score 3	Total	Average	Datum
8	Extension ladder	4	3	3	10	3.33	3
9	Step ladder	6	7	8	21	7	7
10	Step ladder	5	5	6	16	5.33	5
11	Straight ladder	4	6	5	15	5	5
12	Step ladder	3	5	6	14	4.66	5
13	Extension ladder	5	5	6	16	5.33	5
14	Extension ladder	5	4	3	12	4	4
15	Step ladder	9	10	10	29	9.66	10
16	Leaning ladder	3	4	5	12	4	4
17	Step ladder	5	4	5	13	4.66	5
18	Extension ladder	5	4	4	13	4.66	5
19	Extension ladder	4	4	5	13	4.66	5
20	Step ladder	5	6	6	17	5.66	6
21	Extension ladder	5	5	5	15	5	5
22	Step ladder	10	10	10	30	10	10
23	Step ladder	7	7	6	20	6.66	7
24	Leaning ladder	3	3	4	10	3.33	3
25	Step ladder	4	5	5	14	4.66	5
26	Leaning ladder	4	4	5	13	4.33	4

Table 3.5: Datum risk rating scores

The respondents were allocated individual reference numbers (1 - 400) that were used to correlate responses when the data was input into the statistical computer programme using Predictive Analytics Software. Frequency tables were formulated from the data using the PASW output facility and then reproduced (using Microsoft Office Word 2007) in both table and chart format for the following data:

- Mean difference from datum – Age in years
- Mean difference from datum – Years worked with ladders
- Mean difference from datum – Qualifications
- Mean difference from datum – Practical training on how to work safely
- Mean difference from datum – Written information on how to work safely
- Mean difference from datum – Work type
- Mean difference from datum – Occupation
- Mean difference from datum – Company size

3.9.2 Sensation seeking analysis

Results for the sensation seeking survey items were analysed to obtain the scores of respondents to determine if there was any relationship between the participant's age or experience and their level of sensation seeking when using portable ladders. The results of the test are relative, i.e. the values on their own do not have merit. The benefit lies in the comparative scores between individuals in a given population. Using the score, it is possible to correlate personality traits with behavioural traits, for example it could be used as a precursor to risk taking and hence accidents. Results from the questionnaire were input into predictive analysis software , plotted on scatter diagrams and correlation results obtained for:

- Sensation seeking score – Age in years
- Sensation seeking score – Years experience in the construction industry
- Sensation seeking score – Years worked with ladders

3.9.3 Risk rating analysis

Results for the risk rating survey items were analysed to determine if there was any change in a respondents risk perception following the use of the training aid. To test the relationship between the pre-training and post-training responses a paired sample *t* -test (within participants design) was carried out using predictive analysis software. The null hypothesis used was that 'there is no difference between the pre and post training risk rating scores', and the experimental hypothesis was that 'there is a difference between the pre and post training risk rating scores'.

3.10 Limitations

Limitations with the design and methodology used by the research have been identified with regards to the ladder-use images and ladder-use survey.

Ladder use images

Responses could have been influenced by the situational awareness of the respondent in terms of the activity of the ladder user. Respondents may have focussed on the risk associated with the level of harm posed from the activity, rather than the risk associated with the height of fall.

Ladder-use survey

The design on the items for the risk rating section of the ladder-use survey contained up to five images on one A4 sheet. This could have provided the opportunity for the respondents to visually scan between the images before completing the risk rating, and the responses for items could have been adjusted if they ranked the level of risk between the images.

3.11 Chapter summary

The aim of the research was to analyse the risk perception of operatives using portable ladders within the construction industry and to develop and test a training aid. Structured survey questionnaires were considered the most appropriate method of obtaining risk perception responses and three instruments were chosen for data collection; a ladder-use survey, a sensation seeking survey and a risk perception survey. Pilot studies were carried out prior to the ladder-use and risk perception surveys to check their reliability and validity. The sensation seeking survey was not piloted as it was already well established in the research community. The population for the surveys was established from the Altman's Normogram as 400, and respondents from a college of further education were established as being a representative sample for the research. Paper based surveys were administered in three stages to groups of participants; the aim of the first two stages was to establish the participant's level of risk perception on entry, before any training had taken place. The third stage measured any change in the level of participants risk perception following use of a training-aid. Results from the surveys were input into predictive analysis software and analysed using a combination of cross-tabulation and regression analysis to test the research hypothesis. The results and analysis of the three surveys are provided in Chapter 4 and discussion within Chapter 6 of this thesis.

Chapter 4 Results and Analysis

4.1 Introduction

This chapter presents the results and analysis for the three questionnaire surveys. Section 4.2 and 4.3 contain the results and analysis for the ladder-use and sensation seeking surveys, which were administered in advance of the training aid and before any training had taken place. Section 4.4 contains the results and analysis of the risk perception surveys that were carried out following the administration of the training aid. Response data was input into a statistical computer programme (Predictive analytics software - PASW) and frequency tables produced from the output facility. Tables were then reproduced using Microsoft Office Word 2007, to remove unnecessary data and information and are presented within Appendix D.

4.2 Ladder-use survey results

The ladder use survey consisted of a questionnaire containing 37 items. Seven items required responses for the general use of ladders, 19 for risk perception related to ladder use, four for general risk perception and seven for demographic information. Each output includes a statement breakdown of the main observations taken from the data, with percentages given for the total responses. Bar charts have been used to show graphical representation of the frequency of responses and frequency tables of results have been provided within Appendix D. Predictive analytics software was also used to obtain cross-tabulation information for the items involving general risk situations to determine if there was any relationship between the participant's age, experience, qualifications or training.

4.2.1 Items involved in the most falls from height

A total of 30 (7.5%) respondents from a sample size of 398 correctly ranked ladders/step ladders within the order of items involved in the most falls from height. The highest correct responses were for stairs at 40 (10.0%) and the lowest correct responses were for tower scaffolds at 13 (3.3%), chart 4.1 (Table 7.7, Appendix D) shows the full responses for five agents.

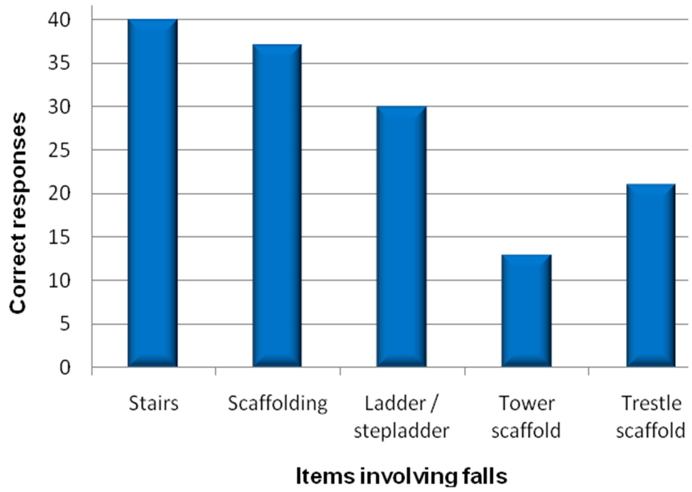


Chart 4.1: Most falls from height

4.2.2 Probability of dying

A total of 93 (23.4%) respondents from a sample size of 398 correctly ranked ladders/step ladders within the order of events linked to the probability of dying. The highest correct responses were for road accidents at 108 (27.3%) and the lowest correct responses was a for fairground ride at 35 (8.8%). The rogue variable for winning the lottery was correct in 58 (14.6%) cases, chart 4.2 (Table 7.8, Appendix D) shows the full responses for the nine events.

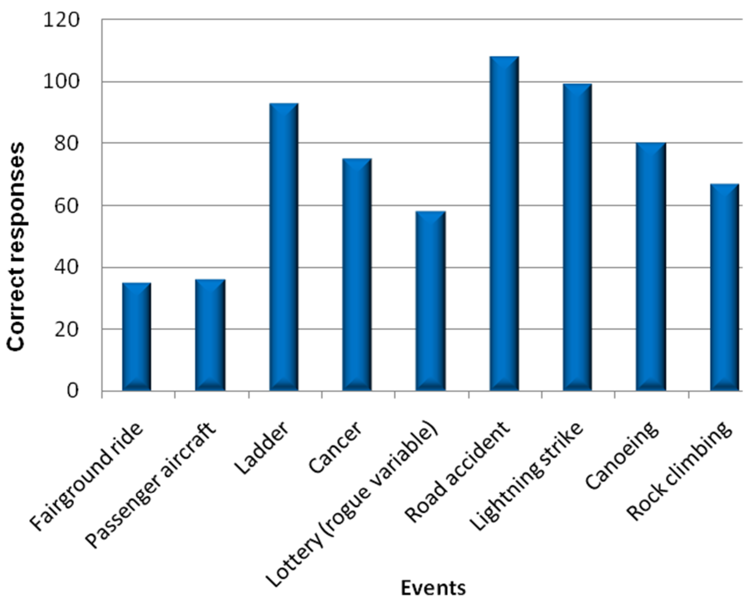


Chart 4.2: Events linked to the probability of dying

4.2.3 Most injuries

A total of 59 (24.8%) respondents from a sample size of 399 correctly ranked ladders/step ladders within the order of items involved in injuries. The highest correct responses were for a knife at 107 (27.0%), and the lowest correct responses was for pliers at 40 (7.0%), chart 4.3 (Table 7.9, Appendix D) shows the full responses for the ten items.

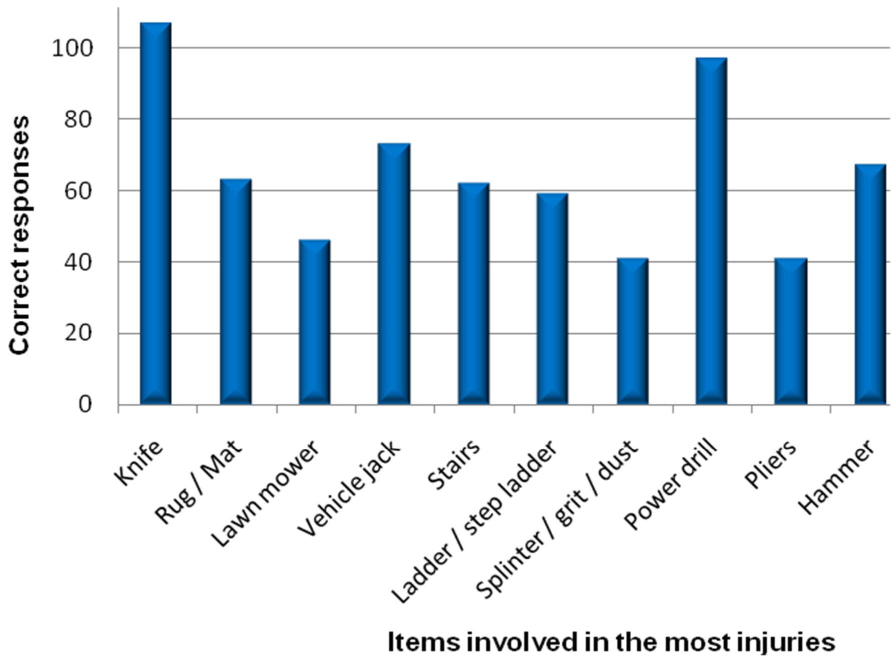


Chart 4.3: Items involved in the most injuries

4.2.4 Most construction deaths

A total of 91 (22.9%) respondents from a sample size of 398 correctly ranked fall from height as one of five items involved with construction deaths. The highest correct response was for contact with electricity at 109 (27.3%) and the lowest correct response was for struck by a moving vehicle at 70 (17.5%), chart 4.4 (Table 7.10, Appendix D) shows the full responses for the five items.

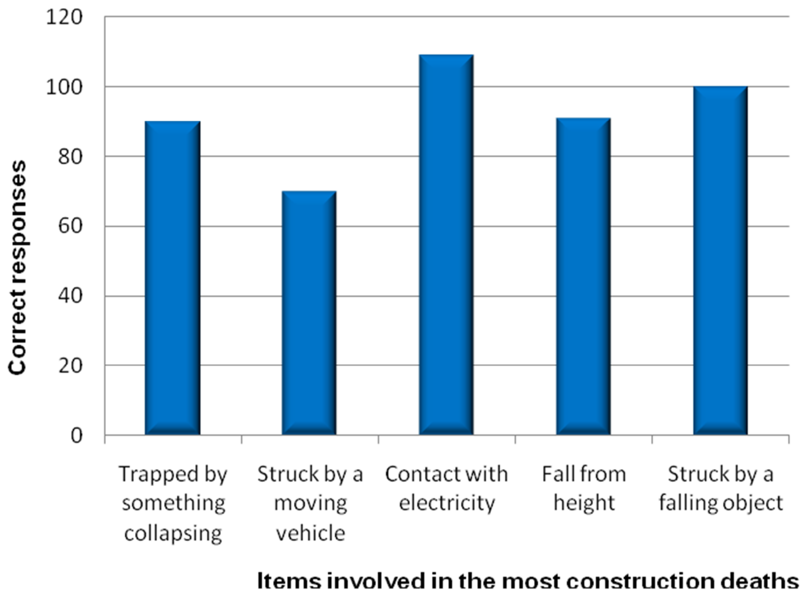


Chart 4.4: Items involved in the most construction deaths

4.2.5 Frequency of ladder use

A total of 294 (73.7%) respondents used a ladder at least once per month, 220 (55.1%) used a ladder every week and 102 (25.6%) every day. 62 (15.5) used a ladder less than once per month, and 43 (10.8%) respondents never used a ladder at work, chart 4.5 (Table 7.11, Appendix D) shows the full responses for a sample size of 399.

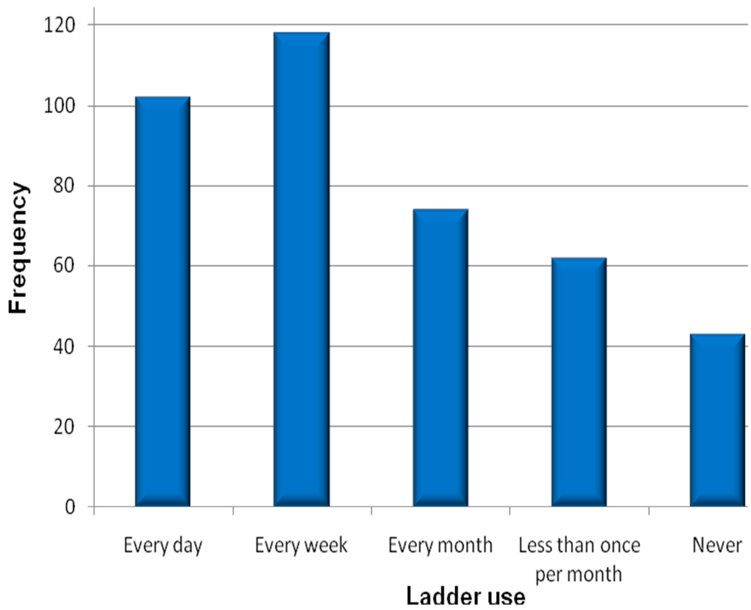


Chart 4.5: Frequency of ladder use

4.2.6 Age in years

The data has a range of 47 years with a minimum age of 16 and a maximum age of 63. 226 (56.8%) of the respondents were under 20 years old, and 319 (80.2%) under 30 years. 40 (10.1%) were between 30 and 40, and 39 (9.8%) were over 40 years old. The mean age was 23.7 years and standard deviation 10.49, chart 4.6 (Table 7.12, Appendix D) shows grouped responses for a sample size of 400.

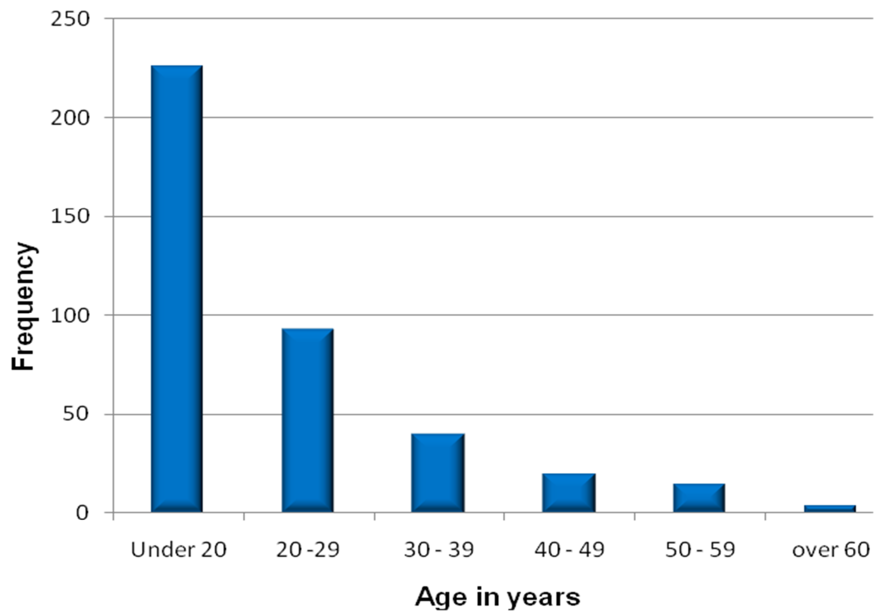


Chart 4.6: Age in years

4.2.7 Gender

A total of 368 (92.2%) respondents were male and 31 (7.8%) female representing a ratio of approximately 11:1, chart 4.7 (Table 7.13, Appendix D) shows the responses for a sample size of 399.

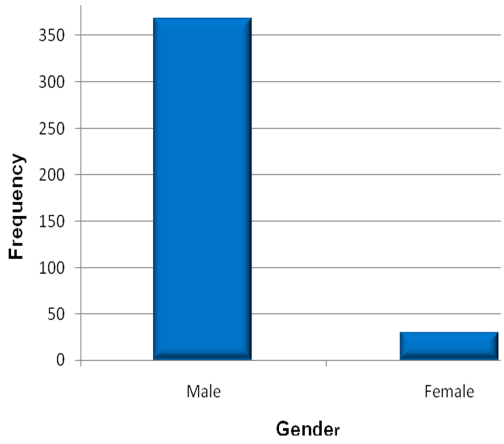


Chart 4.7: Gender

4.2.8 Years worked with ladders

A total of 125 (31.3%) respondents have worked with ladders for less than a year, 95 (23.8%) for between 2 and 4 years, 50 (12.5%) between 5 and 9 years, 37 (9.3%) between 10 and 14 years and 23 (5.8%) over 15 years. 69 (17.3%) responded as never worked with ladders in the construction industry, chart 4.8 (Table 7.14, Appendix D) shows the full responses for a sample size of 399.

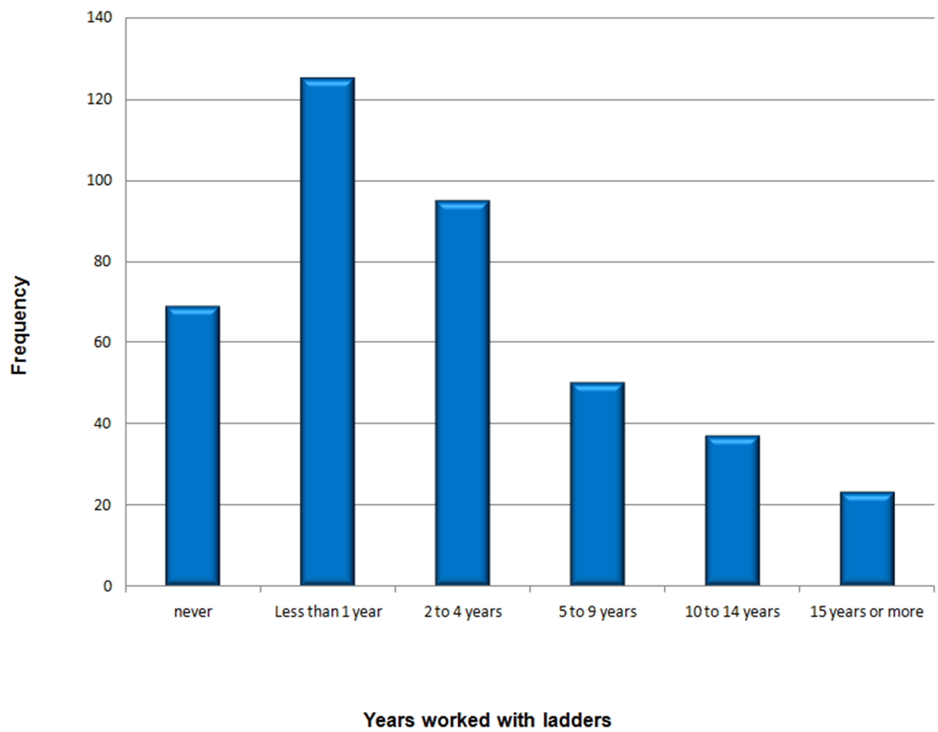


Chart 4.8: Years worked with ladders

4.2.9 Years worked in the construction industry

A total of 176 (44.0%) respondents have worked in the construction industry for less than a year, 106 (26.5%) for between 2 and 4 years, 52 (13.0%) between 5 and 9 years, 40 (10.0%) between 10 and 14 years and 26 (6.5%) over 15 years, chart 4.9 (Table 7.15, Appendix D) shows the full responses for a sample size of 400.

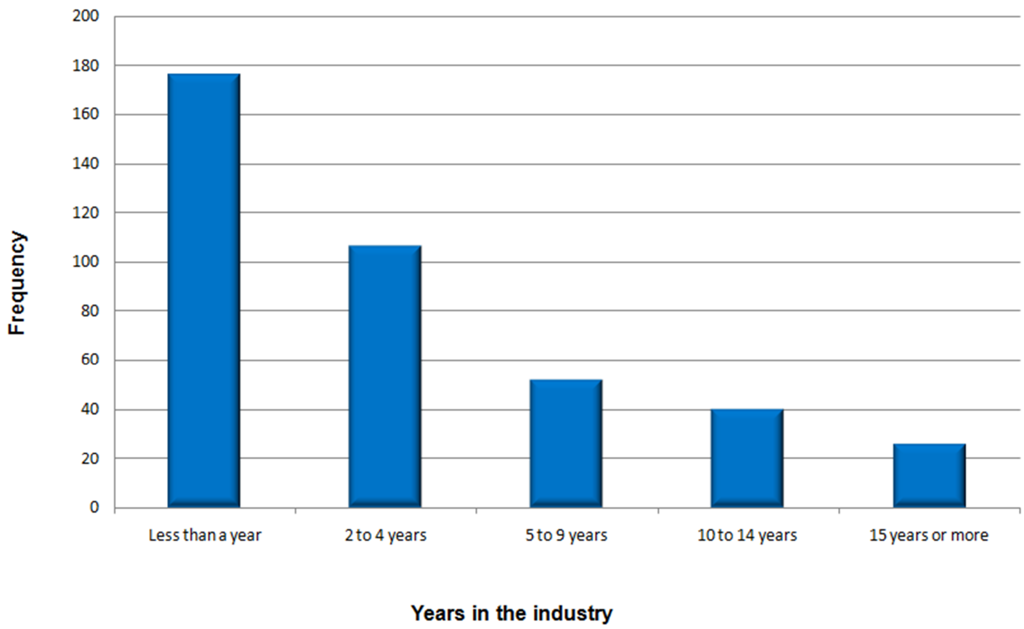


Chart 4.9: Years in the industry

4.2.10 Items involved with the most falls from height

The overall correct responses for the ranking of agents involved with the most falls from height by age group were low, with only 7% of respondents placing individual items in their correct ranking order. The correct responses were within 1% for categories up to the age of 49; however there was an increase in the correct responses for respondents over 50 years old, who were correct for an average of 18% of responses. The numbers of respondents over 49 years old only represented 4% of the total sample, with the majority of incorrect answers (53%) within the under 20 year old category, who represented 57% of the sample, chart 4.10 (Table 7.16, Appendix D)

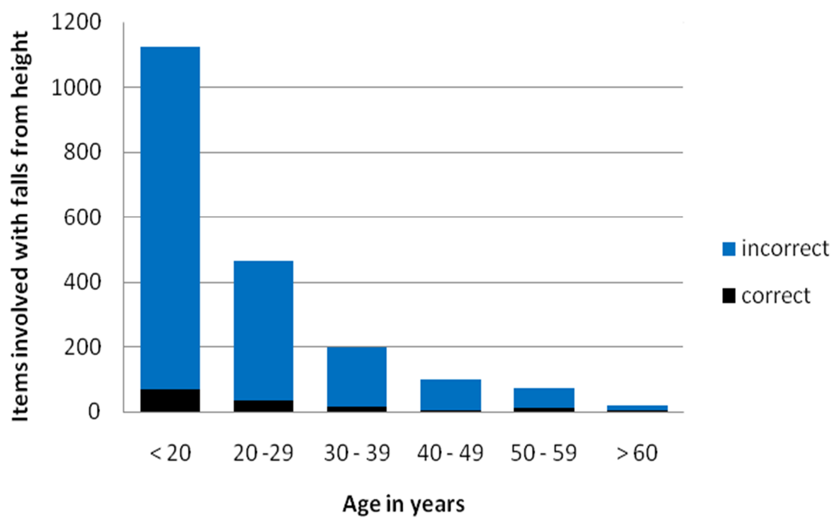


Chart 4.10: Items involved with falls from height - Age in years

Responses for the ranking of ladders/stepladders within the items involved in the most falls from height were low, with only 8% of respondents placing ladders/stepladders in their correct ranking order, chart 4.11 (Table 7.17, Appendix D). Operatives over 50 years old generally provided twice as many correct responses than those under 50, and the spread of correct responses were similar to the overall results in terms of age groups, showing that as age increased, correct responses also increased, chart 4.12 (Table 7.18, Appendix D)

