A Paradigm Shift In Organisational Safety Culture Evaluation And Training

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This thesis results entirely from my own work and has not been offered previously for any other degree or diploma.

Signature………………………………………………

I dedicate this work to my friends and colleagues who lost their lives in the In Amenas terrorist attack in Algeria on the 16th Jan. 2013.

Steve Green, Garry Barlow, Keisuke Kawabata, Yann Desjeux, Tadanori Aratani, Rokuro Fuchida, Yasuji Goto, Fumihiro Ito, Satoshi Kiyama, Hidemi Maekawa, Bunshiro Naito, Hiroaki Ogata, Takashi Yamada, Angelito Manaois Jr., Tore Bech, Hans M. Bjone, Victor Sneberg, Thomas Snekkevik, Alf Vik, Carson Bilsland, Sebastian John, Paul Morgan, Kenneth Whiteside, Frederick Buttacio, Victor Lynn Lovelady, Gordon Lee Rowan, Chong Chung Ngen, Tan Ping Wee, Mihail Bucur, Tiberiu Ionuţ, Mohamed Lamine Lahmar, Carlos Estrada.

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Abstract

The focus of this research is to explore the issues surrounding traditional approaches towards understanding the safety culture of an organisation operating in a high risk environment and to identify an effective technique to educate corporate management in how to measure and evaluate the underlying safety culture of their own organisations.

The results of the first part of the research highlight the concerns being expressed by both academic and industrial communities that current safety culture survey questionnaire techniques exhibit significant flaws and that a new approach to more accurately identify safety culture is necessary. It has been demonstrated that sufficient data are available to any organisation which cares to record it and that this information can be used to model safety culture without the need to continually disrupt the organisation with intrusive surveys.

Part two of the project involves the development of a learning environment based on an expert model of an oil company which is designed to educate management in this approach to safety culture evaluation. Constructed using a rapid prototyping approach, the learning environment is presented individually to a group of volunteers from a variety of industrial disciplines and experiences who undertake the full training programme.

A case study methodology is used to examine the data collected and this demonstrates that participating in the learning environment experience results in improved awareness of how to uncover safety culture issues.

The outcome of this research is a paradigm shift in how to measure and evaluate safety culture. From the analysis of the data, supported by feedback from the participants, it is shown that this is an effective solution to fulfilling both of the aforementioned requirements. Work has begun to adapt the tool so that it can be used in other industries such as mining, construction and nuclear energy.

Contents

Publications

Following are publications and presentations which have been produced following the research described in this thesis –

SPE 148443 – Behaviour, the final frontier. A proven approach to changing organisational behaviours SPE/IADC Middle East Drilling Technology Conference and Exhibition (MEDT), Muscat, Oman, October 2011

Improving safety culture understanding using a computerised learning environment CIB W099 International Conference on Achieving Sustainable Construction Health and Safety, 2-3 June 2014, Lund, Sweden

A real time approach to measuring corporate safety climate. CIB W099 International Conference on Achieving Sustainable Construction Health and Safety, 2-3 June 2014, Lund, Sweden

A learning environment for management safety culture training. Institution of Occupational Safety and Health, Working on Safety Conference October 2014. Glasgow, UK.

Acknowledgements

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Deserving of a special thanks is my partner Conchi Vazquez and her family Inma, Manuel and Marie-Hose who accepted me warmly into their lives when I had not a word of Spanish and who have been a constant source of support and understanding as I continue to learn and adapt in my new homeland. Muchas gracias.

To Lesley Khatibi, and Denis Bourne (and I suspect Judith too), I say a heartfelt thanks for all the proof-reading and the time given to listen to yet another theoretical justification on why or how to construct some other component to add to the project.

To Nathan Hunsworth, I extend my most sincere thanks for his help in supporting the e-mail server.

Finally, I need to give my most profound thanks to the participants who, regrettably, must remain anonymous but who gave so much of their time to help me with this research. Most of them have spent a lifetime engaged in travel for business and there is a vast difference between a business trip and a vacation. To come all the way to Spain simply to return the next day after a highly stressful experience is not something

that many would do willingly or voluntarily. Without them, however, there was no project.