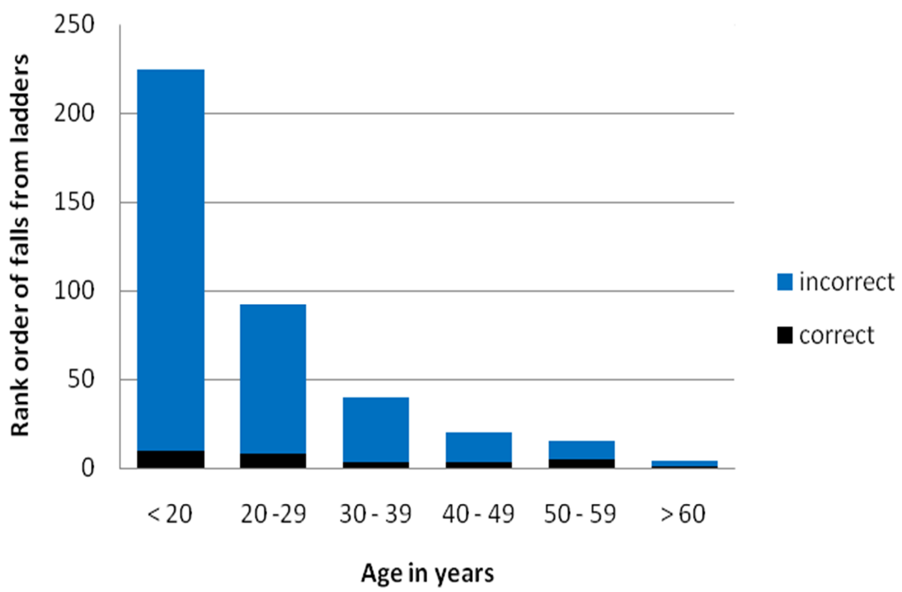


Chart 4.11; Falls from ladders - Age in years

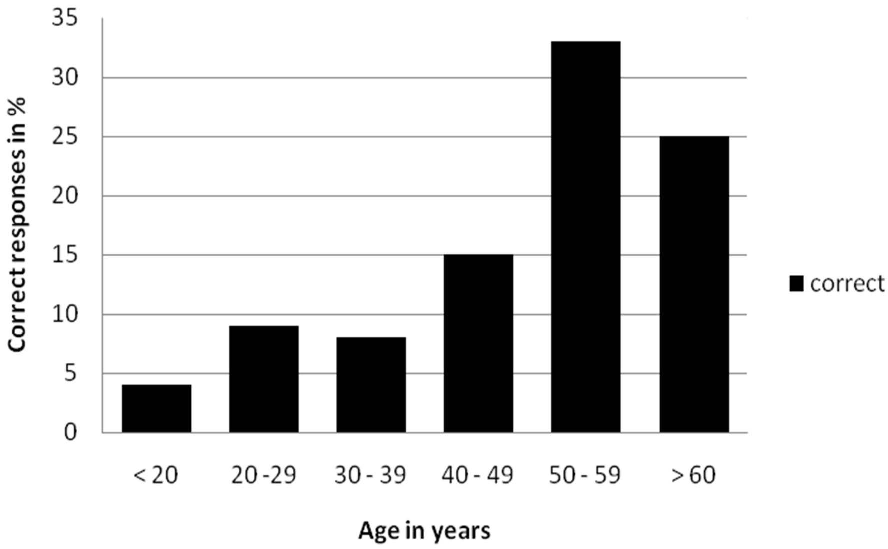


Chart 4.12: Correct responses for falls from ladders - Age in years

Correct responses for the ranking of ladders within falls from height by years worked in the construction industry (experience) were also low, with only 7% of participants placing ladders in the correct ranking order. Of the 870 responses from respondents who had worked in the industry for less than one year, only 5% were correct. The ranking scores were similar for the time periods 2 - 4 years (6%) and 5 - 9 years (7%) with 528 and 259 responses respectively. Respondents with 15 years experience or more in the industry performed best with a 15% correct response rate, however they represented only 7% of the total respondents, chart 4.13 (Table 7.19, Appendix D)

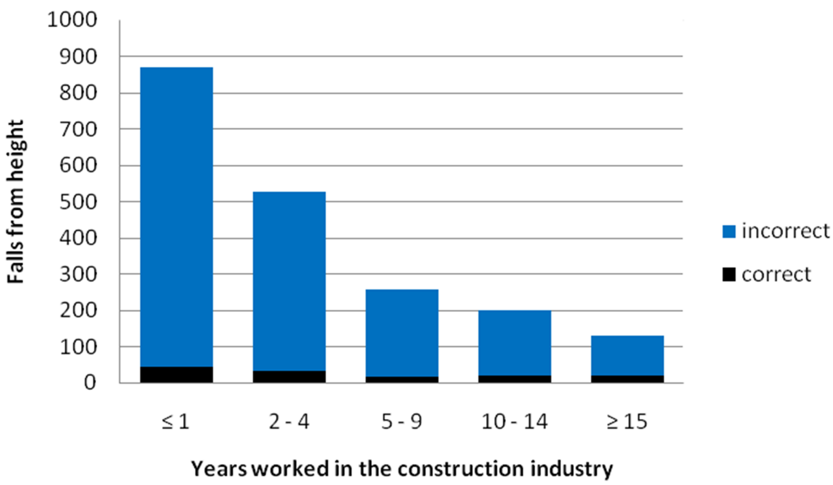


Chart 4.13: Falls from height - years worked in the construction industry

There were 30 correct responses for the ranking of falls from ladders/stepladders by years worked in the construction industry (experience) which was only 8% of the total. Of the 176 respondents who had worked in the industry for less than one year, only 4% correctly ranked ladders/stepladders. The ranking scores were similar for the time periods 2 - 4 years and 5 - 9 years with 7% and 8% correct responses respectively, chart 4.14 (Table 7.20, Appendix D)

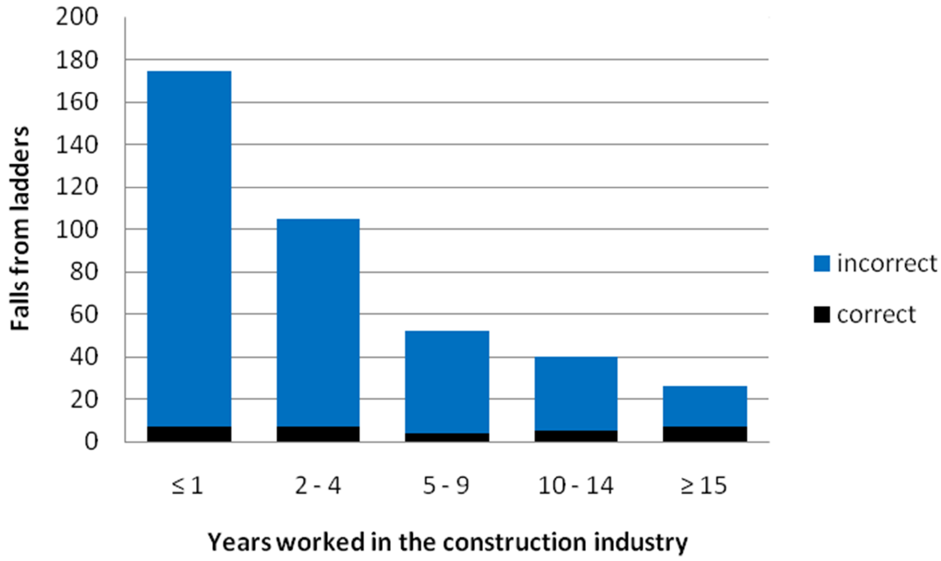
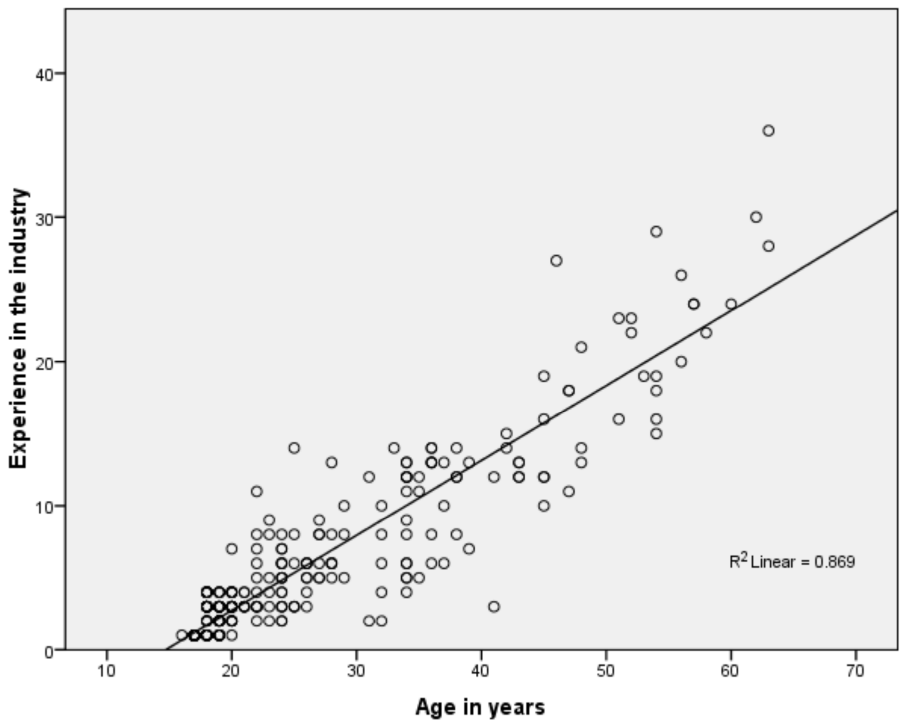


Chart 4.14: Falls from ladders - years worked in the construction industry

Correct responses from respondents that had worked with ladders followed a similar pattern to the number of years in the industry (Chart 4.21). Of the 623 responses from respondents who had worked with ladders for less than one year only 6% were correct. The ranking scores were similar for the time periods 2 - 4 years (8%) and 5 - 9 years (7%) with 29 and 18 responses respectively. Respondents with 15 years or more working with ladders performed best with a 17% correct response rate, however they represented only 6% of the total respondents, chart 4.15 (Table 7.21, Appendix D)

Chart 4.15: Falls from height - years worked with ladders

Regression analysis using predictive analytic software was used to test for correlation between age and experience in the construction industry, with experience being the dependant variable. A strong positive correlation was observed confirming the association found previously by Warr (1998) between increasing age and experience. The probability (p-value) for the slope coefficient was significant at 0.001, therefore the null hypothesis that there was no relationship between age and experience was rejected and the experimental hypothesis that there is a relationship was accepted Chart 4.16.



The slope coefficient for the independent variable is 0.520 and the regression R square accounts for 0.869 (87%) variation in the data. The p-value for the slope coefficient was 0.001.

Chart 4.16: Age in years - years' experience in the construction industry

The number of correct responses for items involved with falls from height increased by approximately 2% for up to nine years experience, after which it increases to 10% for up to 10 years and 19% for over 15 years experience, chart 4.17 (Table 7.23, Appendix D). However the number of respondents with over 10 years experience was quite small (5%), compared with the number of respondents with under one year experience (57%) which may skew the results, and will be taken into consideration when drawing conclusions.

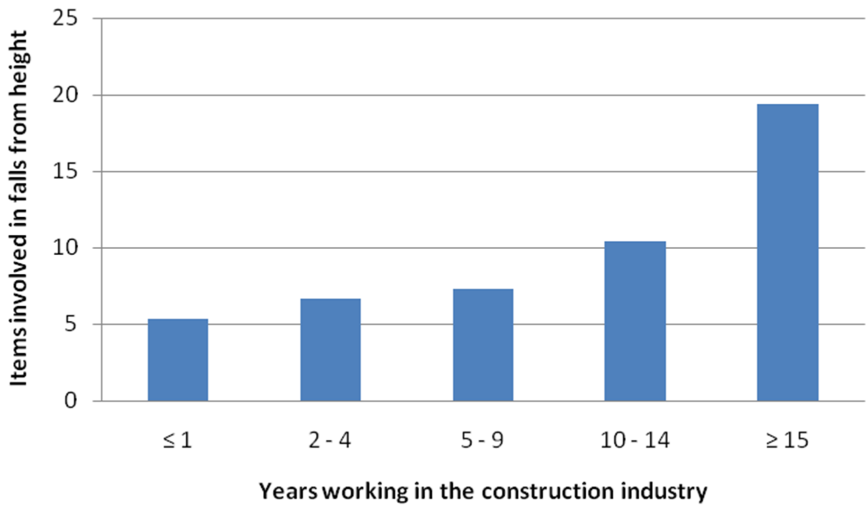


Chart 4.17: Items involved with falls from height – years working in the construction industry

4.2.11 Events linked to the probability of dying

The total correct responses for the nine events linked to the probability of dying (plus the rogue variable) were low, with 18% correct responses indicating that the respondents were generally not aware of the risks posed by the events. Road accidents were correctly identified by 27% of respondents which is surprisingly low considering the amount of publicity given to road accidents by the general media. Likewise the lottery (rogue variable) was correctly identified by only 15% of respondents despite it being fairly well known.

The results for the age group of participants ranking ladders/stepladders correctly in the events linked to the probability of dying showed that only 11% of the under 20 age group correctly identified ladders in the ranking. The percentage of correct responses increased as age increased with 60% of 40 - 49 age group, 67% of the 50 - 59 age group, and 100% of over 60s responding correctly, chart 4.18 (Table 7.24, Appendix D). The percentage of incorrect responses was highest from respondents under 20 years of age (89%) and least from respondents over 60 (0%), however the under 20 year old represent 57% of the responses and the over 60 year old only representing 1% of the responses.

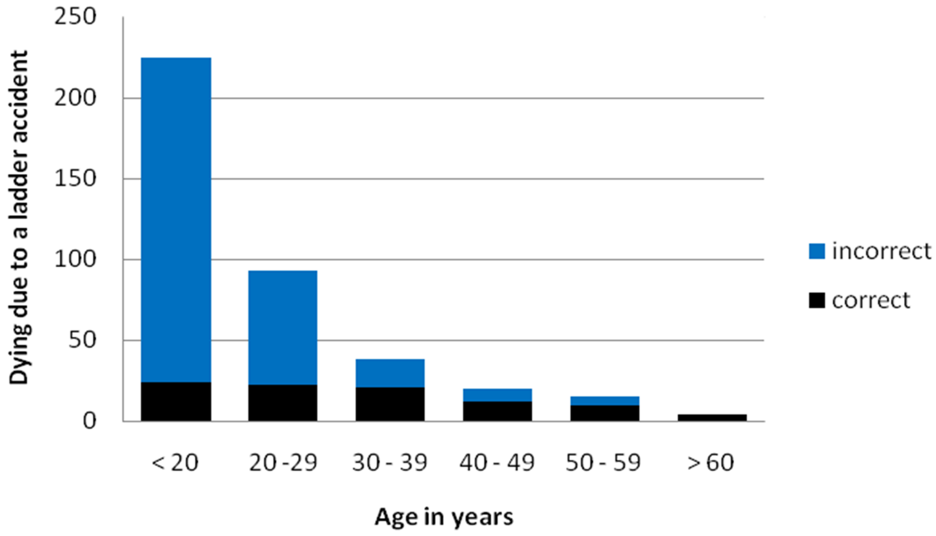


Chart 4.18: Dying due to a ladder accident – age in years

The results for the years worked with ladders and the participants correct ranking of ladders/stepladders in the events linked to the probability of dying showed that 44% of respondents had worked in the construction industry for less than one year, of which only 11% ranked ladders correctly, chart 4.19 (Table 7.25, Appendix D). Respondents with 10 - 14 years experience were correct for 40% of the responses, and 15 years or more experience were correct for 73% of the responses.

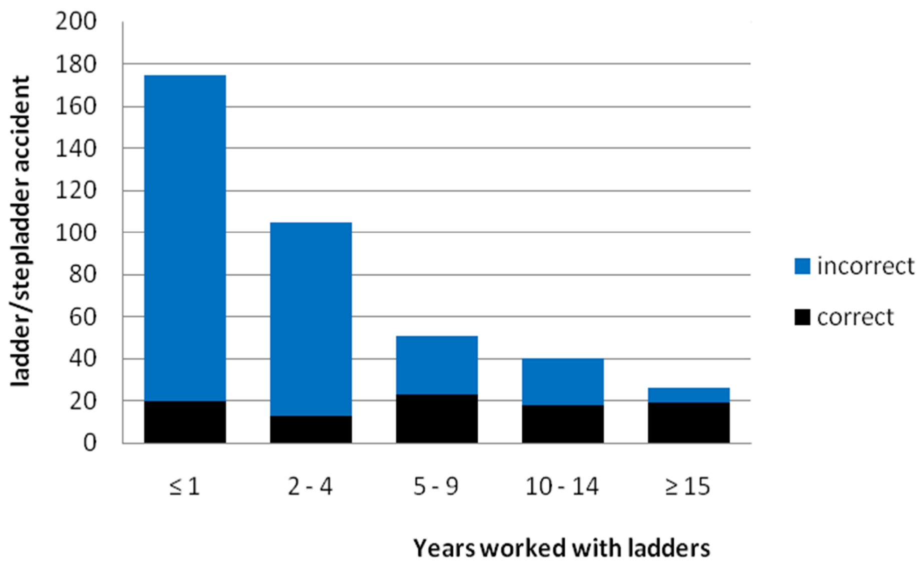


Chart 4.19: Ladder/stepladder accidents – years worked with ladders

4.2.12 Fallen from a ladder

A total of 354 (88.9%) respondents had never fallen from a ladder or step ladder, 32 (8.0%) had fallen once, 10 (2.5%) had fallen between 2 and 4 times and 2 (0.5%) between 5 and 10 times, chart 4.20 (Table 7.26, Appendix D) shows the responses for a sample size of 398.

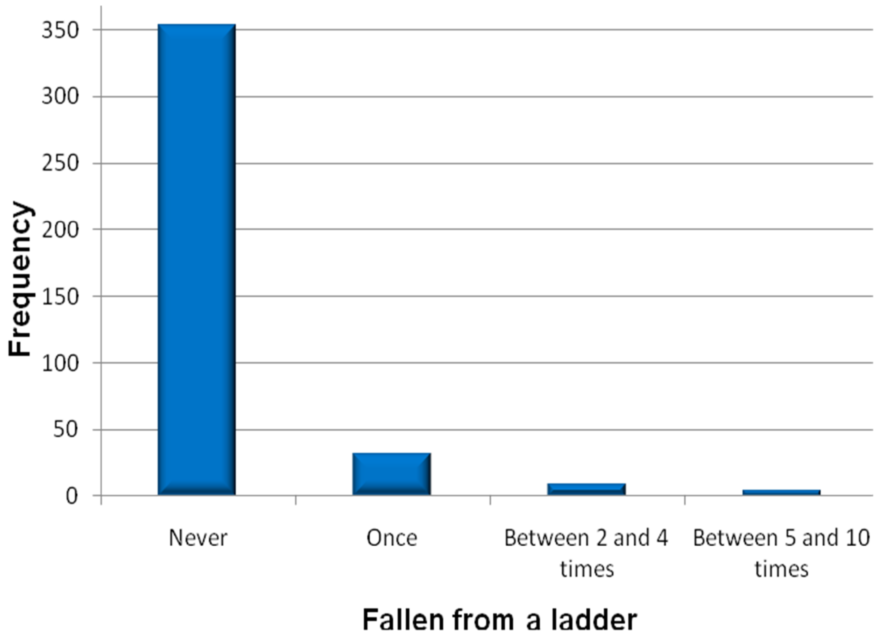


Chart 4.20: Fallen from a ladder

4.2.13 **Written information - how to use a ladder**

A total of 254 (63.5%) respondents received written information on how to use ladders or step ladders, 139 (34.8%) had not received any information and 7 (1.8%) responded that they didn't know, chart 4.21 (Table 7.27, Appendix D) shows the responses for a sample size of 400.

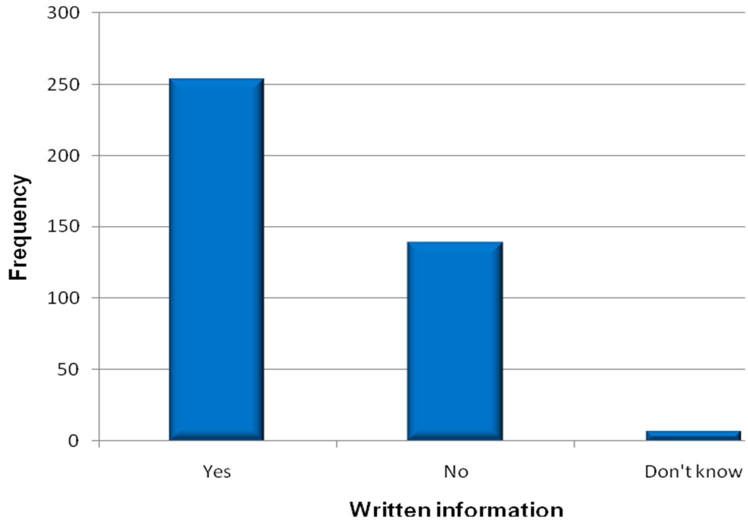


Chart 4.21: Written information - how to use a ladder

4.2.14 Ladder training – how to select

A total of 183 (46.4%) respondents received practical training on how to select ladders or step ladders, 205 (52.0%) had not received any training and 6 (1.5%) responded that they didn't know, chart 4.22 (Table 7.28 Appendix D) shows the responses for a sample size of 394.

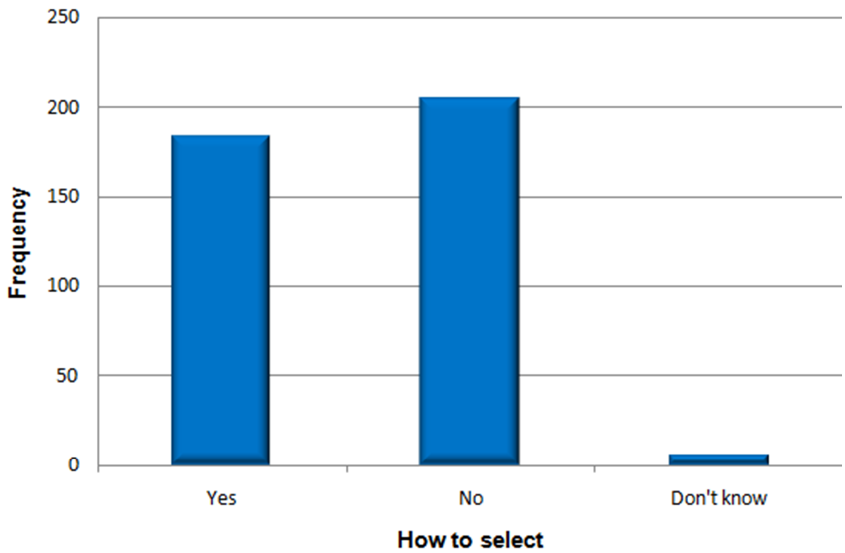


Chart 4.22: Practical Training – how to select a ladder

4.2.15 Ladder training – how to position

A total of 164 (41.5%) respondents received practical training on how to position ladders or step ladders, 227 (57.5%) had not received any training and 4 (1.0%) respondents didn't know, chart 4.23 (Table 7.29, Appendix D) shows the responses for a sample size of 395.

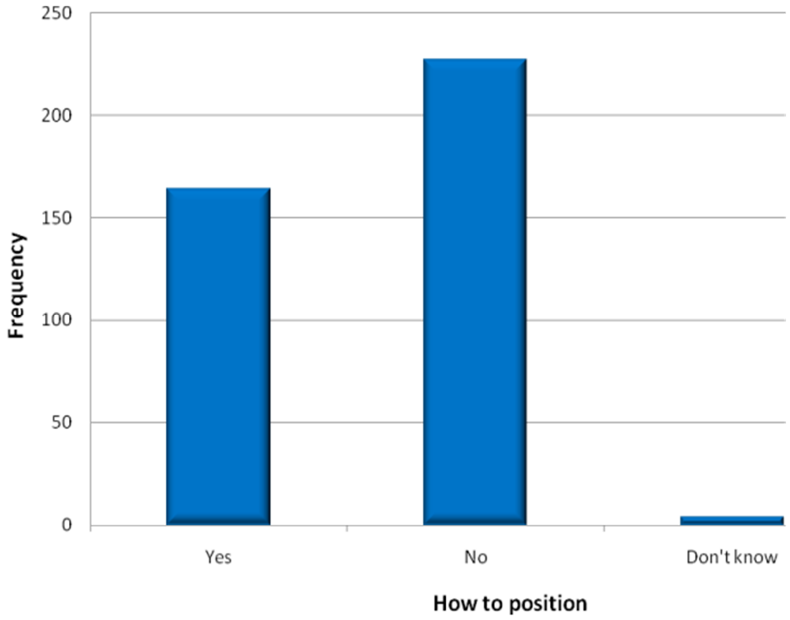


Chart 4.23: Practical training - how to position a ladder

4.2.16 Ladder training – how to use a ladder

A total of 160 (40.2%) respondents received practical training on how to use ladders or step ladders, 232 (58.3%) had not received any training and 6 (1.5%) respondents didn't know, chart 4.24 (Table 7.30, Appendix D) shows responses for a sample size of 398.

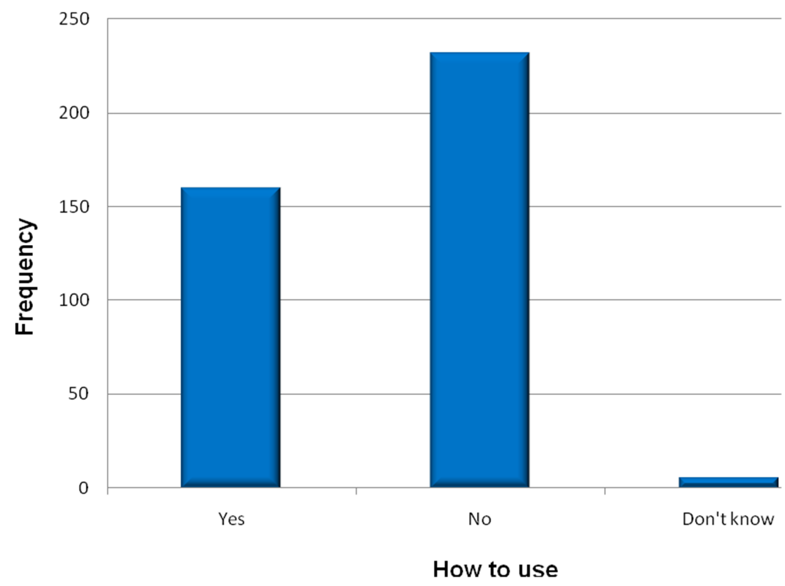


Chart 4.24: Practical training - how to use a ladder

4.2.17 Ladder training – how to work safely

A total of 192 (48.4%) respondents received practical training on how to work safely from ladders or step ladders, 201 (50.6%) had not received any training and 4 (1.0%) responded that they didn't know, chart 4.25 (Table 7.31, Appendix D) shows the responses for a sample size of 397.

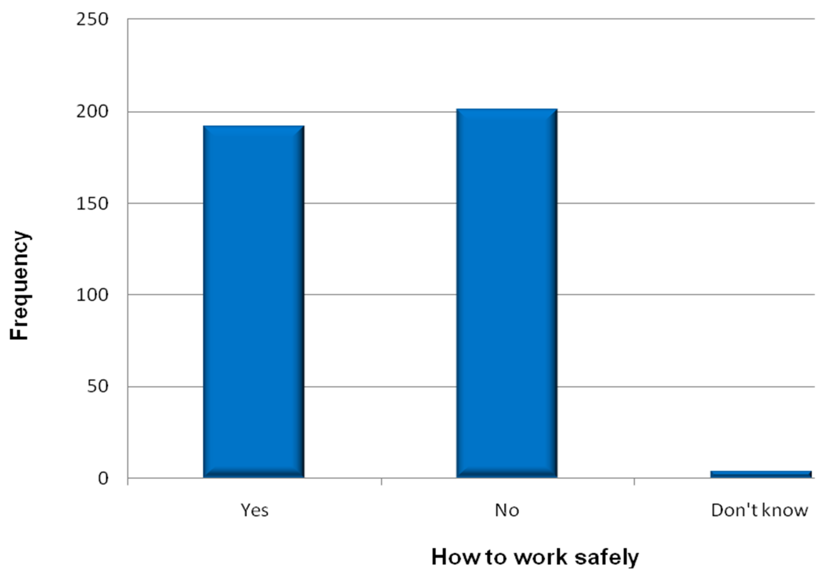


Chart 4.25: Practical training – how to work safely

4.2.18 Health and safety qualifications

A total of 233 (58.2%) respondents have no health and safety qualifications. Of the remainder 108 (27.0%) have safety passport cards and 52 (13.0%) have CSCS cards, chart 4.26 (Table 7.32, Appendix D) shows the full responses for a sample size of 400.

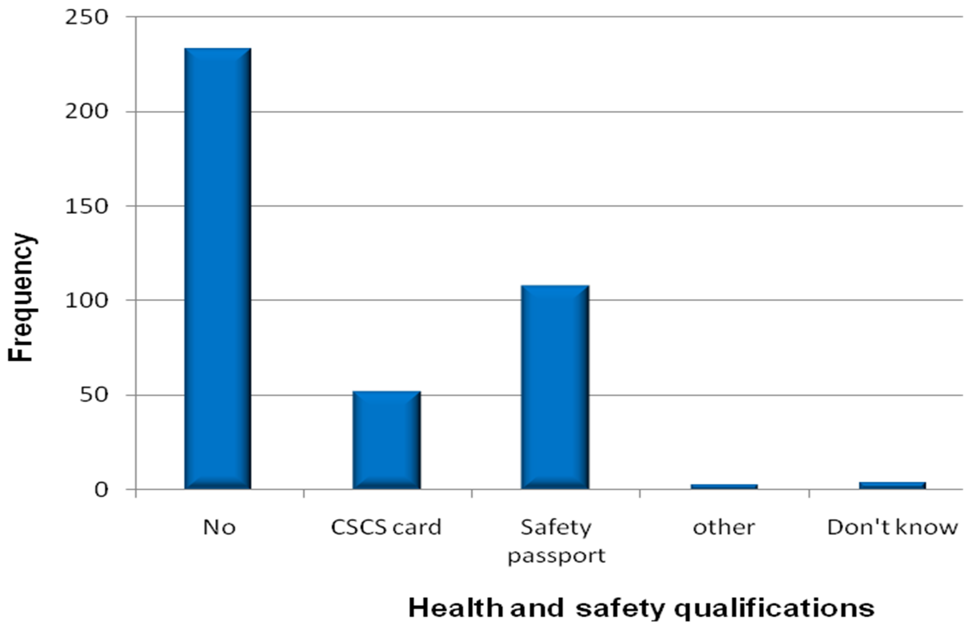


Chart 4.26: Health and safety qualifications

4.2.19 Employer main work type

A total of 114 (28.6%) respondents from a sample size of 398 were employed by a general builder, 113 (28.4%) in general maintenance, 31 (7.8%) in Civil engineering and 39 (9.8%) in building services. A further 52 (13.1%) identified their work type as other and 18 (4.5%) responded as unemployed, chart 4.27 (Table 7.33, Appendix D) shows the full responses for the employers main work type.

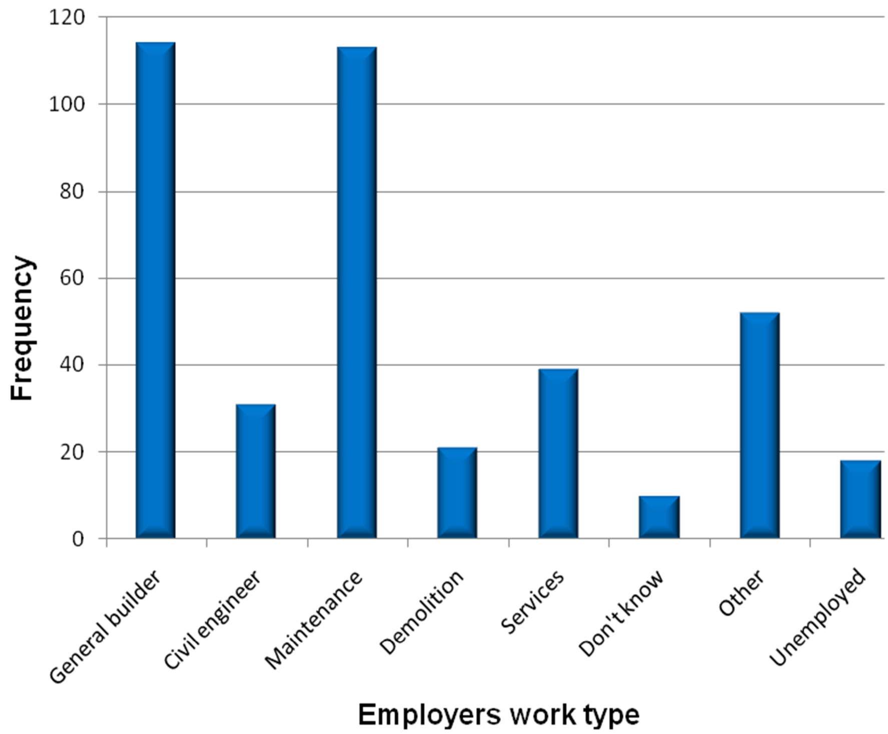


Chart 4.27: Employer main work type

4.2.20 Occupation

The respondents were from fourteen identified occupations within the construction industry. The highest number of 88 (22.1%) were general operatives and the lowest number of 10 (2.5%) were managers/foremen. 8 (2.0%) described their occupation as self employed and 15 (3.8%) as unemployed, chart 4.28 (Table 7.34, Appendix D) shows the full responses for the main occupation types for 399 respondents.

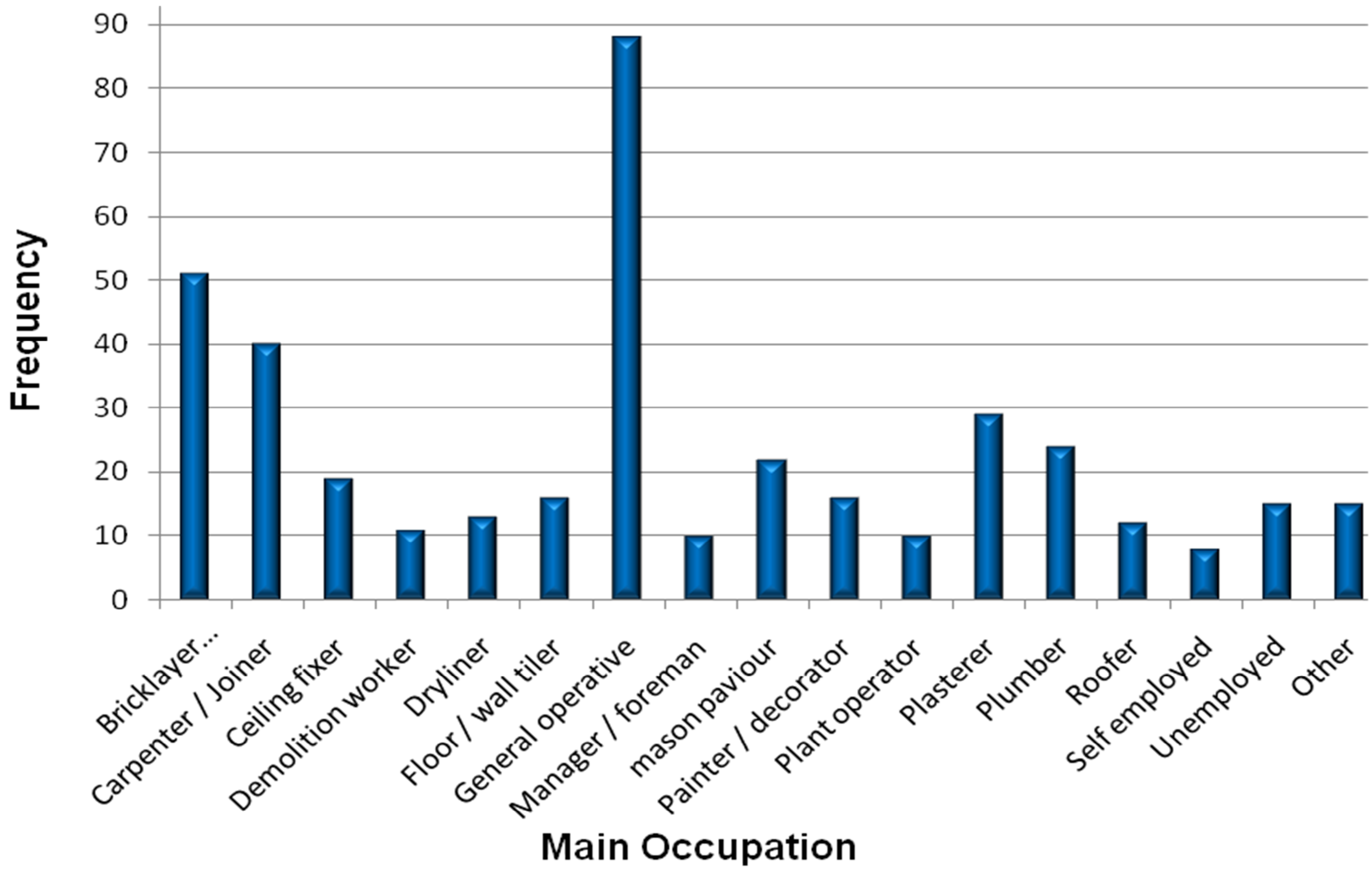


Chart 4.28: Occupation

4.2.21 Company size

A total of 155 (38.8%) respondents work for small organisations, 115 (28.8%) for micro organisations, 47 (11.8%) for medium organisations and 45 (11.3%) for large organisations. 18 (4.5%) are unemployed and 19 (4.8%) responded as don't know, chart 4.29 (Table 7.35, Appendix D) shows the full responses for company size for 399 respondents.

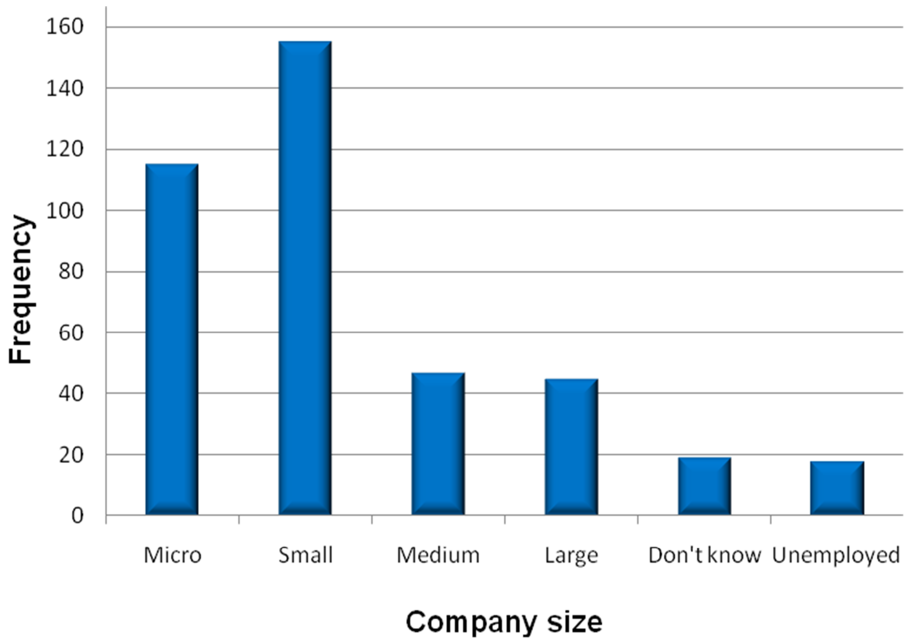


Chart 4.29: Company size

4.2.22 Items involved in the most injuries

Participants placed in rank order the risk associated with the most injuries related to ten relatively ordinary items, including a knife, hammer, and accident rates for ladders/stepladders. The most accurate responses were for knives (27%) and power drills (24%), and the most incorrect responses were for splinters (10%) and pliers (7%). However the total overall responses were only 16% correct, indicating that the respondents were poor at assessing the risk levels for familiar objects. The overall results could have been influenced by the age of the participants as 49% of the incorrect responses were from participants under 20 years of age, who make up 57% of the overall responses, chart 4.30 (Table 7.36, Appendix D).

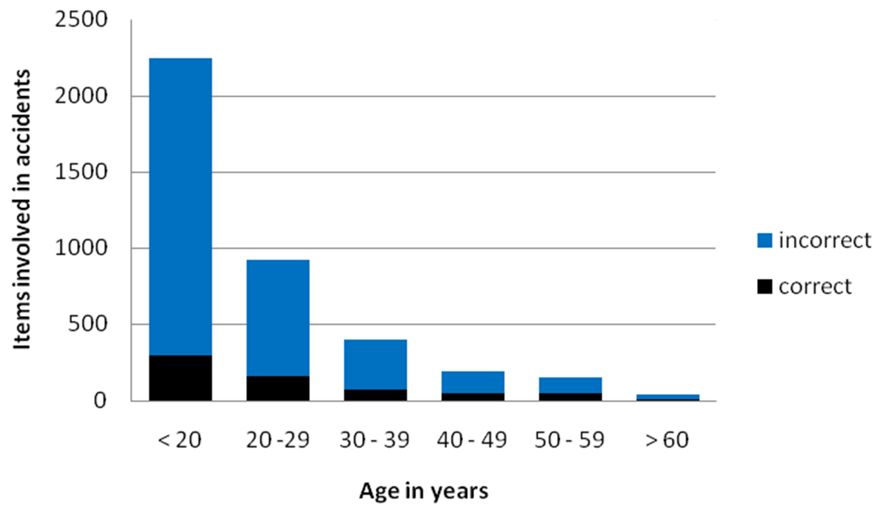


Chart 4.30: Items involved with accidents – age in years

Within the overall results ladders/stepladders were correctly identified by only 15% of respondents who placed ladders accurately within the ranking (Chart 4.29). However only 8% of the under 20 age group correctly identified ladders in the ranking compared with 35% of 40 - 49 age group, 47% of the 50 - 59 age group, and 50% of over 60 year olds, chart 4.31 (Table 7.37, Appendix D).

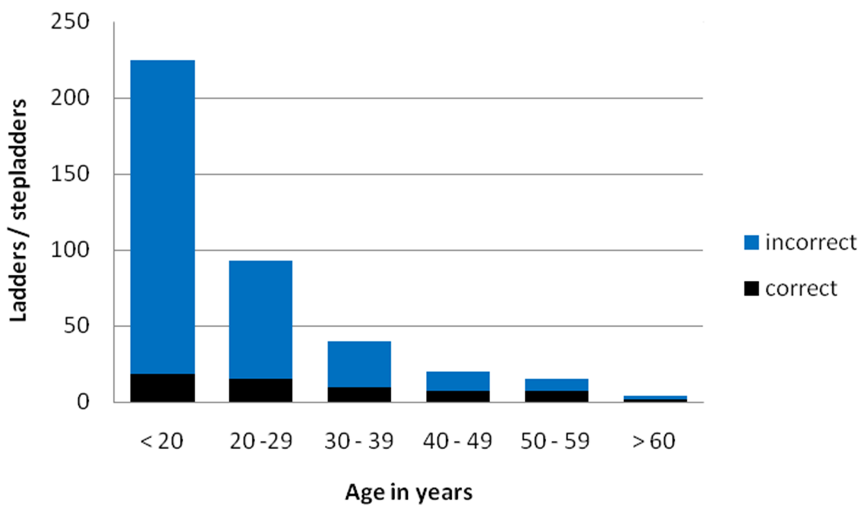


Chart 4.31: Ladders involved with accidents – age in years

Results for items involved with falls from a ladder or stepladder show that correct responses increased from 13% for respondents who had never fallen, to 19% for one fall, 50% for respondents who had fallen between 2 - 4 times, and 50% for respondents who had fallen between 5 - 10 times, chart 4.32 (Table 7.38, Appendix D).

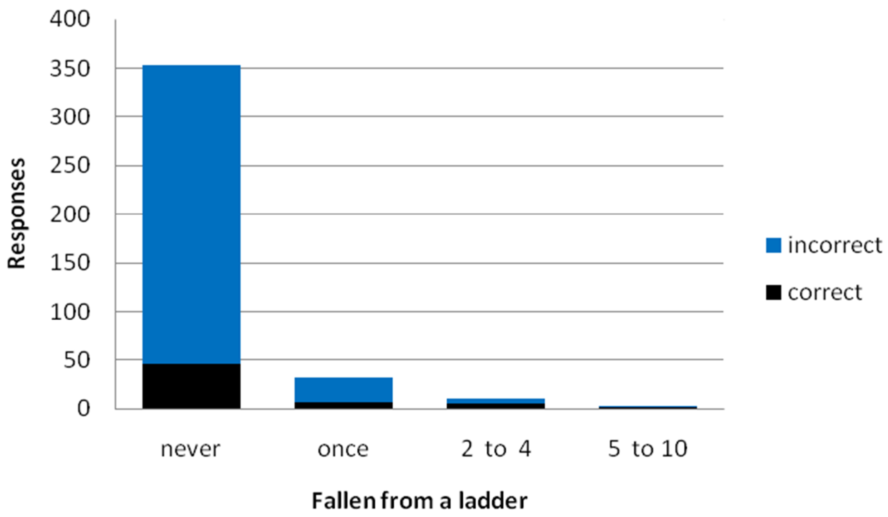


Chart 4.32: Fall from a ladder / step ladder

4.2.23 Items involved in the most construction deaths

The total correct responses for the items involved in the most construction deaths were relatively low at 23%. Of the 176 responses from respondents who had worked in the industry for less than one year, only 14% were correct, compared with 42% for the 5 - 9 year group and 50% for ≥ 15 year group. However these year groups represented only 14% and 7% of the respondents respectively, chart 4.33 (Table 7.39, Appendix D).

Chart 4.33: Years worked in the construction industry

The highest percentage of correct scores (53%) was from respondents who held a qualification identified as other*;* however their total numbers represented only 4% of the total sample. The CSCS and Safety Passport qualifications provided very similar results, both providing success at about 30%, compared with those with no qualifications who provided 18% correct responses, chart 4.34 (Table 7.40, Appendix D).

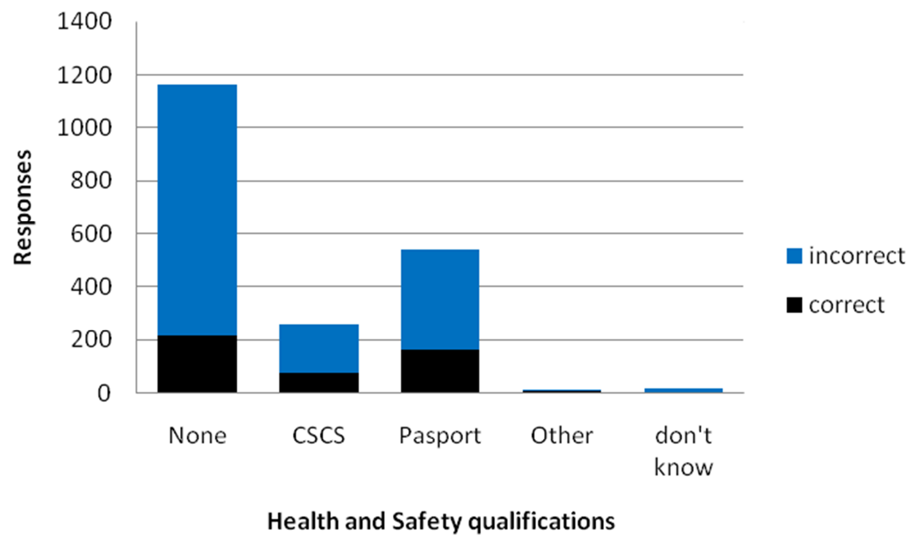


Chart 4.34: Health and safety qualifications

Respondents under 20 years old, with no qualifications correctly ranked 8% of the items associated with construction deaths; with an even spread of approx 2% correct responses across the qualification categories. This was similar to respondents over 20 years of age who correctly ranked 11% of the items, chart 4.35 (Table 7.41, Appendix D).

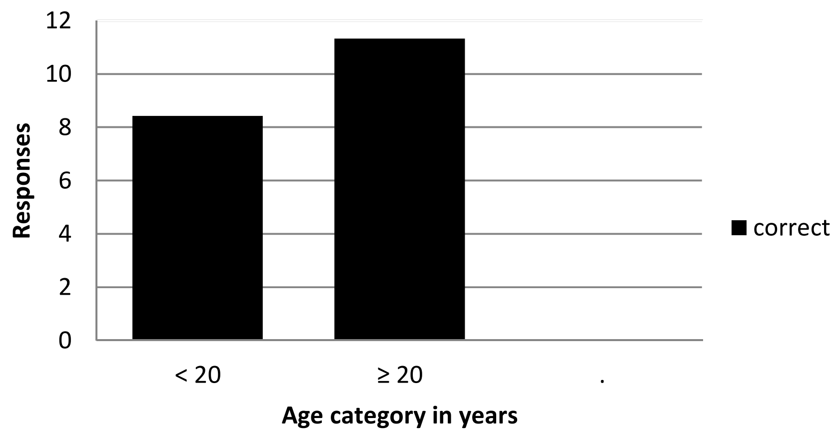


Chart 4.35: Respondents with no health and safety qualifications

Chart 4.36 (Table 7.42, Appendix D). provides the combined responses for the five ladder training results with the falls from height item for the most construction deaths. The results show that correct and incorrect responses for the falls from height item are the same for respondents that had, and those that had not received ladder training.

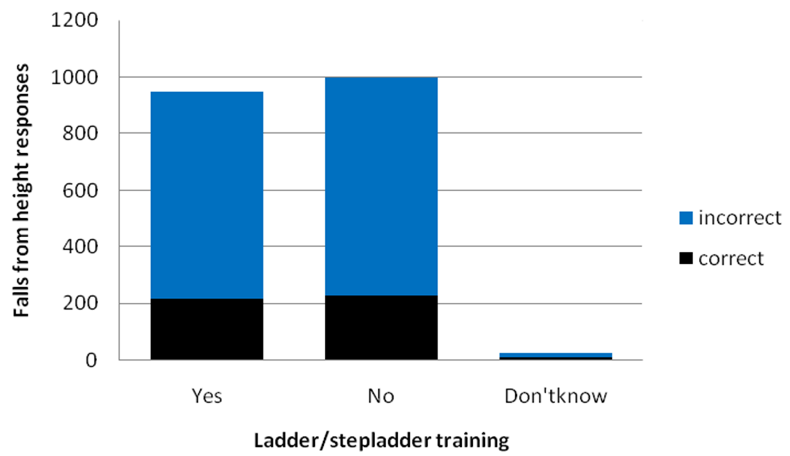


Chart 4.36: Combined ladder training responses for falls from height

4.3 Level of risk to the ladder user

The results for the 'level of risk to the ladder user', items 8 to 26 used a rating scale from 1 to 10. The results statement therefore provides a data range between 1 and 10 for the responses and an average rating for the level of risk responses. Mean and standard deviation for each risk rating have also been provided.

4.3.1 Level of risk to the ladder user – ref. question 8

The highest frequency of responses was 125 (31.3%), rating the level of risk as 6. The data has a range of 6 with a minimum score of 3 and a maximum of 9. 77.7% of scores were within one standard deviation (1.25) of the mean value of 5.8. Chart 4.37 (Table 7.43, Appendix D) shows the full responses for a sample size of 399.