List of abbreviations

ACC	American Chemistry Council
BASI	Bureau of Air Safety Investigation
BSI	British Standards Institute
CANSO	Civil Air Navigation Services Organisation
CBI	Confederation of British Industry
CCPS	Center for Chemicals Process Safety
CDA	Climate Deficiency Analysis
CSB	U.S. Chemical Safety and Hazard Investigation Board
DHSG	Deepwater Horizon Study Group
ECAST	European Commercial Aviation Safety Team
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
HAZID	Hazard Identification
HAZOP	Hazard and Operability study
HRO	High Reliability Organization
HSE	Health, Safety and Environment
HSE MS	Health, Safety and Environmental Management System
IAEA	International Atomic Energy Authority
ICCA	International Council of Chemical Associations
ILO	International Labour Office
IMPEL	European Union Network for the Implementation and Enforcement of Environmental Law
INPO	Institute of Nuclear Power Operations

INSAG	International Nuclear Safety Advisory Group
ISO	International Standards Organisation
LTI	Lost Time Injury
LTIFR	Lost Time Injury Frequency Rate
LSCAT	Loughborough Safety Climate Assessment Toolkit
NTUF	National Trade Union Federation Pakistan
OGP	International Association of Oil and Gas Producers
OHSAS	Occupational Health and Safety Advisory Service
OSHA	Occupational Safety and Health Administration
RCA	Root Cause Analysis
RCMS	Responsible Care Management System
RIDDOR	Reporting of Injuries, Diseases and Dangerous Occurrences
SCLE	Safety Culture Learning Environment
SMS	Safety Management System
TRIR	Total Recordable Injury Rate
UA	Unsafe Act
UC	Unsafe Condition
USIU	United Steelworkers International Union
USNRC	United States Nuclear Regulatory Commission

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Chapter 1 Introduction and background

1.1 Impetus behind this project

The term 'safety culture' is first recorded in a report (IAEA 1986) on the Chernobyl disaster. Since that time, there have been many major industrial disasters. While none of them even approaches the vast number of Chernobyl's victims, they still represent an enormous loss of life in workforces around the world. Table 1.1 highlights a few of these in a variety of industries all of which have happened post Chernobyl.

Date	Location	Industry	Fatalities	Reference
26/04/86	Chernobyl	Nuclear	985,000	Yablokov et al. (2010)
06/07/88	Piper Alpha	Oil	167	Paté-Cornell (1993)
23/10/89	Texas	Chemical	23	FEMA (1989)
10/05/93	Thailand	Manufacturing	188	Shepherd (2003)
13/05/00	Netherlands	Manufacturing	22	IMPEL (2001)
21/09/01	Toulouse	Chemical	30	Grande Paroisse (2009)
23/03/05	Texas City	Oil	15	Risktec (2007)
18/04/07	China	Manufacturing	32	Jianhong (2007)
17/08/09	Russia	Electricity	75	Russian Govt. (2009)
05/04/10	W. Virginia	Mining	29	USNRC (2012)
20/04/10	Gulf of Mexico	Oil	11	DHSG (2011)
19/11/10	New Zealand	Mining	29	NZ Govt. (2012)
11/09/12	Pakistan	Manufacturing	259	NTUF (2013)
17/04/13	Texas	Chemical	14	CSB (2013)

Table 1.1 Selection of major disasters since Chernobyl.

Many of the international disasters identified in Table 1.1 are related to deficiencies in process safety culture rather than 'occupational' or 'industrial' safety. The Center for Chemical Process Safety (CCPS) defines process safety as a *"discipline that focuses on the prevention of fires, explosions and accidental chemical releases at chemical* *process facilities"* rather than concentrating on worker occupational health and safety by addressing safety issues such as fall protection, use of personal protective equipment, etc. (CCPS 2012). With the exception of the Chernobyl figures, the number of fatalities in process safety related events is generally much less than the number of fatalities from occupational safety events (Bureau of Labor Statistics 1994-2012, HSE [1] 2013). Figure 1.1 presents the number of people killed in work-related accidents in the USA since 1993. With a total of over 123,000 deaths during this period (the majority of which were the result of occupational events), the savings of life to be gained by focussing on occupational accident prevention through improved occupational safety culture are clearly worth pursuing.