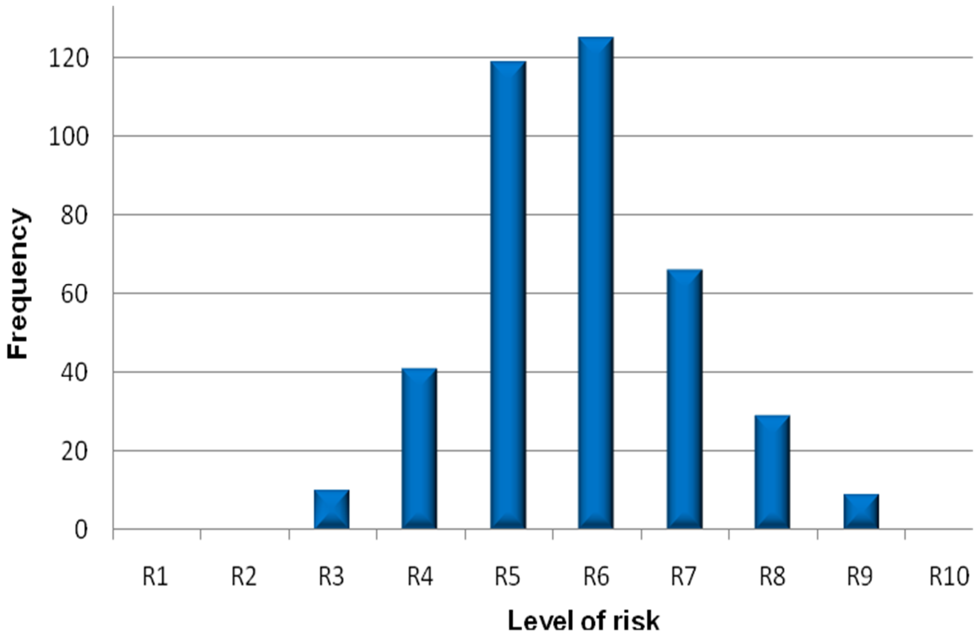


Chart 4.37: Level of risk to the ladder user – question 8

4.3.2 Level of risk to the ladder user – ref. question 9

The highest frequency of responses was 154 (38.8%), rating the level of risk as 2. The data has a range of 5 with a minimum score of 1 and a maximum of 6. 76.8% of scores were within one standard deviation (1.0) of the mean value of 2.0. Chart 4.38 (Table 7.44, Appendix D) shows the full responses for a sample size of 397.

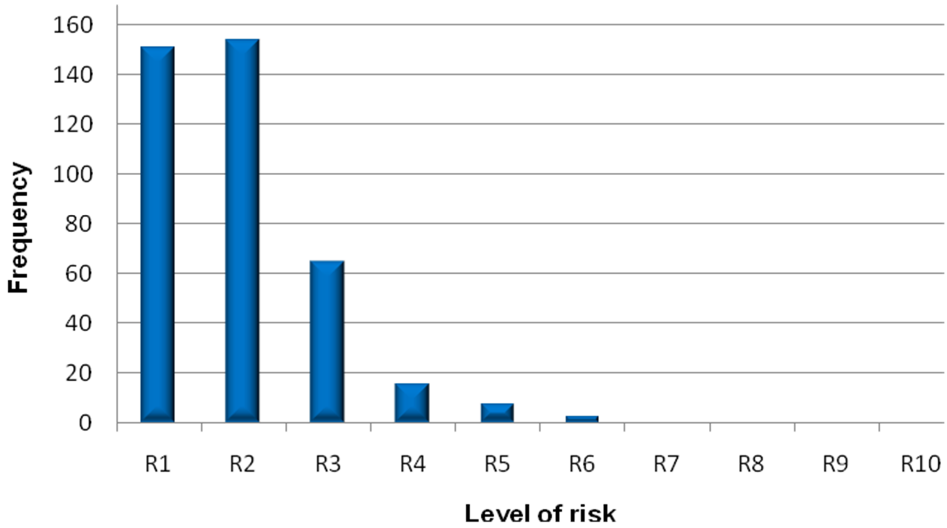


Chart 4.38: Level of risk to the ladder user – question 9

4.3.3 Level of risk to the ladder user – ref. question 10

The highest frequency of responses was 127 (32.0%), rating the level of risk as 5. The data has a range of 9 with a minimum score of 1 and a maximum of 10. 68% of scores were within one standard deviation (1.51) of the mean value of 5.5. Chart 4.39 (Table 7.45, Appendix D) shows the full responses for a sample size of 397.

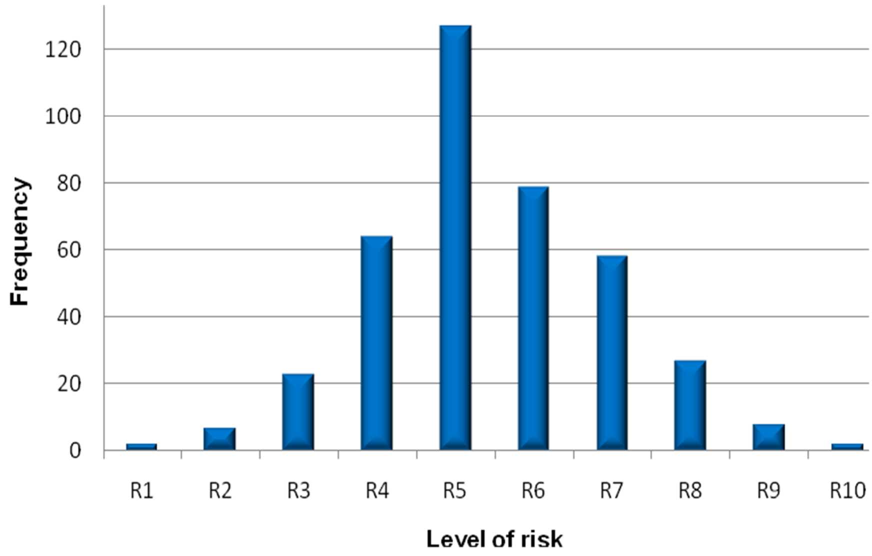


Chart 4.39: Level of risk to the ladder user – question 10

4.3.4 Level of risk to the ladder user – ref. question 11

The highest frequency of responses was 150 (37.6%), rating the level of risk as 9. The data has a range of 6 with a minimum score of 4 and a maximum of 10. 54.6% of scores were within one standard deviation (1.5) of the mean value of 8.7. Chart 4.40 (Table 7.46, Appendix D) shows the full responses for a sample size of 399.

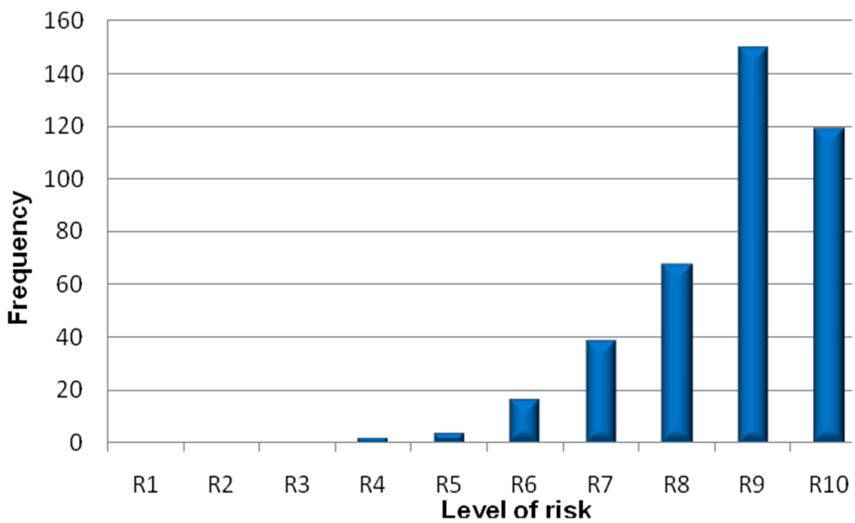


Chart 4.40: Level of risk to the ladder user – question 11

4.3.5 Level of risk to the ladder user – ref. question 12

The highest frequency of responses was 195 (49.2%), rating the level of risk as 2. The data has a range of 9 with a minimum score of 1 and a maximum of 10. 64.4% of scores were within one standard deviation (1.05) of the mean value of 2.1. Chart 4.41 (Table 7.47, Appendix D) shows the full responses for a sample size of 396.

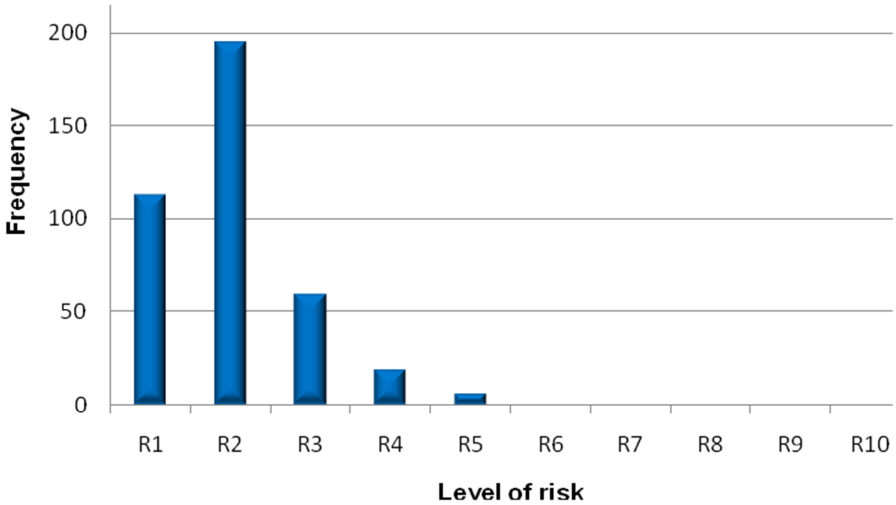


Chart 4.41: Level of risk to the ladder user – question 12

4.3.6 Level of risk to the ladder user – ref. question 13

The highest frequency of responses was 124 (31.5%), rating the level of risk as 8. The data has a range of 9 with a minimum score of 1 and a maximum of 10. 78.9% of scores were within one standard deviation (1.41) of the mean value 7.8. Chart 4.42 (Table 7.48, Appendix D) shows full responses for a sample size of 394.

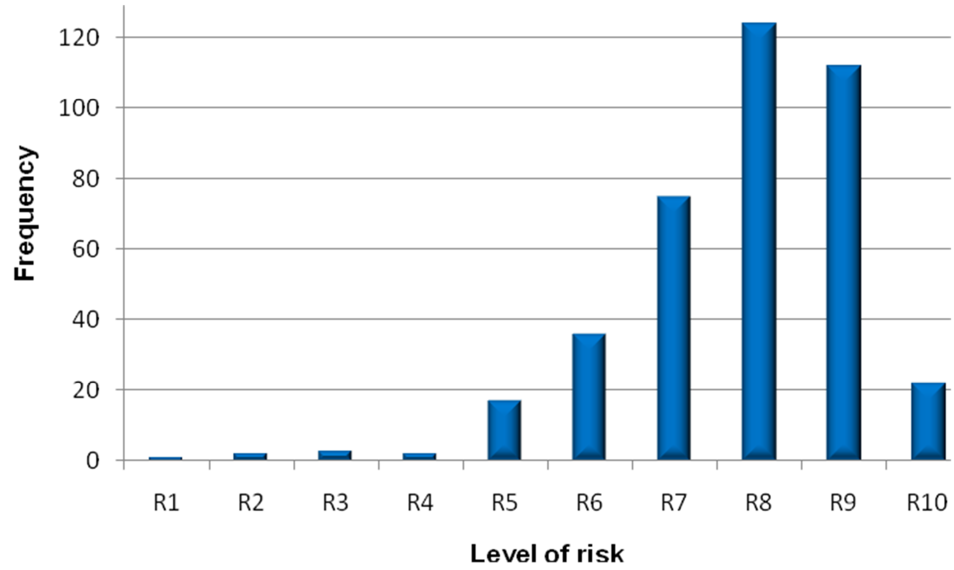


Chart 4.42: Level of risk to the ladder user – question 13

4.3.7 Level of risk to the ladder user – ref. question 14

The highest frequency of responses was 108 (27%), rating the level of risk as 6. The data has a range of 7 with a minimum score of 2 and a maximum of 9. 69% of scores were within one standard deviation (1.4) of the mean value of 5.9. Chart 4.43 (Table 7.49, Appendix D) shows the full responses for a sample size of 400.

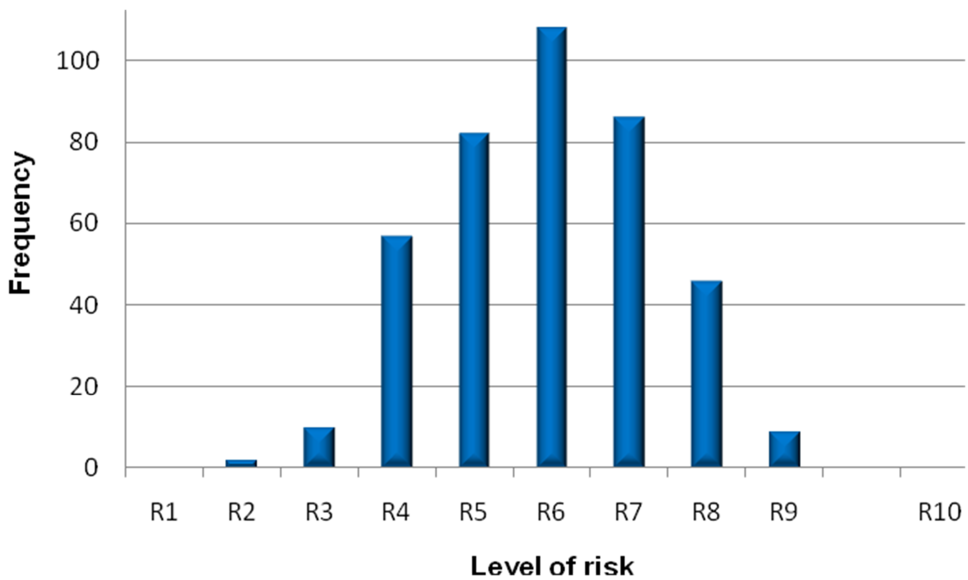


Chart 4.43: Level of risk to the ladder use – question 14

4.3.8 Level of risk to the ladder user – ref. question 15

The highest frequency of responses was 104 (26%), rating the level of risk as 5. The data has a range of 8 with a minimum score of 2 and a maximum of 10. 71.8% of scores were within one standard deviation (2.17) of the mean value of 5.9. Chart 4.44 (Table 7.50, Appendix D) shows the full responses for a sample size of 400.

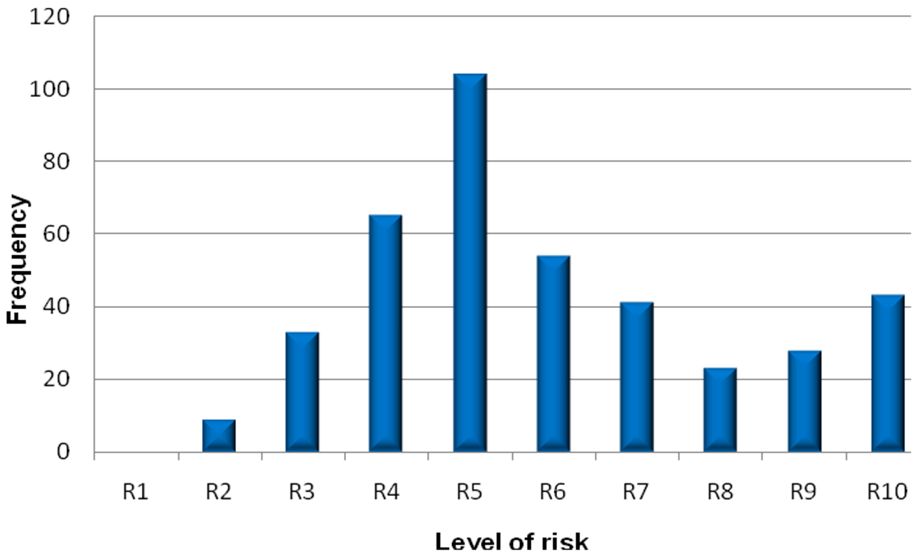


Chart 4.44: Level of risk to the ladder user – question 15

4.3.9 Level of risk to the ladder user – ref. question 16

The highest frequency of responses was 169 (42.2%), rating the level of risk as 5. The data has a range of 7 with a minimum score of 2 and a maximum of 9. 76% of scores were within one standard deviation (1.24) of the mean value of 5.0. Chart 4.45 (Table 7.51, Appendix D) shows the full responses for a sample size of 400.

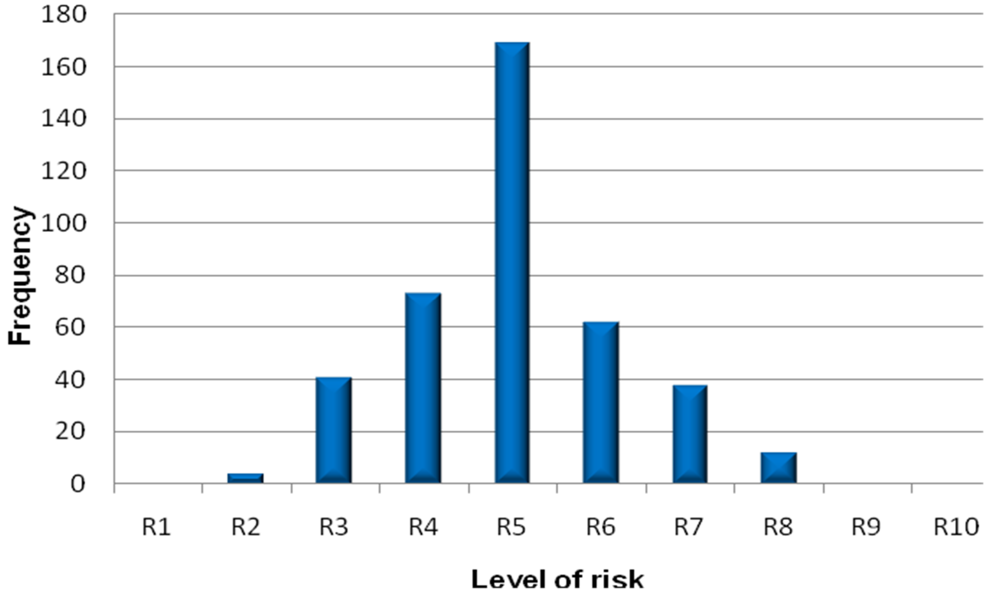


Chart 4.45: Level of risk to the ladder user –question 16

4.3.10 Level of risk to the ladder user – ref. question 17

The highest frequency of responses was 173 (43.4%), rating the level of risk as 2. The data has a range of 7 with a minimum score of 1 and a maximum of 8. 92.2% of scores were within one standard deviation (1.15) of the mean value of 2.0. Chart 4.46 (Table 7.52, Appendix D) shows the full responses for a sample size of 399.

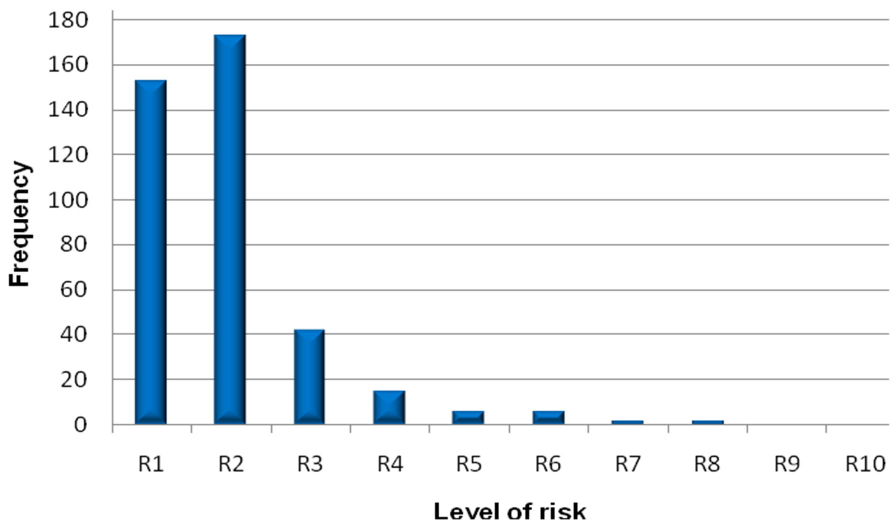


Chart 4.46: Level of risk to the ladder user – question 17

4.3.11 Level of risk to the ladder user – ref. question 18

The highest frequency of responses was 191 (48%), rating the level of risk as 9. The data has a range of 9 with a minimum score of 1 and a maximum of 10. 91% of scores were within one standard deviation (1.26) of the mean value of 8.9. Chart 4.47 (Table 7.53, Appendix D) shows show the full responses for a sample size of 398.

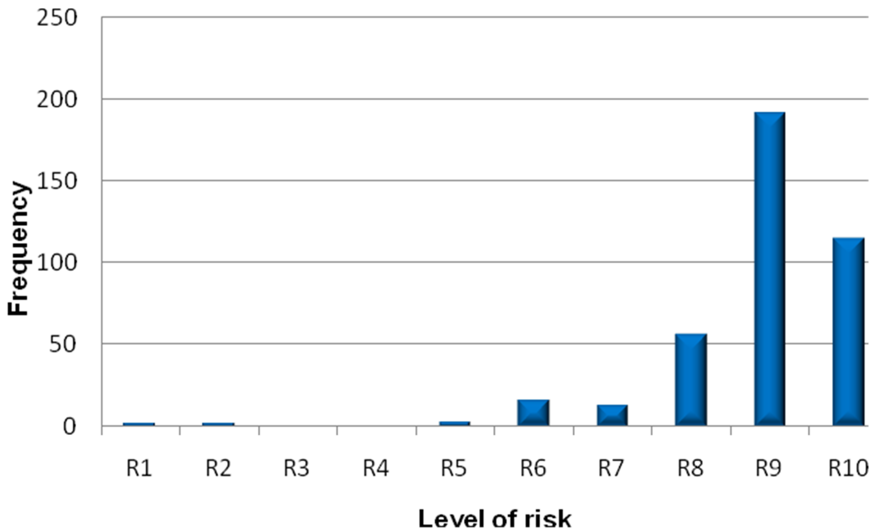


Chart 4.47: Level of risk to the ladder user – question 18

4.3.12 Level of risk to the ladder user – ref. question 19

The highest frequency of responses was 138 (34.8%), rating the level of risk as 6. The data has a range of 8 with a minimum score of 2 and a maximum of 10. 53.9% of scores were within one standard deviation (1.36) of the mean value of 6.4. Chart 4.48 (Table 7.54, Appendix D) shows the full responses for a sample size of 397.

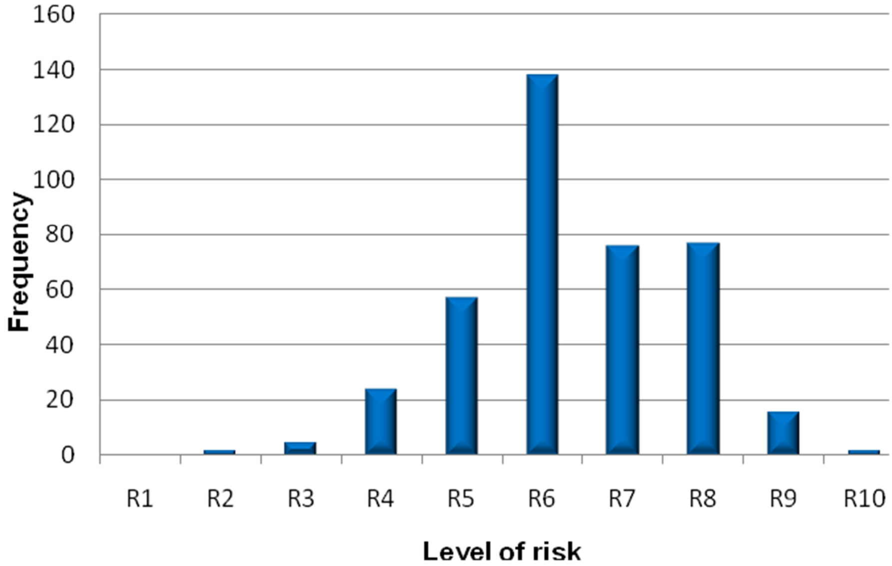


Chart 4.48: Level of risk to the ladder user – question 19

4.3.13 Level of risk to the ladder user – ref. question 20

The highest frequency of responses was 208 (52%), rating the level of risk as 2. The data has a range of 8 with a minimum score of 1 and a maximum of 9. 67.5% of scores were within one standard deviation (1.33) of the mean value of 2.6. Chart 4.49 (Table 7.55, Appendix D) shows the full responses for a sample size of 400.

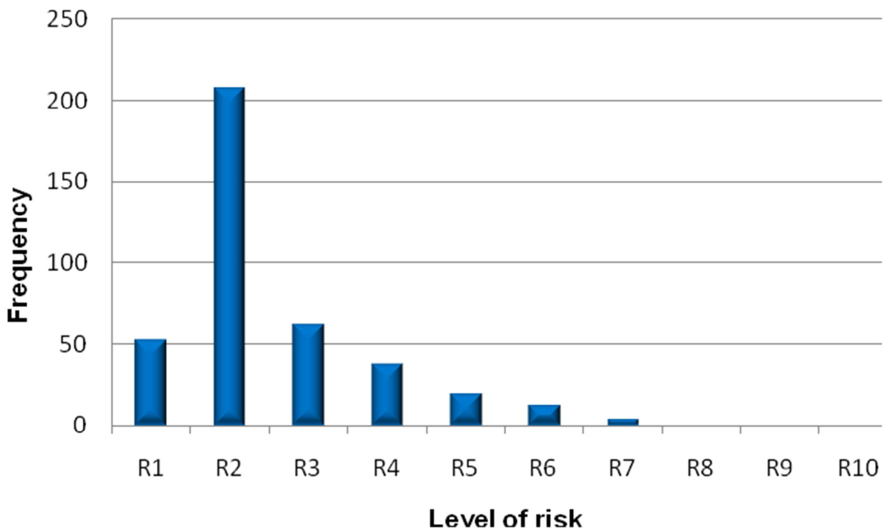


Chart 4.49: Level of risk to the ladder user – question 20

4.3.14 Level of risk to the ladder user – ref. question 21

The highest frequency of responses was 168 (42.1%), rating the level of risk as 5. The data has a range of 7 with a minimum score of 2 and a maximum of 9. 74.7% of scores were within one standard deviation (1.02) of the mean value of 5.5. Chart 4.50 (Table 7.56, Appendix D) shows the full responses for a sample size of 399.

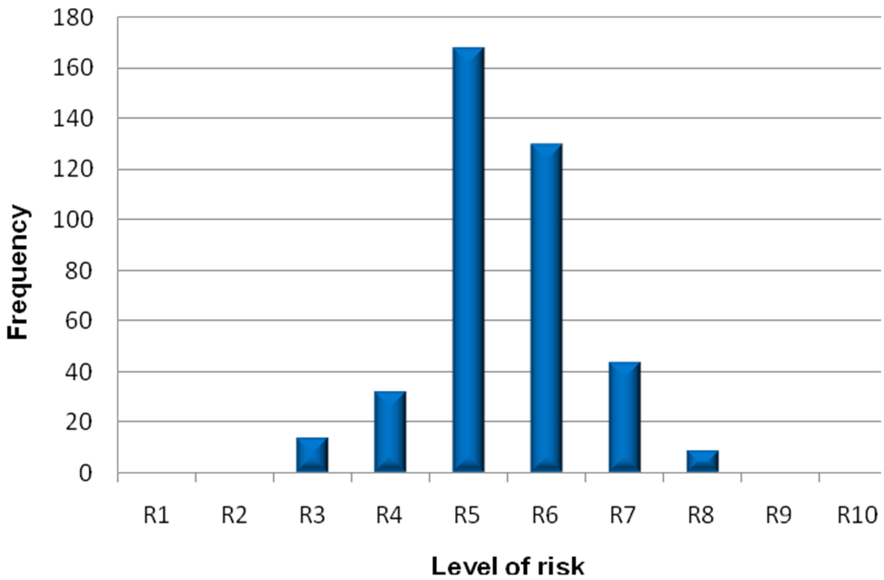


Chart 4.50: Level of risk to the ladder user – question 21

4.3.15 Level of risk to the ladder user – ref. question 22

The highest frequency of responses was 113 (28.7%), rating the level of risk as 4. The data has a range of 9 with a minimum score of 1 and a maximum of 10. 73.4% of scores were within one standard deviation (1.94) of the mean value of 5.3. Chart 4.51(Table 7.57, Appendix D) shows the full responses for a sample size of 394.

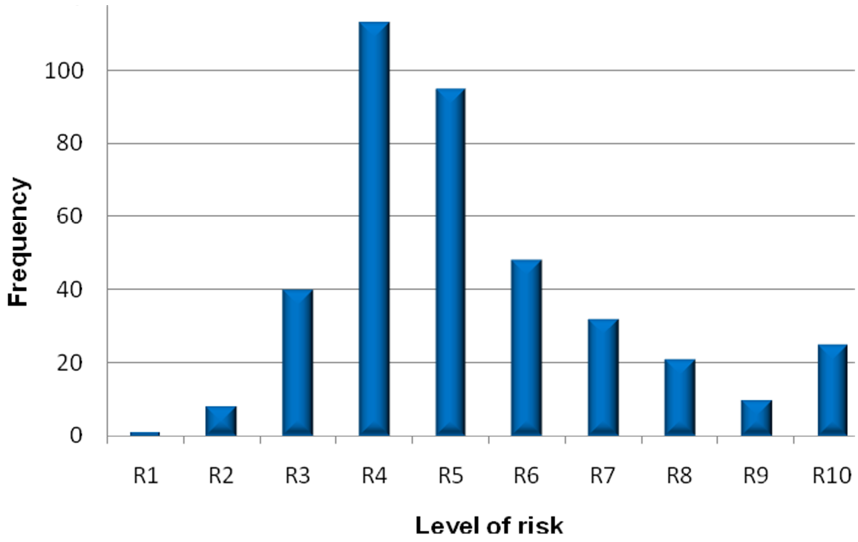


Chart 4.51: Level of risk to the ladder user – question 22

4.3.16 Level of risk to the ladder user – ref. question 23

The highest frequency of responses was 158 (39.6%), rating the level of risk as 3. The data has a range of 7 with a minimum score of 1 and a maximum of 8. 56.6% of scores were within one standard deviation (1.31) of the mean value of 3.6. Chart 4.52 (Table 7.58, Appendix D) shows the full responses for a sample size of 399.

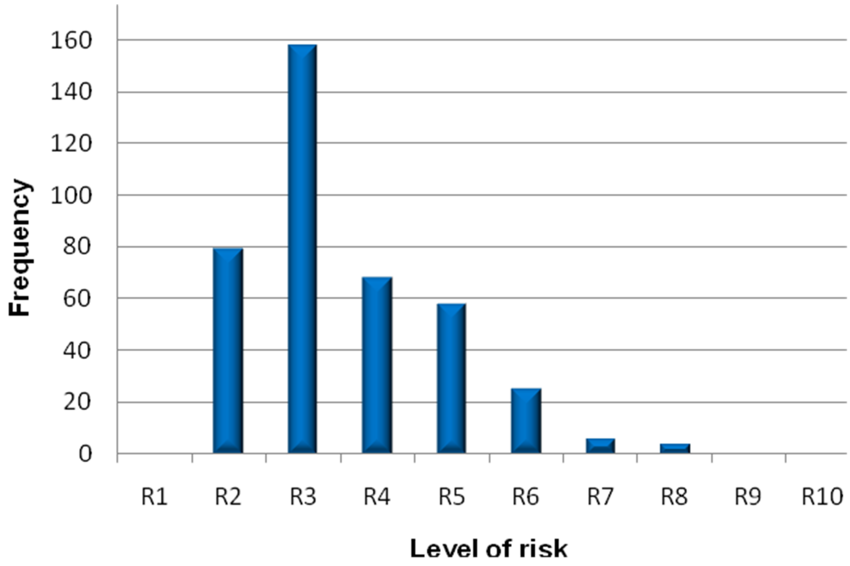


Chart 4.52: Level of risk to the ladder user – question 23

4.3.17 Level of risk to the ladder user – ref. question 24

The highest frequency of responses was 131 (32.8%), rating the level of risk as 6. The data has a range of 7 with a minimum score of 1 and a maximum of 8. 79.7% of scores were within one standard deviation (1.32) of the mean value of 5.7. Chart 4.53 (Table 7.59, Appendix D) shows the full responses for a sample size of 399.

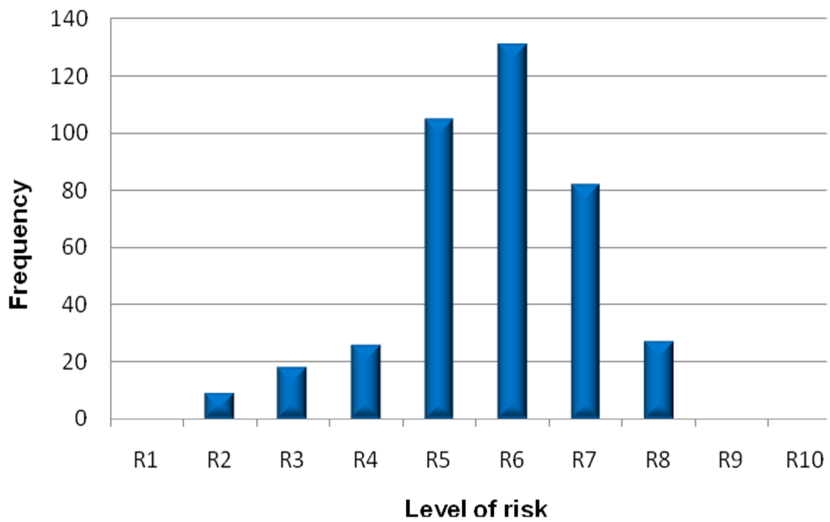


Chart 4.53: Level of risk to the ladder user- question 24

4.3.18 Level of risk to the ladder user – ref. question 25

The highest frequency of responses was 191 (47.9%), rating the level of risk as 2. The data has a range of 7 with a minimum score of 1 and a maximum of 8. 89.7% of scores were within one standard deviation (1.22) of the mean value of 2.1. Chart 4.54 (Table 7.60, Appendix D) shows the full responses for a sample size of 399.

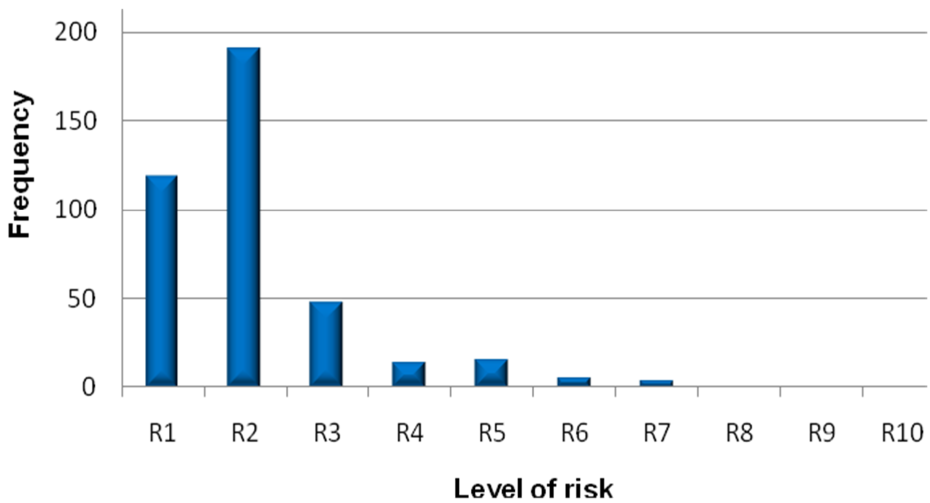


Chart 4.54: Level of risk to the ladder user - image 25

4.3.19 Level of risk to the ladder user – ref. question 26

The highest frequency of responses was 146 (36.5%), rating the level of risk as 5. The data has a range of 6 with a minimum score of 2 and a maximum of 8. 58% of scores were within one standard deviation (1.15) of the mean value of 5.4. Chart 4.55 (Table 7.61, Appendix D) shows the full responses for a sample size of 400.

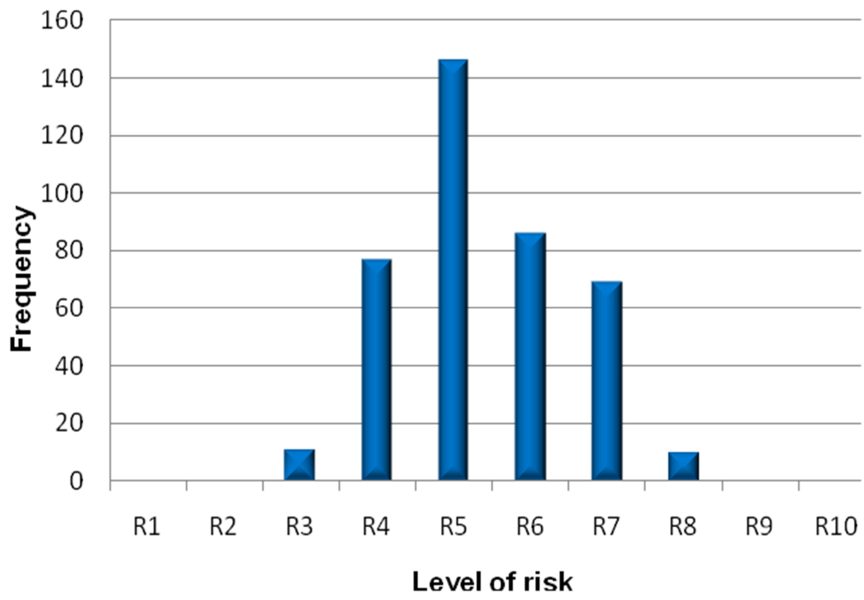


Chart 4.55: Level of risk to the ladder user - question 26

4.3.20 Level of risk to the ladder user

Respondents studied a series of images consisting of actual ladder-use situations, including a mixture of leaning ladders and step ladders, for both high (above 2 metres) and low (below 2 metres) level falls. They rated the level of risk (the chance of the user having an accident) involved in each case, with a number between 1 (low risk) and 10 (high risk). A full range of datum scores from 1 to 10 was not used due to limitations in available images, and was not considered necessary to obtain valid responses for the research. The scores were obtained from the author and two experts who agreed to provide risk ratings for the purpose of the research.

Table 4.1 provides the results for the risk rating scores. The risk 'datum' score (Table 3.5) was used to determine the difference with the respondents mean score for each item, observed as either higher or lower than the datum score. The range of responses for the risk ratings were spread with some respondents rating an item as 1 (low risk) and others rating the same item as 10 (high risk). There were no items with a range closer than six, and there was generally a wide range of responses for all items. All of the high-level fall images were over-estimated, by an average risk rating of 2.05 from the datum, and all of the low-level images were underestimated by an average risk rating of 3.69 from the datum score (Table 4.1).

Risk image	Risk rating scores					
	Height of fall	Range	Datum score	Mean score	Difference	Risk Level
8	High	3 - 9	3	5.80	+ 2.80	Over
9	Low	1 - 6	7	1.95	- 5.05	Under
10	High	1 - 10	5	5.45	+ 0.45	Over
11	High	4 - 10	5	8.74	+ 3.74	Over
12	Low	1 - 10	5	2.06	- 2.94	Under
13	High	1 - 10	5	7.79	+ 2.79	Over
14	High	2 - 9	4	5.93	+ 1.93	Over
15	Low	2 - 10	10	5.94	- 4.06	Under
16	High	2 - 9	4	5.03	+ 1.03	Over
17	Low	1 - 8	5	1.96	- 3.04	Under
18	High	1 - 10	5	8.86	+ 3.86	Over
19	High	2 - 10	5	6.40	+ 1.40	Over
20	Low	1 - 9	6	2.57	- 3.43	Under
21	High	2 - 9	5	5.47	+ 0.47	Over
22	Low	1 - 10	10	5.30	- 4.70	Under
23	Low	1 - 8	7	3.56	- 3.44	Under
24	High	1 - 8	3	5.71	+ 2.71	Over
25	Low	1 - 8	5	2.14	- 2.86	Under
26	High	2 - 8	4	5.38	+ 1.38	Over

Table 4.1: Risk rating scores

4.3.21 Risk rating by age of respondents

The risk rating images were grouped into high-level and low-level falls to enable analysis to take into account the datum risk rating scores for each work level. The respondents mean scores were then compared with the datum mean score from each height level.

All age groups under-estimated the risk from low-level ladder use situations, chart 4.56 (Table 7.62 Appendix D). The difference in mean scores between the age groups was relatively small and generally reduced as age increased. The greatest difference from the datum score was the under 20 age group who underestimated the low level ladder use situations by a mean difference of four points, and the smallest difference was from the 50-59 age group who underestimated by an average of two points.

All age groups also over-estimated the risk from high-level ladder use situations. The difference in mean scores between the age groups was approximately the same with the exception of the 40-49 age group who over-estimated by a mean of over five points from the datum.

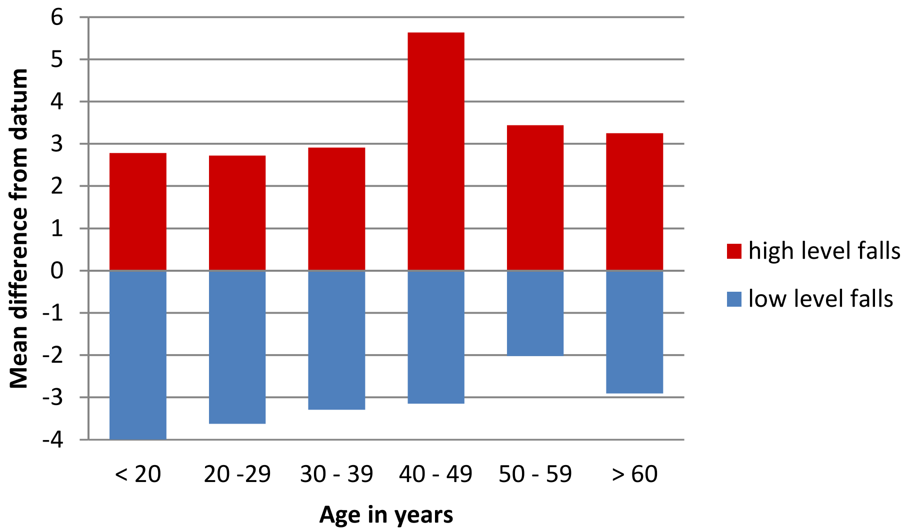


Chart 4.56: Mean difference from datum for age in years

4.3.22 Risk rating by experience of respondents

The difference in scores for respondents working with ladders was very similar with all categories under-estimating the risk from low-level ladder use situations by about two points. In contrast to the scores grouped by age, ladders users with more than ten years experience showed a marginal increase in mean scores, chart 4.57 (Table 7.63 Appendix D). The high-level ladder use situations were all over-estimated by between three and four points for users with under 15 years experience, with those over 15 years scoring slightly better at just over two points difference.

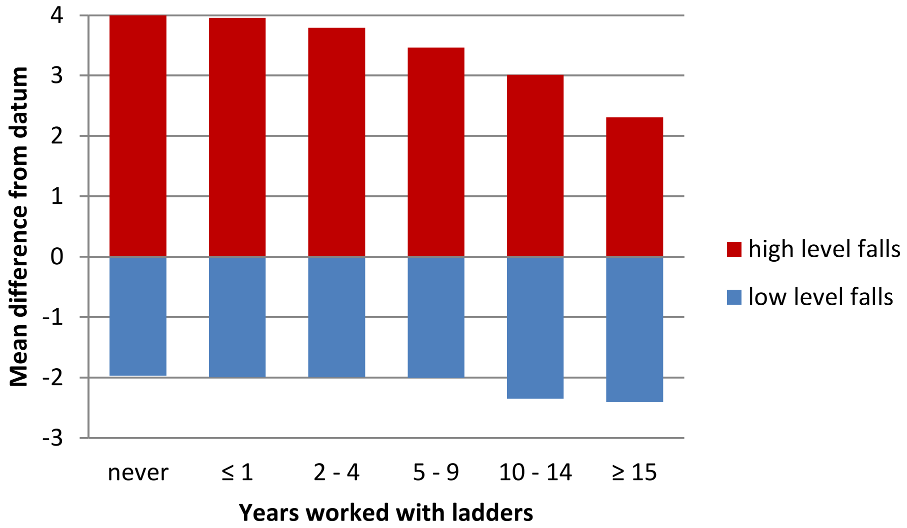


Chart 4.57: Mean difference from datum for years worked with ladders

4.3.23 Risk rating by qualifications of respondents

The difference in mean scores between the qualification categories was very small and only marginally reduced for those holding any health and safety qualifications. The low-level ladder use situations were under-estimated by a mean difference of between three and four points, and the high-level ladder use situations over-estimated by approximately two points from the datum, chart 4.58. (Table 7.64 Appendix D).

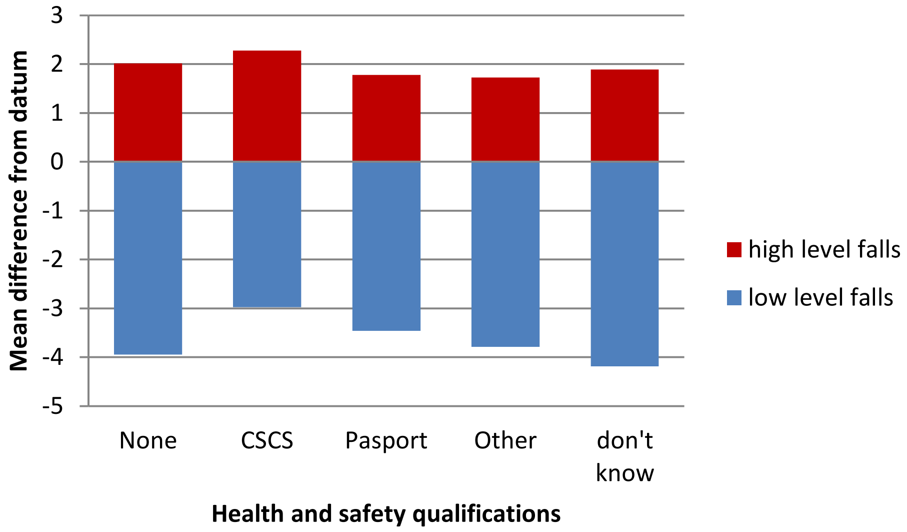


Chart 4.58: Mean difference from datum for qualifications

4.3.24 Risk rating by training and use of written information

The mean scores for respondents who had received practical training or written information on how to work safely from a ladder, were very similar to those who had not received training or information. Both categories underestimated the low-level situations by two points, and overestimated the high-level ladder use situations by between three four points, charts 4.59 and 4.60 (Tables 7.65 and 7.66, Appendix D).

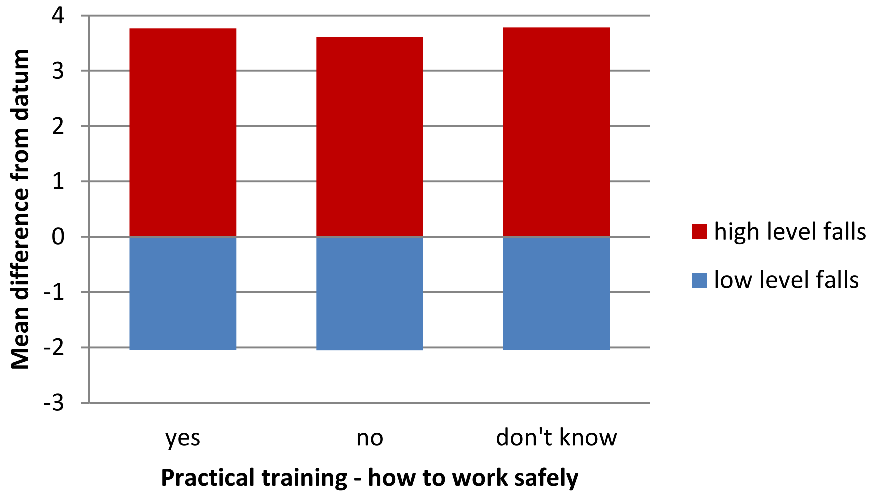


Chart 4.59: Mean difference from datum for practical training

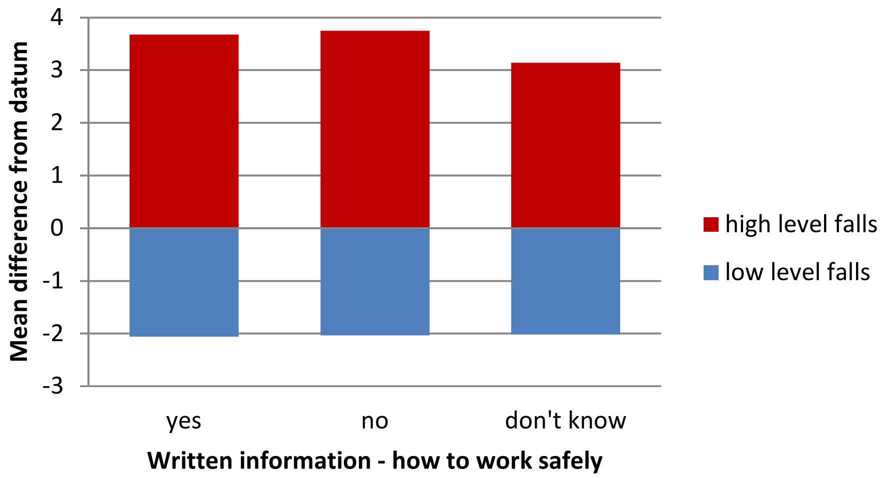


Chart 4.60: Mean difference from datum for written information

4.3.25 Risk rating by work type, occupation and company size

The categories of *work type*, *occupation* and *company size* have been linked together within the analysis. All categories (with the exception of plasterers) over-estimated the risk from high-level ladder use situations by a mean of between three and four points from the datum, and underestimated the low-level ladder use situation by a mean of two points from the datum, charts 4.61, 4.62 and 4.63 (Tables 7.67, 7.68a, 68b, and 7.69 Appendix D).