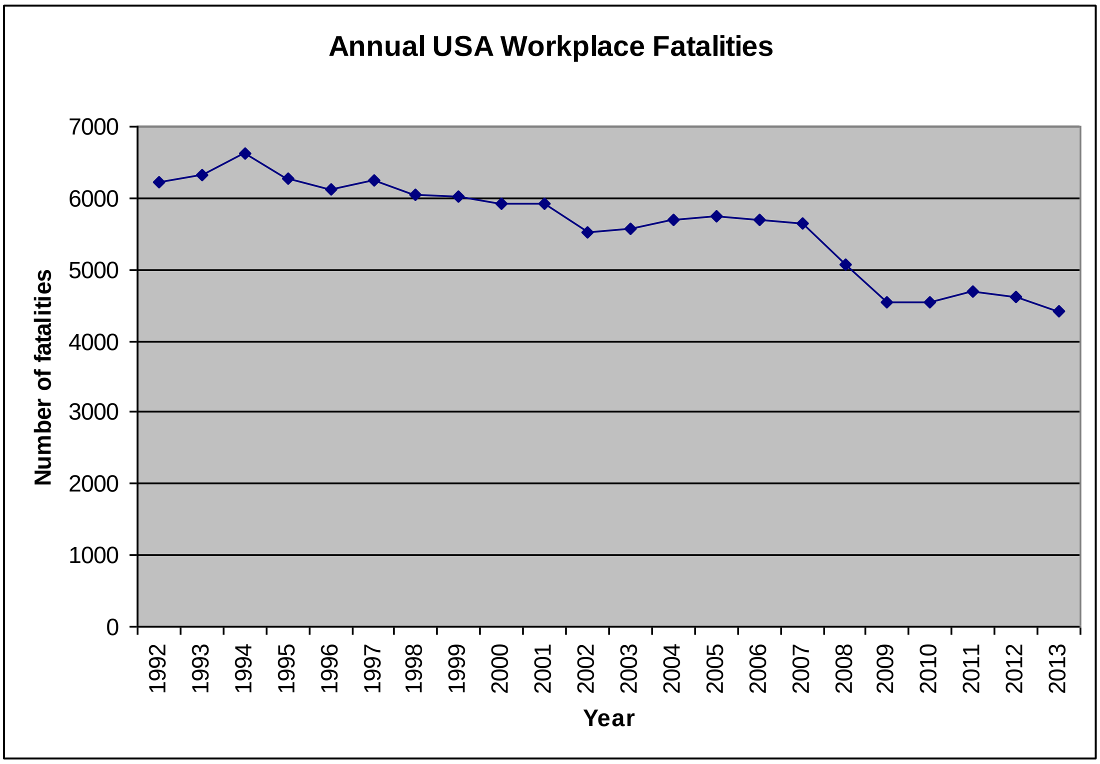

Figure 1.1 Annual USA workplace fatalities.

This does not mean that more work is not desirable in the domain of process safety culture. Much has already been carried out, as highlighted by other authors (Kadri & Jones 2005, Ogle et al. 2013, Olive et al. 2006). Concentrating on the industrial/occupational safety culture enabled clear boundaries to be set for this project. This facilitated delivery of a result that addressed specific goals, thus avoiding confusion with the different approaches that might have been required to successfully model process safety culture within a learning environment such as the one described here. Suggestions for future work on developing a similar tool to address process safety culture are presented in Section 8.2.

Lives continue to be lost through deficiencies in occupational safety culture which have hitherto not been satisfactorily addressed using conventional approaches. It is the author's belief that a more accurate solution to evaluating organisational safety culture exists and that this solution can also be used as an effective management training tool.

1.2 Thesis theme

In addition to the loss of life and with potentially billions of dollars at stake as the price of poor safety performance (BP 2011), organisations can no longer afford to fail to understand their own underlying safety culture. Traditionally, this has been approached through the safety culture questionnaire. There is, however, an abundance of research which suggests that this method is flawed (Fernandez-Muniz et al. 2009, Flin et al. 2000, Glendon & Stanton 2000, Guldenmund 2000 & 2007, Hale 2000, Havold, et al. 2001, Williamson et al. 1997). If the shortcomings of such approaches render their use inappropriate, then a new way of identifying safety culture and of educating management on the importance of understanding their corporate safety weaknesses, resulting from said poor safety culture, is essential.

As Glendon and Stanton observed (2000, p. 4) almost a decade and a half ago - *"If organisational culture, or some aspect of it, is to be measured ..., then complex and imaginative methods of assessment and analysis will be required. Questionnaires or similar measures will be inadequate to measure all aspects of organisational culture"*.

What is required is a tool that can be seamlessly translated across multiple language and cultural boundaries; a tool which provides continuous feedback and which sits squarely within the framework of existing safety activities; a tool which avoids the need for multiple and intrusive safety surveys.

This project presents a novel solution which addresses two aspects associated with corporate safety culture. In the first instance, the research focuses on identifying a solution to the problems identified with using conventional questionnaire-based safety culture surveys as a valid mechanism to establish corporate safety culture.