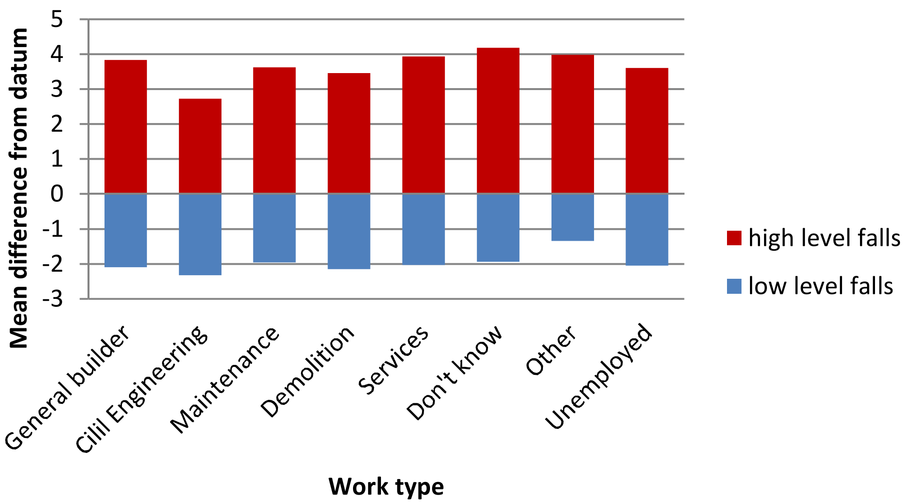


Chart 4.61: Mean difference from datum for work type

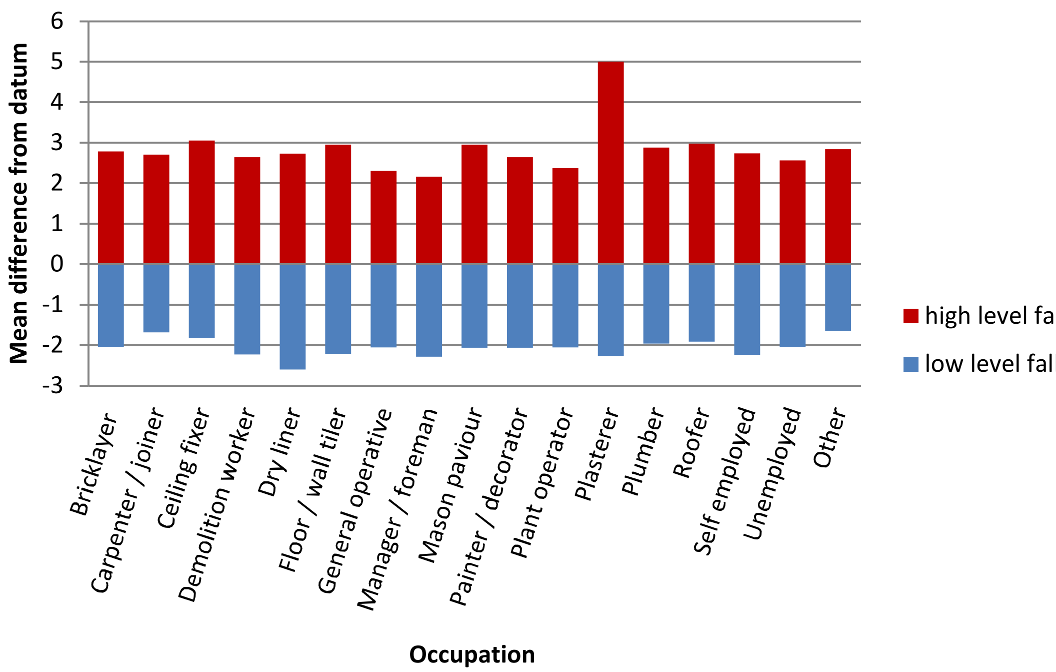


Chart 4.62: Mean difference from datum for occupation

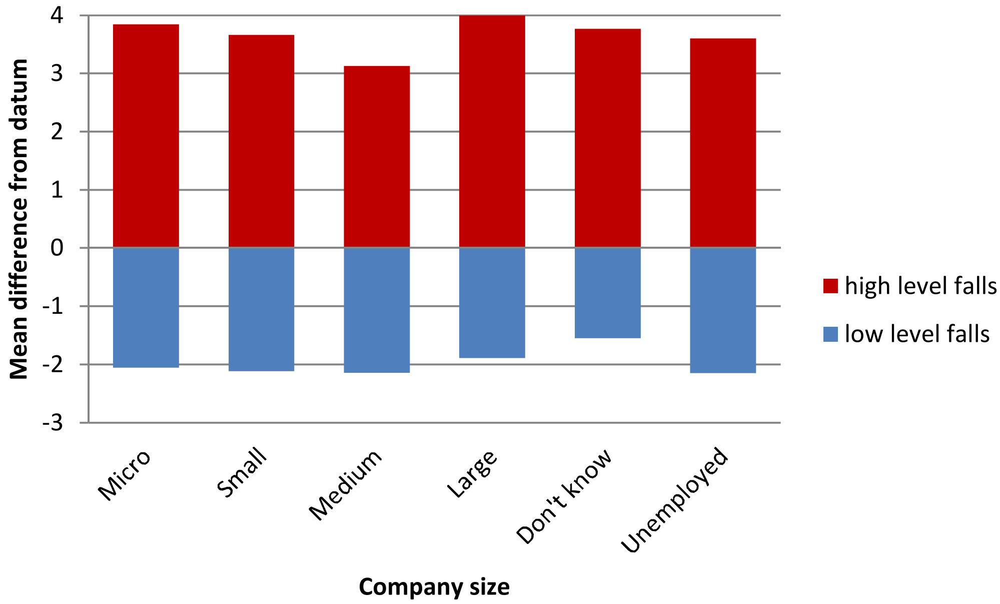


Chart 4.63: Mean difference from datum for company size

4.4 Sensation seeking survey

This section presents the results from items contained within the sensation seeking survey which preceded the administration of the training aid. The respondent's scores have been grouped into four categories to aid clarity.

A total of 320 (80.0%) respondents scored between 21 and 30, and 71 (17.8%) scored between 11 and 20. The data has a range of 23 with a minimum score of 10 and a maximum of 33. The mean sensation seeking score was 23.9 and standard deviation 3.65. Chart 4.64 shows the full responses for a sample size of 400.

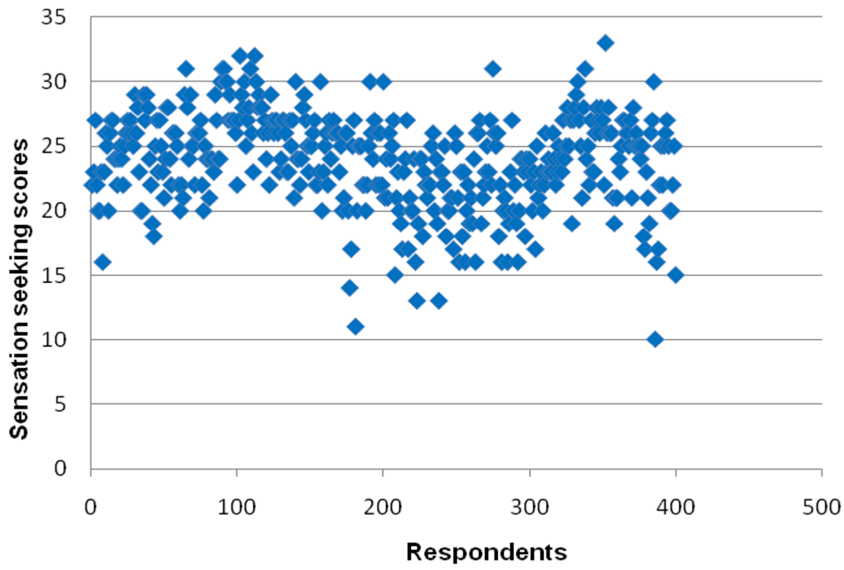
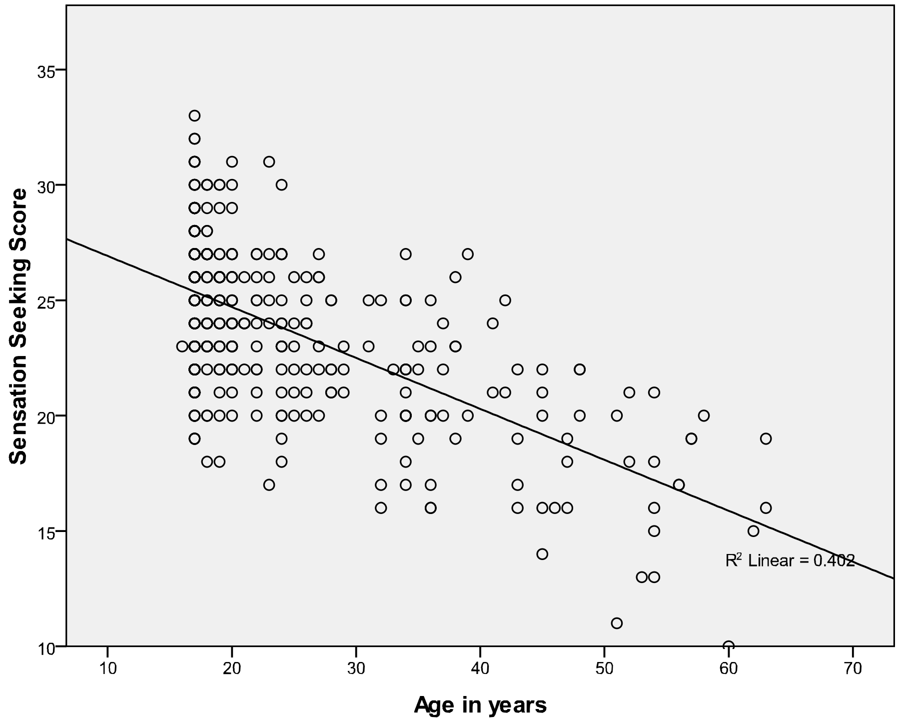


Chart 4.64: Sensation seeking scores

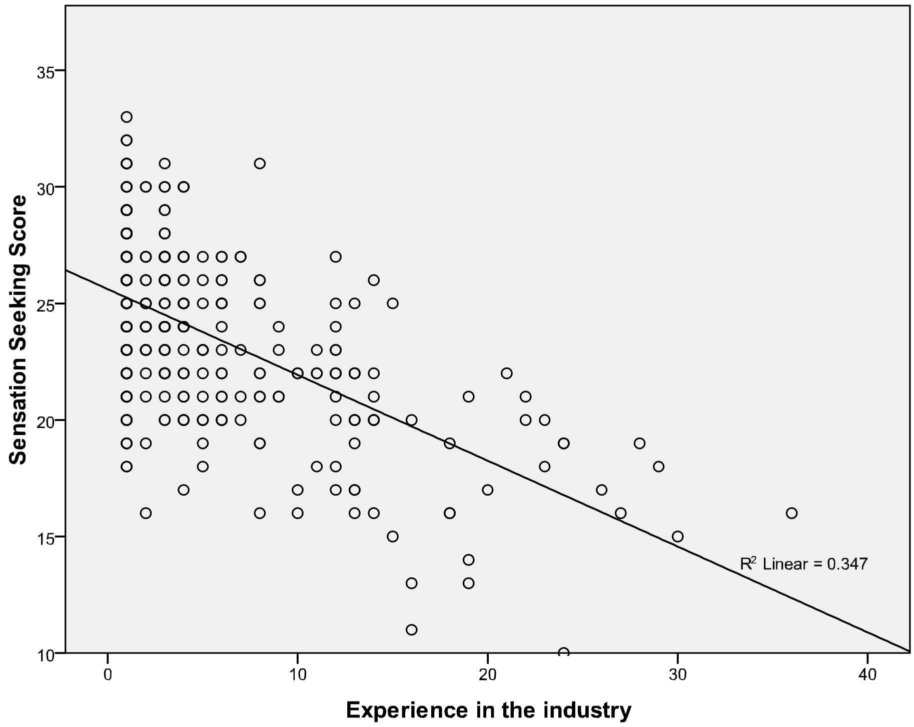
Regression analysis using predictive analytics software was used to test for a correlation between sensation seeking score and age, with sensation seeking being the dependent variable (Chart 4.65). The p-value for the slope coefficient was 0.001, therefore the null hypothesis that there is no relationship between sensation seeking score and age was rejected, and the experimental hypothesis that there is a relationship was accepted.



The slope coefficient for the independent variable is negative 0.221 and the regression R-square accounts for 0.402 (40%) variation in the data. The p-value for the slope coefficient was 0.001.

Chart 4.65: Sensation seeking scores - age relationship

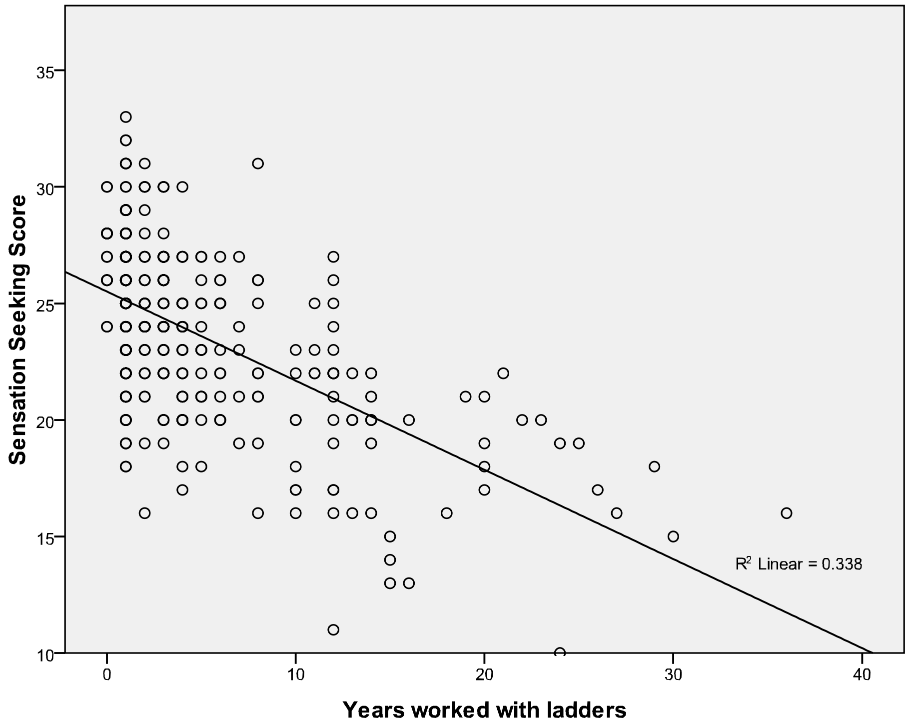
Regression analysis was also carried out to test for correlation between sensation seeking and years experience in the construction industry, with sensation seeking being the dependent variable (Chart 4.66). The p-value for the slope coefficient was 0.001, therefore the null hypothesis was rejected, and the experimental hypothesis that there is a relationship was accepted.



The slope coefficient for the independent variable is negative 0.368. The regression R-square accounts for 0.347 (35%) variation in the data. The p-value for the slope coefficient was 0.001.

Chart 4.66: Sensation seeking scores - years experience in the construction industry

Similarly regression analysis was also used to test for correlation between sensation seeking and years worked with ladders with sensation seeking being the dependant variable (Chart 4.67). The p-value for the slope coefficient was 0.001, therefore the null hypothesis was rejected, and the experimental hypothesis that there is a relationship between the sensation seeking scores and working with ladders was accepted.



The slope coefficient for the independent variable is negative 0.382. The regression R-square accounts for 0.338 (34%) variation in the data. The p-value for the slope coefficient was 0.001.

Chart 4.67: Sensation seeking scores - years worked with ladders

4.5 Risk perception survey

Sections 4.5.1 to 4.5.6 present the results from items contained within the risk perception survey which followed the administration of the training aid.

4.5.1 Level of risk to the ladder user – ref. question 1

The highest frequency of responses was 109 (27.4%), rating the level of risk as 2. The data has a range of 9 with a minimum score of 1 and a maximum of 10. 94.5% of scores were within one standard deviation (1.54) of the mean value of 3.0, chart 4.68 (Table 7.70, Appendix D) shows the full responses for a sample size of 399.

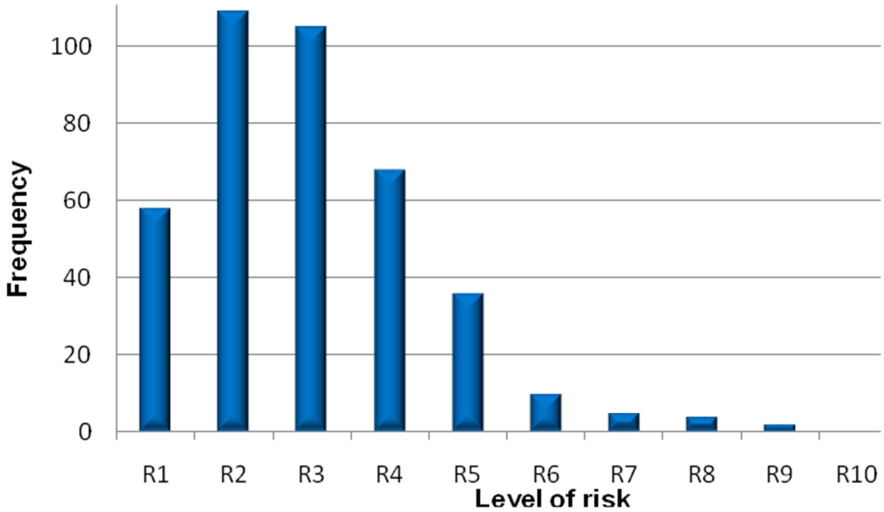


Chart 4.68: Level of risk to the ladder user – question 1

4.5.2 Level of risk to the ladder user – ref. Question 2

The highest frequency of responses was 166 (41.8%), rating the level of risk as 9. The data has a range of 9 with a minimum score of 1 and a maximum of 10. 70.9% of scores were within one standard deviation (1.61) of the mean value of 8.4. Chart 4.69 (Table 7.71, Appendix D) shows the full responses for a sample size of 397.

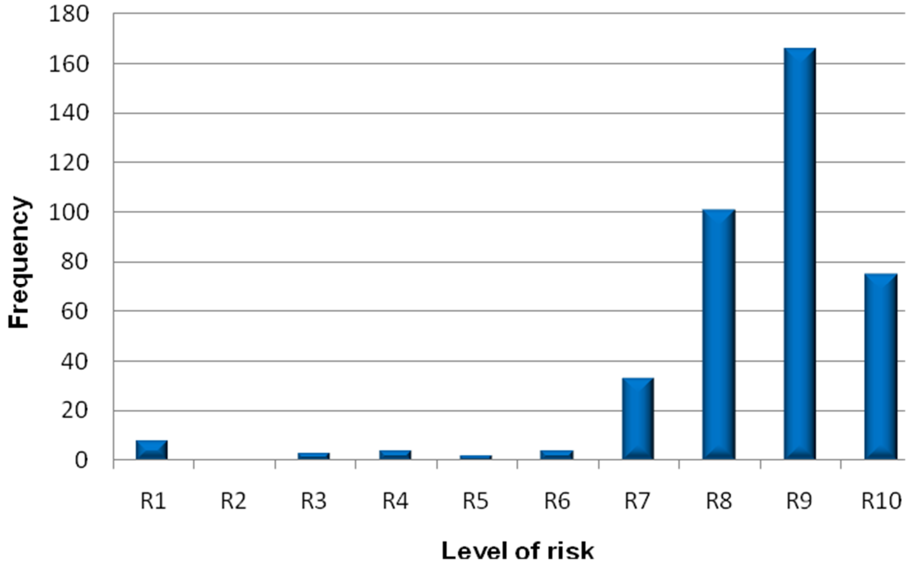


Chart 4.69: Level of risk to the ladder user – question 2

4.5.3 Level of risk to the ladder user – ref. Question 3

The highest frequency of responses was 74 (18.6%), rating the level of risk as 4. The data has a range of 9 with a minimum score of 1 and a maximum of 10. 67.5% of scores were within one standard deviation (1.90) of the mean value of 4.5. Chart 4.70 (Table 7.72, Appendix D) shows the full responses for a sample size of 397.

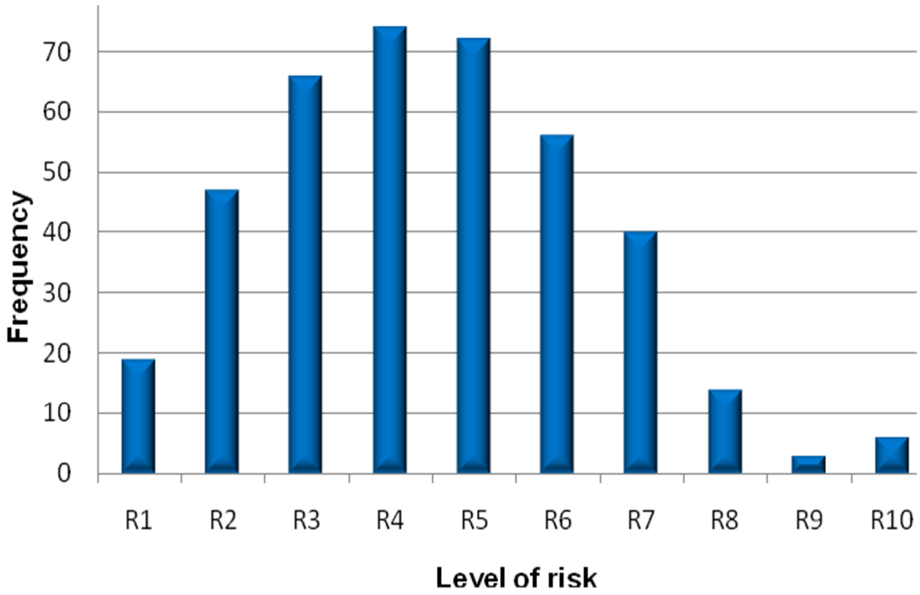


Chart 4.70: Level of risk to the ladder user – question 3

4.5.4 Level of risk to the ladder user – ref. Question 4

The highest frequency of responses was 171 (43.0%), rating the level of risk as 9. The data has a range of 9 with a minimum score of 1 and a maximum of 10. 91.7% of scores were within one standard deviation (1.22) of the mean value of 9.0. Chart 4.71 (Table 7.72, Appendix D) shows the full responses for a sample size of 398.

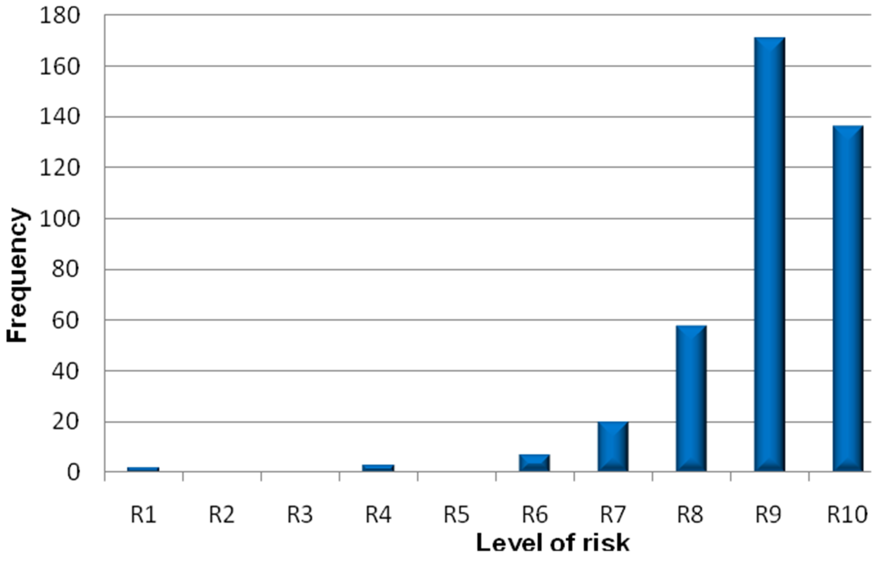


Chart 4.71: Level of risk to the ladder user – question 4

4.5.5 Level of risk to the ladder user – ref. Question 5

The highest frequency of responses was 77 (19.2%), rating the level of risk as 4. The data has a range of 9 with a minimum score of 1 and a maximum of 10. 69% of scores were within one standard deviation (1.97) of the mean value of 4.7. Chart 4.72 (Table 7.74, Appendix D) shows show the full responses for a sample size of 400.

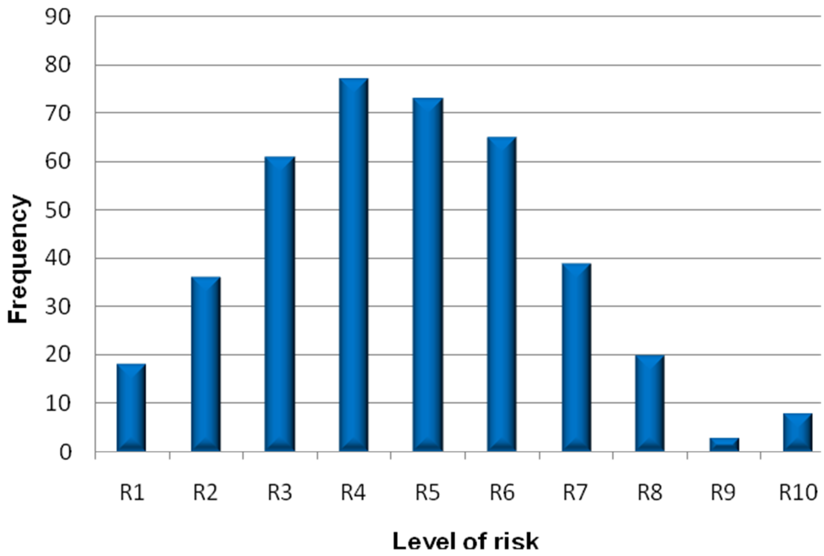
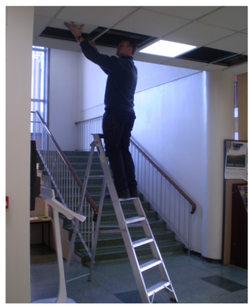


Chart 4.72: Level of risk to the ladder user – question 5

4.5.6 Level of risk to the ladder user – ref. question 6



The highest frequency of responses was 176 (44.4%), rating the level of risk as 9. The data has a range of 9 with a minimum score of 1 and a maximum of 10. 67.4% of scores were within one standard deviation (1.40) of the mean value of 6.4. Chart 4.73 (Table 7.75, Appendix D) shows show the full responses for a sample size of 396.

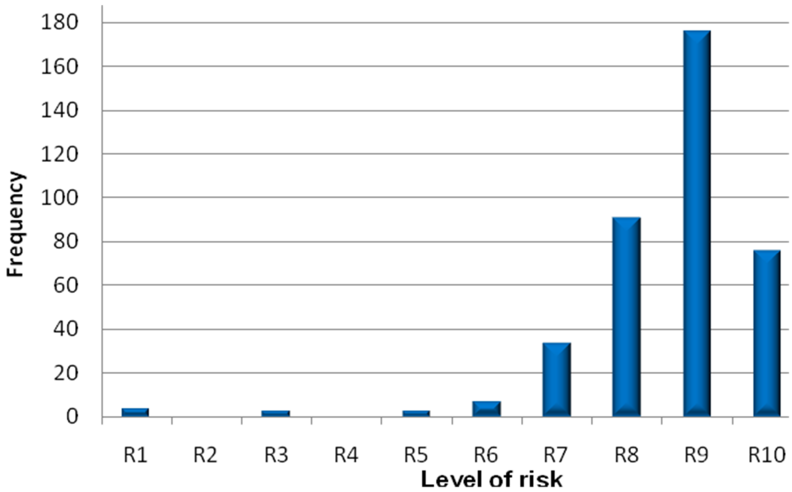


Chart 4.73: Level of risk to the ladder user – question 6

4.5.7 Change in risk perception

The risk perception survey was designed to measure any change in a participants risk perception following the use of the training aid. The survey consisted of a range of six portable ladder-use images selected from the ladder-use survey that the respondents had already completed. The images were selected to include three 'high-level' ladder use situations (items 13, 16, & 19), and three 'low-level' ladder use situations (items 20, 22 & 23). The pre-training aid results (Table 4.2) taken from the ladder-use questionnaire were compared with the post-training aid results taken from the risk perception survey (Table 4.3) to determine any change in the level of risk perception. Some respondents rated an item as 1 (low risk) and others rated the same item as 10 (high risk), resulting in a wide range of scores for all six items in both surveys.