The second part of the project takes the solution to part 1 and uses it to design, construct and evaluate a teaching tool which is able to educate corporate management to effectively measure and understand the underlying safety culture of their own organisations.

It is important to note that the terms 'measurement' and 'evaluation' are used extensively in this thesis. For the purpose of clarity, what is being measured is not the safety culture itself. Unlike physical parameters such as distance, time, weight, etc., no actual unit of measurement of safety culture exists. To say that one is ‘measuring culture’ is akin to saying that one is ‘measuring weather’. Items such as rainfall, wind speed, wind direction, humidity, atmospheric pressure, etc., can all be measured and, combined, can be used to build a picture of weather. Similarly, in the case of safety culture, what can be measured are pointers to where issues with safety culture may be found. Metrics including reporting ratios, training uptake, goal achievement and many others, which are described in the following pages, provide indications as to where management should concentrate its efforts in identifying overall safety culture.

As far as establishing the reasons for these deficiencies, this will most likely still require traditional approaches such as interviews or questionnaires. In this case, however, the investigation will be focused on finding answers to previously identified areas of concern. A similar and effective approach has been used by the author in the past when patterns identified in neural network models of accident reports provided clear pointers to management system deficiencies which had contributed to occupational safety accidents (Cram 2004).

Schein (1996, 2002) talks extensively about sub-cultures which exist in organisations and the difficulties in promoting safety within these differing cultures. He describes 4 different categories; executive, operations, engineering and worker/union. It is beyond the scope of this thesis to examine the validity or otherwise of these sub-cultures other than to observe that there is always a difficulty in attempting to try and classify disparate groups into broad classifications. Within the typical oil company operating in partnership with other oil companies and employing a diverse workforce comprising multiple linguistic, religious, social, educational and technical backgrounds, there are unlikely to be easily definable sub-cultures along the lines of those proposed by Schein. The author’s previous experience in many such organisations includes time spent in operating entities comprising individuals from over 20 nationalities, working together, many times on the same task, though frequently unable to communicate directly with one another; often subject to inconsistent managerial influence from various partner management teams as well as from their own company management in the case of contract labour.

Previous work by the author (Cram 2004), investigating how to improve HSE Management System implementation levels using neural networks, identified differing approaches and attitudes across various oil production platforms operated by the same company in the same country and employing mostly nationals of the country where the operations were being conducted.

Regardless of the sub-cultures which exist in an organisation (and acknowledgement is given to the fact that they exist and that they have an influence on safety culture and hence safety performance), the purpose of this project is not to address specific cultures or sub-cultures. The project is intended to identify how to teach participants to evaluate the safety culture of their organisations and where to look to address highlighted issues. The indicators they learn to identify and interpret are equally valid whether the participant is from the worker/union sub-culture or the executive sub-culture though their ability to invoke change in their organisations may vary greatly.

A poor reporting culture applies to the entire organisation though the reasons why it is poor are likely to differ considerably, depending on the sub-culture being reviewed/analysed.

1.3 History and motivation

"Culture is set by the collective behaviour of an organisation's leaders and, therefore, it is vitally important that the message must originate at the top". So said Frank Bowen in an interview for BP's corporate magazine (BP 2011, p. 1). In order to effectively manage safety performance, it is essential that line management has a clear understanding of the prevalent safety culture within the organisations they direct. Without effective insights, traditional safety management is a blunt instrument directed at perceived issues in the hope or expectation of some sort of successful outcome.

Lord Cullen, in his report following the Piper Alpha disaster (Cullen 1990) drew attention to the importance of safety management and its fundamental role in offshore safety, focusing as he did on the conclusion that regulations were no substitute for effective safety management and that it did not matter how many regulations were in place, that they could not compensate for deficiencies in safety management.

Since 1990 the changes brought about by the Cullen Report have led to substantial improvements in industrial safety performance. D.J. Fennell's (2006) graph (Figure 1.2) of step changes in safety performance identifies the role of safety management systems in helping industry get to where it is today.

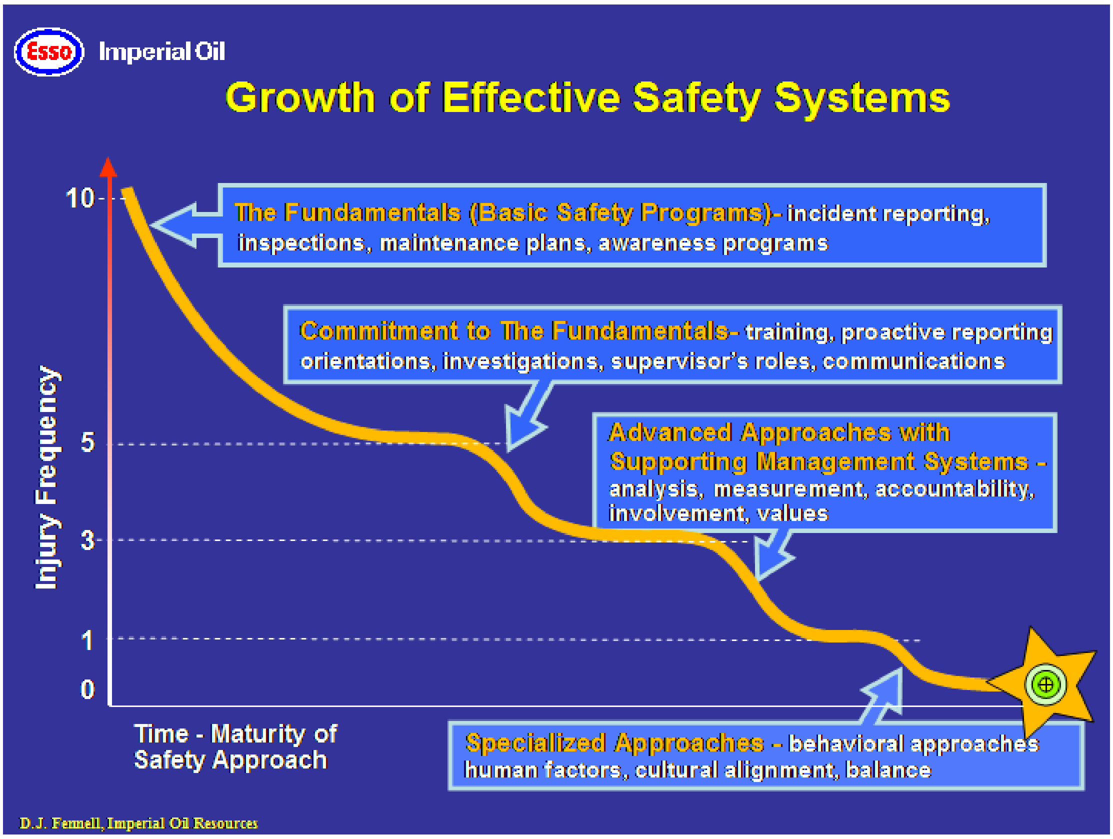

Figure 1.2 Growth of effective safety systems.

Provided by D.J. Fennell, *Imperial Oil Resources.* Reprinted with permission

Fennell (2006) illustrates that safety management is only a single contributor to improving safety performance and that it is not the key contributor to helping industry achieve the final and hitherto elusive step towards the goal of an accident free workplace. Fennell regards behavioural approaches, cultural alignment and human factors as essential in capitalising on historical improvements in safety performance.

Fennell's assessment is reinforced (Figure 1.3) by the United Kingdom Health and Safety Executive in their briefing note on safety culture (HSE [2] 2013) where it observes that, while safety culture per se is not a particularly difficult idea with which to come to terms, the problem is that it is usually described in subjective terms such as 'values' and 'attitudes'. These terms do not always mean the same thing to different people from the same cultural and linguistic heritage let alone completely different backgrounds. The Executive go on to say that the real safety culture of an organisation can be determined by what its workforce does rather than says.