Risk image	Ladder use results						
	Height of fall	Range		Datum score	Mean score	Difference	Level of risk
13	High	1	10	5	7.79	+ 2.79	Over
16	High	2	9	4	5.03	+ 1.03	Over
19	High	2	10	5	6.40	+ 1.40	Over
20	Low	1	9	6	2.57	- 3.43	Under
22	Low	1	10	10	5.30	- 4.70	Under
23	Low	1	10	8	3.56	- 3.44	Under

Table 4.2: Ladder-use survey results (Pre-training aid)

Risk image	Risk perception results						
	Height of fall	Range		Datum score	Mean score	Difference	Level of risk
13	High	1	10	5	3.01	- 1.99	Under
16	High	1	10	4	4.69	+ 0.69	Over
19	High	1	10	5	4.49	- 0.51	Under
20	Low	1	10	6	8.44	+ 2.44	Over
22	Low	1	10	10	8.95	- 1.05	Under
23	Low	1	10	8	8.55	+ 0.55	Over

Table 4.3: Risk perception survey results (Post-training aid)

The mean score, and risk rating difference from the datum score, highlighted the total mean change in the level of risk perception between pre and post training results for each item as:

- Image 13 - (high-level fall, datum score of 5) changed from a mean over-estimation of 7.79 to a mean under-estimation of 3.01, representing a total mean change of 4.78.

- Image 16 - (high-level fall, datum score of 4) changed from a mean over-estimation of 5.03 to a mean over-estimation of 4.69, representing a total mean change of 0.34.

- Image 19 - (high-level fall, datum score of 5) changed from a mean over-estimation of 6.40 to a mean under-estimation of 4.49, representing a total mean change of 1.91.

- Image 20 - (low-level fall, datum score of 6) changed from a mean under-estimation of 2.57 to a mean over-estimation of 8.44, representing a total mean change of 5.87.

- Image 22 - (low-level fall, datum score of 10) changed from a mean under-estimation of 5.30to a mean under-estimation of 8.95, representing a total mean change of 3.65.

- Image 23 - (low-level fall, datum score of 8) changed from a mean under-estimation of 3.56 to a mean over-estimation of 8.55, representing a total mean change of 4.99.

Collectively the mean post-training scores for the high-level images (13, 16, & 19) were lower by an average risk rating of 2.34, and the mean post-training scores for the low-level images (20, 22 & 23) were higher by an average of 4.84. The risk rating difference from the datum score changed from a pre-training mean over-estimation of 1.74 for high-level falls, to a post-training underestimation of 0.4, (21% difference), and from a pre-training underestimation of 3.86 for low-level falls to a post-training overestimation of 0.65 (45% difference).

To test the relationship between the risk-images (pre-training) and risk-images (post- training) a paired sample *t*-test (within participants design) was carried out using predictive analytic software to analyse the data (Table 4.4). The dependent variable was measured on an interval scale (self-report scores) that were independent of each other, and were not influenced by other respondent's scores, and the numbers were normally distributed and did not have any major extremes. The null hypothesis used was that 'there is no difference between the pre and post training risk rating scores', and the experimental hypothesis was that 'there is a difference between the pre and post training risk rating scores'.

	Risk		Paired differences							
Pair	Risk image	Rank image	Mean	Std. Deviation	Std. Error Mean	95% CI diff Lower	95% CI diff Upper	t	df	Sig. (2-tail)
1	13	13	4.783	2.122	0.107	4.572	4.994	44.629	391	0.000
2	16	16	0.337	2.365	0.118	0.105	0.570	2.854	399	0.005
3	19	19	1.898	2.416	0.122	1.659	2.138	15.598	393	0.000

4	20	20	-5.864	2.089	0.105	-6.070	-5.658	-55.922	396	0.000
5	22	22	-3.640	2.324	0.117	-3.871	-3.410	-31.009	391	0.000
6	23	23	-4.985	1.942	0.098	-5.177	-4.793	-51.015	394	0.000

Table 4.4: Paired samples t-test between risk and rank images

The p-values for the six paired scores within the *t*-test did not exceed the alpha 0.05 (5%) significance level (probability of 5 in 1,000 that the result would be by chance alone) showing that the mean difference between pre and post training was significantly different. The null hypothesis was therefore rejected in favour of the experimental hypothesis that there is a difference between pre and post risk perception.

4.6 Chapter summary

This chapter presented the results and analysis of the ladder-use survey, the sensation seeking survey and the risk perception survey. Outputs for each item of the ladder-use and risk perception surveys were presented separately, using histogram charts to show the number of responses in each particular category. Results for the sensation seeking survey were grouped and presented using a scatter diagram to aid clarity.

The analysis focussed on the results taken from the ladder-use and sensation seeking surveys carried out before the administering of the training aid, and the risk perception survey carried out after the use of the training aid. The analysis showed that there is a relationship between a respondent's age, experience and their awareness of agents involved with falls from height, such as ladders and scaffolding, and that as age increases awareness of accidents attributed to working at height also increases. Analysis of sensation seeking recognized as a trait having an influence on risk taking behaviour agreed with the previous research, that experienced participants are less likely to engage in risk taking behaviour, and inexperienced young participants, under 20 years of age are more likely to engage in risk taking behaviour. Respondents generally over-estimated the risk from high-level ladder use situations and under-estimated the risk from low-level ladder use situations. Analysis of the risk perception of respondents identified that they had a greater risk perception of working at height for both high-level and low-level situations following the use of a height awareness training aid, establishing that there was a difference between pre-training and post-training risk perception. Design and use of the training aid have been presented in chapter 5 and discussion of the results has been presented in chapter 6.

Chapter 5 Training-aid

5.1 Introduction

It is clear from the research of Lester (2006) that visual communication is an effective means of communicating health and safety information to individuals, as it has greater power than the written word to inform and educate. People learn most effectively through visual means as images are more evocative than words and have the advantage over textual content in that they focus attention (JISC, 2011). By absorbing information in a format that makes sense e.g. a hazard image; individuals increase their understanding of risk concepts, which affects their risk perception, and subsequently their work behaviour (Timmermans, 2005).

In order to gain maximum impact from the training aid, it was considered necessary to use visual communication techniques via the production of a visual learning tool. The tool could take advantage of the effectiveness of the visual medium by using a mixture of different types of images and graphics comprising ladder use photographs and accident scenarios. A further advantage of a visual tool is that it is especially appropriate to meet the needs of a diverse construction workforce, as images can be used effectively as substitutes for words and would be suitable for low educational achievers and operatives with poor English communication skills (Peters, and Katalytik, 2011).

The original concept for the training aid was derived from general health and safety posters depicting hazardous situations and containing messages designed to raise risk awareness. The layout style, format and content of the training-aid were developed from a culmination of good features and elements taken from a large number of general e-learning packages. The training aid was also developed to follow established learning conventions in terms of content and timing as described in the following sections.

The training-aid is a computer based electronic learning (e-learning) resource that uses images, audio and video clips to enhance and reinforce the learning experience by interactive engagement (Hake, 1998). It was designed and developed by the author with the aim of raising the risk awareness of portable ladder users within the construction sector; however it is suitable for use in any work sector and can be customised as required.

The aid focuses on reinforcing the message that working below head height can be high risk, and that users need to be height aware if to avoid accidents and injuries. It is an interactive and engaging resource that can be accessed multiple times, allowing the user flexibility to navigate back and forward, with a degree of self-pace to help their understanding. However it can also be customised to be used as part of a training presentation to an audience through the use of hand held voting technology (Betts and Kambouri, 2007).

The training-aid was designed specifically for this research and is a personal learning resource with no emphasis on checking achievement or progress. There is no means of tracking how often the sections are accessed, or how many times the resource is used, scores are not taken as it is not a test, and the numbers of tries are not recorded and therefore the user cannot fail. However following its application for the research it could be customised quite easily to record demographics and scores. The main focus of the training aid was to constantly reinforce the same learning message and thereby raise the users risk awareness without worrying about a test at the end, (Refer to Appendix E for a complete copy of the training-aid).

5.2 Format

The training aid was designed and produced using a PowerPoint presentation software program available as part of the Microsoft Office suite, running on Microsoft Windows or Apple's Mac OS X operating systems. The PowerPoint format was chosen as it is readily available and easy to use by anyone who has access to a computer. A PowerPoint viewer is installed by default with a Microsoft Office installation or a viewer file is available for download from the Microsoft Office Online Web site. The PowerPoint programme can also be made accessible as a webcast, which is a media file distributed over the Internet using streaming media technology although some of the functionality may be lost.

5.3 Design

The e-learning format was developed to provide convenience and flexibility to users, and to provide some interaction which was considered essential, especially for adult learners (Knowles, 1990). It was also necessary to use a format that the young could associate with as it is considered to be more exciting, educational and engaging than traditional forms of learning (Luskin, 2002). A requirement of the e-learning format is that it needed to transfer information effectively, within a limited time frame before the user 'switched-off'. An approximate fifteen minute target time for completion was therefore set which was slightly under the twenty minutes generally recommended, and the amount of material was adjusted accordingly taking into consideration the self-pace of the user. It was also considered necessary to change the title of the training-aid from risk perception to height awareness to avoid any confusion, misunderstanding or ambiguity for the users. The information style, layout, format and grammar were aimed at a reading age of 12 (Klare, 1963) to reflect the average reading age of the United Kingdom working population which would help to ensure that the message was understandable. The aid was designed to be used by all construction personnel, including operatives, supervisors, and managers, and would also be suitable for use in schools and colleges.

5.4 Content

The PowerPoint presentation consists of thirty two individual slides (pages) divided into seven sections, and accessed via a menu page (Figure 5.1). Eleven slides are devoted to general instruction and information that the user has a choice of accessing depending upon their experience or needs, e.g. the disclaimer section. The work at height section contains twenty one slides of specific height awareness information including case studies and questions.

Figure 5.1: Menu page

5.4.1 Images

Emphasis for the training aid was placed on the use of colourful ladder-use images (Figure 5.2), with the aim of adding reality to the content that could be recognised by the users, rather than using cartoon characters, clipart or humorous material, which may distract from the message. The images were chosen to reflect common everyday use of both leaning and step ladders, and were selected to provide clear examples of the risks associated with working at height. Some of the images were utilised from the HSE's Height Awareness Campaign (HSE, 2004) material to provide an additional context by showing typical accident scenarios caused by falling from height. They also provided a good link between the training-aid and further information that could be accessed by the user. The style and format of the images were the same as those used within the ladder-use surveys administered both prior to and following the training, to provide continuity and reduce any possible confusion by the respondents.

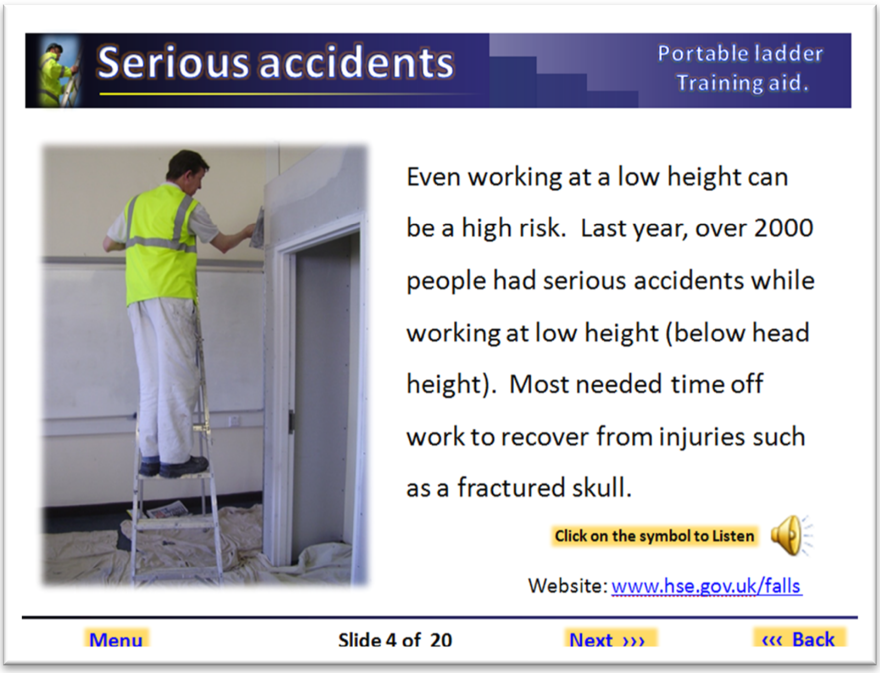


Figure 5.2: Example of ladder-use image

5.4.2 Case studies

Four basic case studies have been used towards the beginning of the training aid (slides 4, 6, 7 and 9), using three different formats to help focus the user's attention on the problem, maintain interest and to provide an element of interactivity. The first is an audio file which forms part of the interactive content described in section 5.4.4. The next two consist of images depicting accidents occurring from ladder use situations together with some basic written information describing the result of the accidents to the ladder user (Figure 5.3). The fourth uses a media video file also described in section 5.4.4.

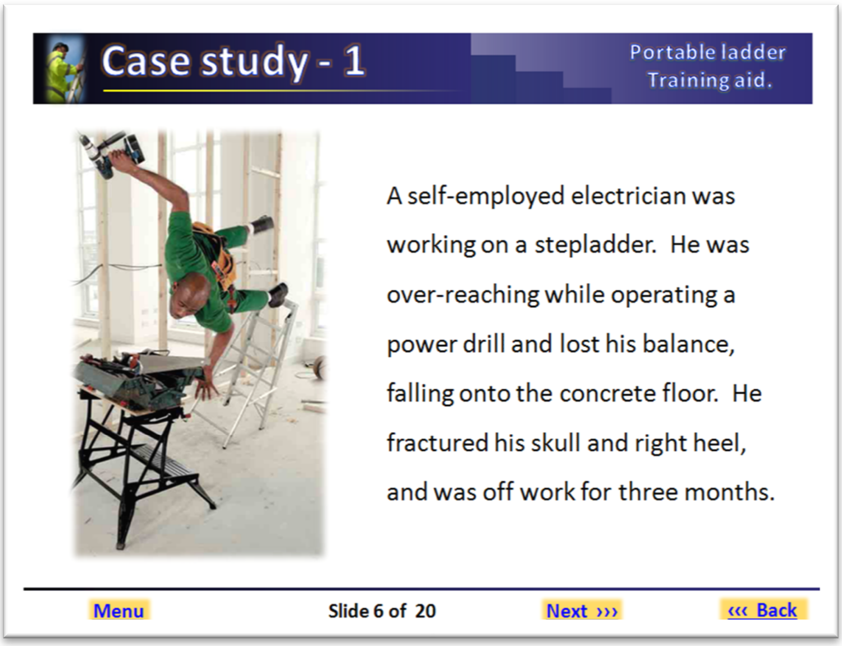


Figure 5.3: Example of case study slide

5.4.3 Interactive content

Slide number four contains a 40 second, 640 kilobyte (kb) embedded Moving Picture Experts Group (MPEG) audio layer 3 audio file, more commonly referred to as MP3, and slide number nine contains a 45 second, 519 kb embedded Windows Audio/Media Video file. The files were designed and produced as advertisements by the Health and Safety Executive as part of their height awareness campaign. The audio uses a case study of an operative who is injured falling from the second step of a ladder, and the video uses a case study of a builder who falls due to the incorrect selection of a ladder. Both emphasise the point that even low heights can be high risk. The files can be accessed by clicking onto hyperlinked audio or video icons when prompted during the presentation, and the user is informed that they can be played as many times as required before moving on. A built in function of the presentation prevents the user moving onto the next slide until the file has been played to ensure that it is not missed or ignored.

Slide numbers 4, 9 and 20 have some text (hypertext) that contains hyperlinks to the World Wide Web (www), enabling the user to leave the presentation to obtain further information from the Health and Safety Executives WebPages, (provided they have internet connection). They can browse the information from the WebPages for as long as necessary before returning to continue the presentation as the training-aid does not have a time-out function.

5.4.4 Questions

Four ladder use questions have been used towards the end of the training aid (slides 11, 13, 15 and 17) to allow the user to test their level of risk awareness. The first three questions require the user to select the correct option from a high and low ladder use situations (Figure 5.4). The fourth question uses the same format as the ladder use questionnaire whereby the user studies an image of a ladder use situation and rates the level of risk to the ladder user from a scale of 1 (low risk) to 10 (high risk) (Figure 5.5). All of the questions provide immediate feedback, praising the user if the response is correct and providing supportive comments when an incorrect response was selected.

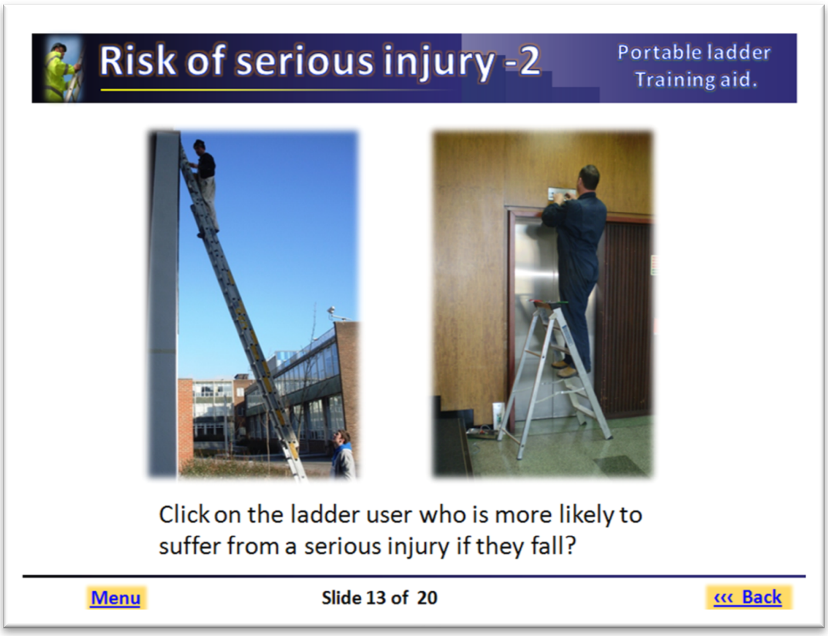


Figure 5.4: Example of height awareness question

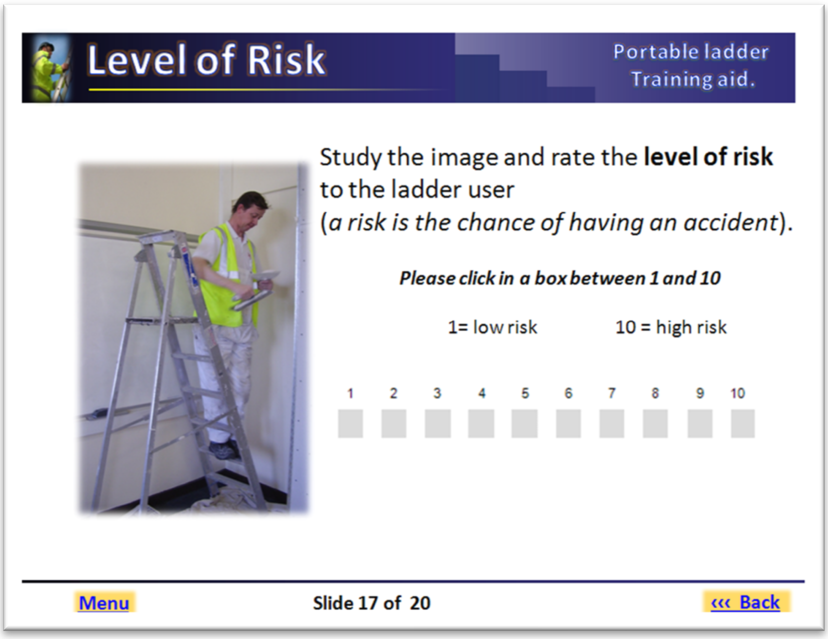


Figure 5.5: Example of Risk perception question

5.5 Use

The training aid does not need an instructor as it is self administered following the installation of the PowerPoint presentation from either a

CD-Rom (CD), digital versatile disk (DVD) or Universal Serial Bus (USB), onto a suitable computer. When the training aid is accessed the title page is automatically launched, without the need to provide any personal information or password. The slides are arranged sequentially and the user is prevented from altering either the sequence or arrangement of the training because the PowerPoint functions are locked. The pace of the learning material has also been controlled with a slide being populated with text, graphics etc. using specific set timings to prevent the user skipping or missing information. At the bottom of each page there are hyperlinked navigation buttons, menu, back and next (Figure 5.3), clicking on these buttons moves to the relevant section or page within the training aid. Some sections or pages do not contain all of the navigation buttons, for example there is no 'next' button on the last page. Some pages require a response to a question before allowing the user to move to another section or page (Figure 5.5).

5.6 Chapter summary

This chapter provided details of the design and use of the height awareness training aid. It provided the reasons and justification for inclusion of learning material, access requirements, and the format and navigation through the interactive programme. It was emphasised that it is a training aid and could be accessed multiple times. It was not designed as a test and there is no method for others to check progress or scores. However risk perception questions have been provided to enable the user to check their own perception score, which would be helpful when completing the risk perception questionnaire designed to be administered following completion of the training aid. The height awareness programme contains embedded World Wide Web (www) hyperlinks to provide access to further information if required. A copy of the training-aid has been provided in Appendix E.

Chapter 6 Discussion

6.1 Introduction

This chapter discusses the main findings of the results and analysis taken from the ladder-use and sensation seeking surveys carried out before the administering of the training-aid, and the risk perception survey carried out after the use of the training -aid. The discussions are grouped and follow the same format as the analysis contained within section 4.

6.2 Falls from height

The results indicate that there is a relationship between age and awareness of items involved with falls from height, and that older respondents are more aware of the items associated with falls than younger respondents. However the significance of the analysis is based on low numbers of respondents over 50 years old and may also be linked to other variables e.g. experience of working at height. The analysis highlights that as the number of years experience of respondents increased, their awareness of items associated with falls also increased. Generally the longer respondents had worked in the construction industry the more aware they were of the items associated with falls from height, and falls from portable ladders. As expected, a respondent's age and experience have a significant influence on their ability to correctly identify agents associated with falls from height during construction operations. The positive correlation shows that as a respondents age/experience increases, their fall related knowledge also increases, and that they are more aware of fall related information than younger respondents, especially those under 20 years of age. One reason for this may be that older respondents with more experience are more likely to be able to recall an incident or an event that could positively influence their decision. Incidents involving personal injury or near misses are especially memorable and would also have an effect on responses from older respondents who would have been exposed to incidents over a longer period.

6.3 Probability of dying

Within the overall results dying due to a ladder accident was correctly identified by 24% of respondents who placed ladders accurately within the ranking. Conversely this indicates that 76% did not correctly identify ladders within the ranking, potentially placing themselves at risk of falling. This generally agrees with Clift (2004) who also observed that ladders were poorly ranked by respondents, and who concluded that *"if a user is aware of the risk they better manage their safety strategy"*. Generally the longer respondents had worked with ladders the higher the percentage of correct scores. The responses have a loose correlation with the falls from height responses indicating that as the experience of the user increases the percentage of correct responses also increases, which agrees with previous research carried out by Watts (1998). To mirror the original research carried by Clift (2004), ladders were included within the probability of dying events to see how well individuals could judge the true level of risk in comparison to other life threatening events. However, despite relatively poor results for the placing of ladders within the overall list, the most interesting observation is that ladders were well placed towards the top (three of nine) of the event rankings by respondents. This is contrary to the original research carried out by Clift (2004), where ladders were placed within the bottom two of nine. Showing that although the overall results for the placing of ladders within the events were generally poor, respondents were reasonably aware of risks posed by ladders.

6.4 Most injuries

This indicates that as age increases awareness of accidents attributed to ladder use also increases, which is also positively linked to experience in using ladders and years worked in the industry. Personal experience of a fall from a ladder/stepladder could affect a respondent's perception of risk and the position of the item within the ranking, as the person who has fallen according to Johnson and Tversky (1983) has an increased perception of the situation as the fall has had a personal impact on their future actions and perception. This theory is supported by the research of Sunstein (1999) who agreed that a person tends to think that an event is more likely if they can recall an incident of its occurrence. Karnes, et al. (1986) concluded that the greater a person's experience of a hazard the lower their perception of risk, as exposure to a risk which does not result in harm will lessen an individual's perception associated with the event. It should be noted that the numbers of falls recorded for the latter categories are very small (0.5% of the sample) and may be prone to exaggeration by respondents, however the results clearly show that as the number of times a person experiences a fall increases, the correct response also increases. The step change of correct responses for respondents who had experienced two or more falls, as opposed to those that had never fallen is significant, and clearly shows that the respondents are more risk aware in terms of ladder use.

6.5 Most construction deaths

Generally the longer the respondents had worked in the construction industry the more aware they were of the items involved with fatalities. Respondents holding a health and safety qualification should be more 'height aware' and subsequently provide more correct responses than respondents with no health and safety qualifications. However this expected outcome was not observed within the results as the total correct responses for those with qualifications was 12%, and those without qualifications was 11%. This result could be partly attributed to the type of health and safety qualification held by the respondents. As described in improving competence within section 2.7 it is possible to gain either a CCNSG safety passport or a CSCS card without providing evidence of competence regarding working at height. A weakness of both of the qualifications is the lack of emphasis on appropriate questions within the tests focussed on working at height or working with portable ladders, which may need to be addressed if the qualifications are to deal with the problem. Bomel (2003) in a research report to the HSE concluded that one of the primary influences of falls from height was training, and recommended that it should be more effective. It is unknown if training is being carried out for working at height at site tool-box-talk level rather than qualification level, which may explain the similarity of the results, as all operatives will be receiving the same training. More specific questions may be needed as part of future studies to establish the effectiveness of training in relation to the perception of risk when working at height. Respondents are generally informed during formal ladder training of the high incidence of deaths related to falls from height (Bomel 2003), and therefore those that had received training should be more height aware.

The results show that correct and incorrect responses for the falls from height item are the same for respondents that had, and those that had not received ladder training. This indicated that training had no effect on the 'height awareness' of respondents. This is contrary to previous research carried out by Heinz, et al. (2002) who concluded that safety training was responsible for reduced accidents related to falls from height. However it is supported by McDonald and Hrymak (2002) who established that although safety training was carried out by contractors, it mainly formed part of a site induction which was perceived as a formality by operatives, with little expectation that it would influence knowledge or behaviour. Bomel (2003) also reported that contrary to some opinions, training was probably not a practical means of improving safety in terms of working at height, and that awareness was the key factor opposed to training. The analysis shows that there is no significant difference between a respondent's level of qualifications/training and their awareness of the situations that cause fatalities. However 'height awareness' is linked to experience as those that had worked in the industry the longest provided the most correct results.

6.6 Level of risk to the ladder user

The results indicate that respondents generally have a greater perception of risk at high levels and a lesser perception of risk at low levels. This agrees with the research of Bomel (2001) who investigated the underlying influences on falls from height and developed an influence network of causes. The network identified that one of the main influential factors was complacency towards risks, and that people have a greater perception of risk for work at high levels but an underestimation of risk at low levels. Bomel's research also identified that operatives generally have '*it won't happen to me'* attitude towards their safety are willing to take unnecessary risks while working at height due to poor risk perception. One consequence of this is that there may be more risk of a low level fall because the risks do not register as being significant. McDonald and Hrymak (2002) in a study of the safety behaviour of portable ladder users on construction sites within Northern Ireland also identified that operatives may not perceive risks accurately. In general working with ladders was perceived as a high risk, the major exception being short ladders which were perceived as medium risk.

6.7 Risk rating by age of respondents

All age groups under-estimated the risk from low-level ladder use situations. The difference in mean scores between the age groups was relatively small and generally reduced as age increased. The greatest difference from the datum score was the under 20 age group who underestimated the low level ladder use situations by a mean difference of four points, and the smallest difference was from the 50-59 age group who underestimated by an average of two points. All age groups also over-estimated the risk from high-level ladder use situations. The difference in mean scores between the age groups was approximately the same with the exception of the 40-49 age group who over-estimated by a mean of over five points from the datum.

6.8 Risk rating by experience of respondents

The results show that respondents have a greater perception of risk at high levels but an underestimation of risk at low levels. This may be because they associate the seriousness of an injury with the height of a fall, assuming that there must be more harm, and therefore more risk from a high level fall than a low level fall. This is also characterised by an operative's familiarity with the hazard, whereby if the risk of working at height is familiar to an operative and faced on a regular basis they will have a tendency to be overconfident, and therefore there may be more risk of a low level fall because the risk seems less significant. Harrell (1990) found that if a person believes a risk to be under their control, as in the case of working at low level, it is perceived to be lower; they feel comfortable and do not make any behavioural adjustment. Likewise, the more a person is aware of a risk the better it is perceived and the greater the concern leading to adjustments in behaviour.

6.9 Risk rating by qualifications of respondents

Similar to the previous results showing risk rating by experience, the respondents have a greater perception of risk for work at high-levels but an underestimation of risk for work at low-levels. Respondents holding a health and safety qualification should be more 'height aware' and subsequently provide more correct responses than respondents with no health and safety qualifications. This could be partly attributed to the type of health and safety qualification held by the respondents, as Safety Passport or Construction Skills qualifications do not provide evidence of competence. Unexpectedly, the point scores were very similar and there is only a very small difference in mean scores between those holding a qualification and those that don't. The reasons for the closeness of results are not clear however they could be attributed to a lack of emphasis within the courses specifically for working at height, or the possible commonality of on-site training delivered as part of tool-box-talks, which may explain the similarity of the results. It is not possible to comment on the qualifications designated as ‘other’ as the qualification type was unknown.

6.10 Risk rating by training and use of written information

Similar to the previous section for qualifications the reasons for the closeness of results are not clear however they could be attributed to the possible commonality of on-site practical training. This is undertaken as a mandatory requirement of the Health and Safety at Work Etc. Act 1974 and a range of statutory regulations including The Provision and Use of Work Equipment Regulations 1998. The regulations require employers to ensure the safe selection, inspection and use of portable ladders and mandatory training is usually carried out as part of ongoing tool-box-talks, which may explain the similarity of the results, as the training usually follows a common format. Similarly, written information provided to operatives on portable ladder safety is generally generic in nature and virtually all guidance contains checklists of recommended ladder use, however there is virtually no information of the risks associated with high and low-level falls. In the absence of specific height/risk awareness training for portable ladder use it is likely that operatives will continue to underestimate the risks posed from low-level working and continue to suffer the consequences.

6.11 Risk rating by work type, occupation and company size

According to Douglas (1978) risk perception goes beyond the individual and is partly affected by an organisation, it is a social construct, embedded in a person’s attitude that can influence their perception of risk, and is directly related to the safety culture of an organisation. Biggs, et al. (2005) found that large construction organisations tend to take ownership and responsibility for site safety and try to embed a holistic form of safety culture into work activities. However smaller construction organisations do not put safety high on their agenda, if at all. They only have basic forms of safety culture that may not be helpful in influencing a person's risk perception. The situation is also not helped by the transitory nature of the workforce, as operatives move between organisations to obtain the most favourable pay and conditions, which has the tendency to hinder attempts to maintain a positive safety culture. The culture of risk taking is also seen as endemic in the construction sector as more emphasis is placed on meeting production goals rather than on safety. Furthermore, it has been suggested by Covello (1989) that particular risks could be selected for attention and therefore be exaggerated. This could be the case with the misperception of high-level portable ladder use, as operatives generally over-estimate the risks posed from working at high-levels and underestimate the risk of working at low-levels.

The respondent's scores for all categories were only marginally different, and there was no clear indication of any work type, or company size that differed significantly from the overall mean scores. Only the occupation of plasterers scored high-level risks differently at five points above the datum score, however the reasons for this anomaly are not clear as there is insufficient evidence within the research. Also there is no evidence in terms of how long an operative had worked for an organisation or how often, if at all, they had moved between organisations, which could have a bearing on the results in terms of possible embedded safety culture. If respondents had similar cultural experiences it could explain the closeness of results, however this is very unlikely given the broad range of respondents and organisational types within the sample. There is no evidence within the results to support previous research regarding embedded safety culture of large organisations, and no evidence of any positive effects on an operative's perception of risk.

6.12 Sensation seeking

Sensation seeking is a recognized trait that is widely accepted as having an influence on risk taking behaviour. It is an important variable to quantify, as it allows the performance of a participant to be understood in terms of norms of behaviour, which then places the individual in a rank of likelihood to take risks. The Zuckerman's (1994) sensation seeking survey (Appendix B) was used to measure the sensation seeking scores of the respondents. The majority of scores (80%) were within the 21 to 30 range, indicating that the majority of respondents had a high propensity to take risks. Regression analysis carried out to test for correlations with sensation seeking provided weak negative correlations for age, years of experience and ladder use experience, indicating:

- That the older the participant, the lower the sensation seeking score, and the less likely they are to take risks. Conversely the younger the participant, the higher the sensation seeking score and the more likely they are to take risks.
- That the longer a participant has experience working within the construction industry the less likely they are to engage in a risk taking behaviour. Conversely, less experienced respondents have a higher sensation seeking score and the more likely they are to engage in a risk taking behaviour.
- That the longer a participant has experience working with ladders the less likely they are to engage in a risk taking behaviour.

The findings of the regression analysis agree with the research carried out by Clift (2004), who also observed weak negative correlations when using the Zuckerman scale as part of research into the performance and effectiveness of ladder stability devices. Zuckerman came to similar conclusions that experienced participants are less likely to engage in risk taking behaviour, and inexperienced young participants are more likely to engage in risk taking behaviour. It was concluded that *"it is possible to correlate personality traits with behavioural traits"* placing an individual in a rank of likelihood to take risks.

6.13 Risk perception

The risk perception survey measured any change in respondent's level of risk perception following the use of the height awareness training-aid. Respondents risk rating scores were compared against a risk rating datum score which indicated that there was an overall reduction (21%) in risk rating scores for high level falls, and an increase (45%) in risk rating scores for low level falls. The change in risk rating scores indicated that respondents had a greater risk perception of working at both high and low levels following the use of the training aid, as their scores were closer to the datum score in each case. A paired sample *t*-test also showed that the mean difference between pre and post training was significantly different, and confirmed an experimental hypothesis that there was a difference between respondent's pre and post risk perception.

6.14 Chapter summary

The discussion focussed on the results and analysis of the data taken from the ladder-use, sensation seeking and the risk perception surveys. The analysis confirmed that there is a significant relationship between a respondent's age, experience and their awareness of falls from height, and that as age increases awareness of accidents attributed to working at height also increases. Generally the longer respondents had worked in the construction industry the more aware they were of the items associated with falls from height, and falls from portable ladders.

The expected outcome that respondents holding a health and safety qualification are more 'height aware' was not observed within the results. This could be partly attributed to the type of health and safety qualification held by the respondents, as Safety Passport or construction skills qualifications do not provide evidence of competence. The analysis also shows that there is no significant difference between a respondent's level of qualifications and their awareness of the situations that cause fatalities. Respondents generally over-estimated the risk from high-level ladder use situations and under-estimated the risk from low-level ladder use situations.

Previous research identified that risk perception goes beyond the individual and is partly affected by the culture of an organisation was not identified within the analysis. Results were to the contrary, showing that respondents were not affected by their occupation, work type or company size. Also there was insufficient evidence regarding the possible transitory nature of the workforce to reach a conclusion.

Analysis of sensation seeking recognized as a trait having an influence on risk taking behaviour agreed with the previous research, that experienced participants are less likely to engage in risk taking behaviour, and inexperienced young participants, under twenty years of age are more likely to engage in risk taking behaviour. Analysis of the risk perception of respondents identified that they had a greater risk perception of working at height for both high-level and low-level situations following the use of a height awareness training-aid, establishing that there was a difference between pre-training and post-training risk perception.

Chapter 7 Conclusions and further research

7.1 Introduction

This thesis was initiated with the aim of analysing the risk perception of operatives using portable ladders in the construction industry, and developing and testing a ladder use training aid. This chapter summarises the main contributions of the thesis to the perception of risk. It presents the key findings of each objective that were carried out to meet the stated aim and to test the hypothesis that 'the use of a training aid can improve a construction operative's risk perception when using portable ladders'.

A summary of the key literature review findings in terms of construction sector falls from height and general risk perception are provided in section 7.2. Section 7.3 reviews the appropriateness of the study design, data collection methodology and results obtained from the surveys. The development and testing of the ladder use training-aid are discussed within section 7.4, and the main research findings provided within section 7.5. The final sections of the chapter discuss the wider implications of the research to the construction sector (section 7.6), the constraints and limitations of the research (Section 7.7), and areas for future research (section 7.8).

7.2 Falls from height and risk perception literature

The first research objective consisted of identifying and analysing the large existing body of knowledge focussed on falls from height and the perception of risk. The falls from height data proved to be readily available as the Health and Safety Executive publish comprehensive annual accident statistics. However, comparative international statistics were not as easy to establish especially as countries have different methods of compiling results. The review highlighted that falls from height was the most common cause of injuries and death to employees in the construction industry and that injury rates from falls from height were similar to the rest of the world at approximately 50%. The objective accurately established that accidents involving falls from portable ladders occur at a rate of forty per week in the UK construction industry. It also established that ladders are so common that they are taken for granted and the perceived low-level risks are often under-estimated, placing the operatives in a position of risk.

The review of literature for risk perception highlighted that despite the very large existing body of knowledge covering a wide variety of different research types only a small part of the research focussed on people working at height, and very little research related to portable ladder use. It also revealed that a lack of site operative involvement when gathering research data was a major weakness in previous research, as information was not being obtained from the people who are directly involved with the falls from height problem. The procedural framework within which the risk perception research was conducted therefore focused on obtaining information from construction operatives who were ladder users. Some good helpful literature was available for research into the sensation seeking characteristics of an individual that was replicated well into the research and met the requirements of objective 2.

7.3 Research design and data collection

The research design required to meet objective 3, required respondents to complete three questionnaires and also complete a ladder-use training-aid. The aim of the first stage was to establish the participant's level of risk perception on entry, before any training had taken place. The second stage involved the administering of the ladder use training-aid, and the third stage measured any change in the participants risk perception. The questionnaire stages worked effectively as very high response rates were achieved with relatively few errors, mainly attributed to the controlled method of administration. The pilot stages and subsequent developments for the ladder-use and risk perception surveys also worked effectively, as they provided information for improvement of the surveys essential for participant understanding and hence successful questionnaire completion.

The research population numbers and attendance by different cohorts created substantial overlapping of the research stages. This was challenging, at times confusing, had the potential for error and was very time consuming. However the research objective was well met as the data collection was highly successful, providing valid and reliable results for the targeted population whilst following essential ethical considerations, and would form a good basis for any future research.

7.4 Development and testing of the ladder use training-aid

Research objective 4 involved the development and testing of a ladder-use training-aid designed to improve the risk perception of portable ladder users. The review of literature established that although there was a large number of training aids emphasising ladder-use, there were none devoted specifically to risk perception. The emphasis was therefore to improve the risk perception of operatives through the completion of the 'height awareness' aid which was designed to be a self administered personal learning resource with no emphasis on achievement or progress checking. The aid successfully focussed on reinforcing the message that working below head height can be high risk, and that users need to be height aware in terms of perceived risk if to avoid falls. The pilot stages and subsequent developments for the aid worked very effectively, as they provided information essential for improvement. Administration of the training-aid was ultimately successful and enhanced by the use of touch screen technology. However computer facilities were sometimes unavailable or operating systems unreliable, which led to re-scheduling or delays of some sessions, which could have created anxiety for some respondents and hence could have affected the effectiveness of the aid.

7.5 Improvement in risk perception

Chapter 4 of this thesis provided an analysis of the results from the ladder-use and sensation seeking surveys carried out before the administering of the training aid, and the risk perception survey carried out after the use of the training aid. The following presents the main findings that can be drawn from this study in more specific terms.

The research hypothesis that, 'the use of a training aid can improve a construction operative's risk perception when using portable ladders' has been demonstrated conclusively. The use of the training-aid increased levels of risk perception by an average of 21% for high-level falls, and 45% for low-level falls, representing a highly significant change in perception. Pre-training risk perception results revealed that operatives over-estimated the risks from high-level ladder use situations, and under-estimated the risks from low-level ladder use situations. The post-training results showed an improvement in an operatives risk perception, especially for low-level situations, indicating that the training-aid had a positive impact on the improvement of portable ladder-use risk perception. It has also shown that risk perception varies with the individual in terms of age, experience, training, qualifications, occupation and levels of sensation seeking. How long the positive effects of the training-aid will last may be the subject of further research, as it may be proved that familiarity does breed contempt for the ladder user. The operative may revert back to their pre-training condition and disregard the lesson learnt, placing themselves in a greater propensity of harm from low-level falls.

7.6 Behavioural change

Intervention strategies centered on individuals are crucial to the effectiveness of any positive behavioural change that is designed to become part of a construction workers normal work practice. An effective intervention strategy could add value to risk behavioural change by ‘nudging’ workers to make safe work at height choices. The training-aid used in this research could be used as part of an effective intervention that actively engages construction workers in raising risk perception. By doing this, the end product will shift away from merely raising awareness to more serious considerations of tangibly changing risk behaviour, and reducing accidents associated with working at height. However evidence from research carried out by Lunt and Staves (2008) identified that whilst ‘nudge’ can be effective in changing safety behaviour it can be short lived. Long lasting behavioural change may need to be supported by a ‘think and ‘shove’ framework. Therefore, if the training-aid was incorporated into the ‘think’ stage of a ‘nudge’, ‘think’, ‘shove’ framework, the research evidence suggests that it should influence a workers risk perception and subsequently their behaviour. To prevent the learning effect being ‘short lived’ it could be incorporated into a training programme designed to keep individuals engaged and reinforce the nudge effect by focusing on automatic processes of behaviour. The training-aid could also support the ‘shove’ stage of the framework by automatically following safe working practices contained within health and safety legislation, for example, selection and use of portable ladders, contained the Work at Height Regulations. By using the training-aid as part of the ‘think’ approach it can compliment ‘nudge’ and be more effective than ‘shove’, creating the conditions under which ‘nudge’ is effective in changing behaviour.

The effectiveness of an intervention strategy could also be affected by an individual’s self-attribution bias or sensation seeking personality traits, which can have an influence on risk taking behaviour:

Self-attribution bias - is particularly hazardous, as it leads to an overestimation of knowledge and underestimation of risk. If an overconfident self attribution bias persists over a long period of time without some form of behaviour intervention an individual may gain an illusion of control which reduces risk perception especially if the operative is familiar with the workplace. This type of bias could affect an intervention strategy within the 'nudge' framework, as a worker may be unwilling or reluctant to change their belief in their ability to carry out the work safely.

Sensation seeking - this research measured a respondent's sensation seeking trait, which is an important behavioural variable to quantify, as it allows the performance of a participant to be understood in terms of norms of behaviour, which then places the individual in a rank of likelihood to take risks. The findings from regression analysis carried out as part of this research indicated that the majority (80%) of respondents had a high propensity to take risks, and that experienced participants and older participants are less likely to engage in risk taking behaviour and subsequently less likely to take risks. A sensation seeking trait could negatively affect intervention strategies, and prevent a 'nudge' framework from being effective. A construction workers high propensity to take risks could be used as a precursor to risk taking behaviour and hence accidents.

The process of change involves independent variables that occur gradually over time, with individuals progressing from being aware and unwilling to make a change, to considering making a change, to deciding to make a change, which is then followed by positive change behaviour. Therefore if the training-aid is to be effective it should be used at the appropriate behavioural stage for an individual, if it is not tailored to an individual or progressed too quickly then it is less likely to be effective. However, the effectiveness of the aid could be affected by the disparate nature of the construction industry in terms of transient workforce, production pressures, site complexity and safety culture. If the training-aid is to be effective and change behaviour then it needs to be integrated into a wider system which is reinforced over time.

7.7 Implications of the research to the construction sector

Falls from ladders occur at the rate of 40 per week in the construction industry and research suggests that it is mainly caused by a lack of risk perception by the users. The research has identified that an intervention strategy in the form of a training-aid is effective in positively changing construction workers risk perception, and that the change is consistent across different demographic groups. If the intervention is carried forward and used effectively by employers as part of a behaviour change strategy, then it may be possible to affect long term behaviour change within the construction sector and have some effect on accidents involving falls from height. It may then be possible to affect work at height behaviour within the construction sector, and subsequently reduce the number of accidents associated with the activity. Workers will directly benefit from the strategy by being more risk aware and more empowered to recognize and respond to work at height risk situations reducing their propensity for personal injury, through fall related accidents.

The results of the early stages of the research which included the data collection and initial analysis were published within the proceedings of the Association of Researchers in Construction Management (ARCOM) conference. The research paper was titled 'Situational Awareness & Risk Perception of Operatives Using Portable Ladders in the Construction Industry'. It highlighted the issues involved with risk perception and raised awareness of the planned production of the training-aid. The follow up research paper will provide analysis of the use of the training-aid, and provide links to the location of the aid which will be freely available for use on the internet.

7.8 Areas for improvement

The following have been identified as possible areas for improvement for the research design.

7.8.1 Risk perception survey items

The controlled questionnaire format for the risk perception items in both the ladder-use and the risk perception surveys worked as planned, providing clear results for analysis from ten point risk rating scales. The risk items contained within the ladder-use questionnaire consisted of a series of 19 images showing a random series of photographic ladder use situations. The post-training risk perception survey used six items taken from the ladder-use survey depicting three low level and three high level risk situations. It was considered that six items would be appropriate to test for changes in perception levels, and that using the full set of items would not be necessary and would be too time consuming considering that there were three questionnaires to complete for the research. However, upon reflection and re-consideration the research design could have been improved if the risk items from the ladder-use survey had been repeated in full for the risk rating questionnaire, following a standard form of survey convention. This would have provided a more comprehensive set of results for the full range of items, and would have negated any possible accidental bias in the selection of the six items used.

7.8.2 Control group

The population for the research was taken from operatives attending construction related programmes at a college of further education, and training programmes were chosen to allow participants to be revisited for each of the survey stages. A control treatment group was not considered necessary for the research, as incidental factors were regarded as being minimal. However, upon reflection and re-consideration the research design could have been improved if a control group had been used to help isolate and eliminate confounding variables or bias. A control group that completed the third stage risk perception survey without completing the training aid could have been used to provide comparative results, and help identify any external learning factors that were not related to the training-aid.

7.8.3 Respondent's

While efforts were made to include a diverse population in terms of age, experience, occupation and employer work type, the respondents were limited to those attending construction related training programmes at one training centre in the north east of England. Although it was considered that participants were representative of the construction industry due to the random way they entered the study, there could still be the potential for bias due to regional or demographic profile differences. Upon reflection and re-consideration the research design could have been improved if the participation base was widened to incorporate a selection of training establishments over a wider area. This method could provide more reliable research results provided administering of the questionnaires remained consistent across the establishments.

7.9 Constraints and limitations

This section focuses on the constraints and limitations of the research with regards to the ladder-use images, ladder-use survey, non-practical application and limitations of respondents considered to have had a potential effect on the research outcomes.

7.9.1 Ladder-use images

Participants were given a series of photographic images showing a random series of ladder use situations and scored them in relation to the extent of the risk. The research was designed to place an emphasis on the risks associated with working at different heights. However risk perception could have been influenced by the situational awareness of the respondent in terms of the activity of the ladder user. For example image 15 in section 4.4.15 shows an operative standing on the top step of a ladder, and image 22, section 4.3.15 shows an operative with one foot on an adjoining surface. Respondent's may have rated the risk associated with the level of harm posed from the activity rather than the risk associated with the height of fall. This could have been further exacerbated as 13 images depicted incorrect ladder use, and only six depicted correct ladder use. An image that eliminates the situational awareness posed by the ladder use activity may have provided more reliable results and is recommended for follow up studies. Furthermore eight of the nine step ladder images were of low level use and all of the leaning ladders were for high level falls. This is an oversight in the research as the respondents may have recognized this pattern and responded accordingly skewing the results and affecting reliability.

7.9.2 Ladder-use survey

The design of the portable ladder use questions (numbers 8 to 26) within the ladder-use survey had the potential to affect the results. The response sheets contained up to five images which inadvertently gave the opportunity for the respondents to scan between the images before completing their risk rating. The responses for each item could have been adjusted if they ranked the level of risk between the images. This may not necessarily have an effect on the final risk rating outcomes but is best avoided if possible to ensure validity and reliability of the results.

7.9.3 Questionnaire completion

The time interval between the pre-training and post-training questionnaires was designed to be kept to a minimum. It was important to ensure validity by minimising the threat of any external learning that may have taken place during the testing period, which was typically 14 days. This had the potential to skew the results as the extent of any additional external learning during the test period was unknown, likewise the extent to which the participants forgot the information provided at the training is also unknown, and could have had a bearing on the results. It would be beneficial to complete the three stages of the surveys in one session, which would remove the time delay and possibly provide more reliable results.

7.9.4 Non-practical application

The research was limited to a non-practical application, using information portrayed on a computer screen, which in many cases created anxiety for the respondents as it was perceived to be outside of their comfort zone. The use of practical ladder-use situations could have been more beneficial as participants could have experienced the height differences when deciding the perceived level of risk.

7.10 Areas for future research

This research focused on measuring the risk perception of ladder users and concluded that operatives over-estimated the risks from high-level ladder use situations and under-estimated the risks from low-level ladder use situations. However the critical height at which a person's risk perception changes is not known and further research into this area is necessary if to begin to understand the falls from height problem. An outline that the 'critical' research might follow is outlined below, together with thoughts as to how the participant base can be widened, how further cross analysis can be carried out on results and some basic ideas for further research.

7.10.1 The 'critical' height

A person's perception of risk and hence their behaviour is mainly determined by the level of harm associated with the height of fall, the general perception being that, the higher the fall, the greater the level of injury. As this is a major determinant of a person's risk perception further research would be beneficial to determine the critical height at which a person's risk perception changes from say low-medium and medium-high risk. The research could focus on using a series of images showing the same type of work activity, using different incremental heights of portable ladders to obtain numerical scores that could be tested against a datum score. The research should be designed to use a work activity that will not affect the results, as perceptions could be affected by the activity rather than the height. A typical activity that is suggested would be painting a wall, maintaining three points of contact with the ladder, which is universally recognized as safe practice for ladder users. It is suggested that the activity is staged to use the same operative, using the same type of ladder and painting the same wall, and that the image angle remains constant. This will help to remove any bias caused by lack of continuity of the images, and provided the sample is of adequate size should provide valid results. The research could also be carried out to determine if risk perceptions are different for different types of ladder, for example leaning ladders and step ladders. The same scenario described above could be used, or the different types of ladders could be combined within the same survey and the two sets of data analyzed together.

7.10.2 Widening the participant base

Further research could aim to widen the participant base and provide a more representative sample of the construction sector population outside of the confines of a training centre. This could include operatives who do not normally have the opportunity to participate in training activities, and may involve operatives from micro and small organisations where the requirement for any safety certification is not enforced, but may be desirable. Finding site-time to conduct surveys always has the potential to be problematic especially if it is a longitudinal type survey. The research could therefore be extended to use on-line facilities for administration of the surveys. This could include the use of the training aid to help reinforce the falls from height message and perhaps improve ladder users risk perception. An on-line facility could be a method of attracting a larger number of ladder users to complete the study, and it could possibly be made available to a world-wide audience. This would bring associated data handling problems which would need to be considered as the number of respondents could be large. It also has the potential to cause ethical problems for the identification and control of respondents.

7.10.3 Cross analysis of data

This research has not fully investigated all of the possibilities for analysis of the data; an opportunity therefore exists to carry out further in depth and cross-analysis of the results obtained from the surveys. For example, the relationship between a person's risk perception and:

- Their employing organization size
- Their employing organization work type
- Their gender
- The agents involved with the most falls from height

It may also be possible to conduct a multi-analysis approach to the data results by grouping results together to test for relationships, for example:

- Years worked in the industry / Health and safety qualifications / Age
- Frequency of ladder use / Occupation / Ladder training
- Gender / Years worked with ladders / Company size

7.10.4 Additional areas for further research

The following could also be considered for further research:

- How a respondents level of risk perception will be affected by actual ladder-use situations on-site, rather than using photographic images.
- How long the effects of risk perception training last before the operative reverts back to pre-training perceptions.

- The effectiveness of using a single image (poster) to reinforce the risk perception message, without the need for further training.
- Using a cross industry approach including respondents from a range of different work sectors.

It is proposed that future research be focussed on determining if a ‘critical height’ exists which affects a person’s risk perception, and hence their decision making in terms of ladder use. An important step in that direction has been taken with the research presented in this thesis, which provides a platform for the development of further investigation.

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