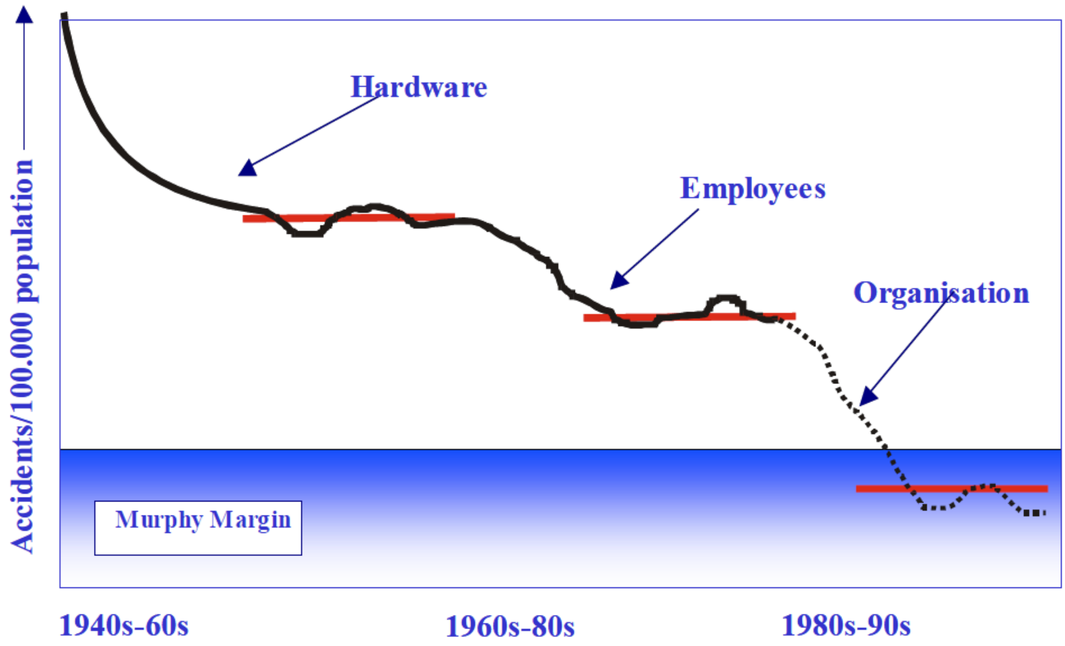

Figure 1.3 Step improvements in safety performance.

'Contains public sector information published by the Health and Safety Executive and licensed under the Open Government Licence v1.0'.

The Health and Safety Executive attribute step improvements over the last 70 years to

- Hardware - (effective guards, safer equipment)
- Improved employee performance (selection and training, incentives and reward schemes)
- Management changes (management styles, organisation, safety management systems)

They claim that the next big step change has begun and that it focuses on creating and developing organisational safety cultures which have beneficial impacts on workforce behaviours in a drive to reduce breaches of safety policies.

Further support for culture change comes from the workforce themselves. In a survey for a United States Offshore Safety Summit (2012) the response to the question *"What is the most important aspect of offshore safety?"* revealed that 40% of respondents believed 'Human factors in safety' and 41% believed 'Company culture and leadership' were the most important aspects in safety offshore. Participants in this instance were safety specialists working in the offshore Gulf of Mexico though actual numbers surveyed were not revealed.

Given that the most common method of assessing safety culture is through the use of culture surveys, the time factor itself becomes another key deficiency in the use of such surveys. A safety culture survey involves considerable time, effort, cost and, often, disruption to the organisation. Additionally, even if all of the previous constraints can be adequately addressed, there is no avoiding the fact that discrete surveys in themselves provide only a snapshot of the safety culture of the organisation.

Bourne (2002) refers to the formation and dissolution of what he terms 'Informal Networks'. These networks form and dissolve in response to the need of individuals and teams within the organisation to identify solutions to the barriers put in place by the organisation in order to enable it to conduct its normal activities. Comprised entirely of members of the workforce these networks play a major role in the culture of the organisation. Their inherent instability however inevitably affects the overall safety culture of the organisation, thus rendering any snapshot survey effectively useless much beyond the immediate time frame in which it was conducted. In light of this, any instantaneous view of an organisation's safety culture provides no more useful information about the real issues facing the entity over time than would a single frame from a film reveal any insights with respect to the overall film plot.

There is a case to be argued that basing culture initiatives from a single static survey of an organisation might in fact be counter productive. The very fluidity of the typical organisation means that it is possible that original initiatives, based on the snapshot survey, may not be applicable to a continuously evolving entity. Short of running multiple surveys over extended time periods, a process which is both expensive and disruptive, there is currently no realistic way of continually evaluating the effect of proactive measures on organisational safety culture.

Industry is therefore faced with a conundrum. On the one hand, safety culture is an important contributor to the constant drive toward a zero accident environment, yet, on the other hand, major deficiencies exist in the validity of the current techniques for safety culture evaluation and little, if anything, is available to educate and train management effectively to measure and understand safety culture in their organisations.

It is interesting to note that a review of the Lost Time Injury Frequency Rate (LTIFR) reported by the International Association of Oil and Gas Producers (OGP) seems to reinforce the perception that, the oil industry at least, may have reached a plateau of sorts. Figure 1.4 shows the global LTIFR reported in the annual OGP safety statistics from 1987 until 2013 (OGP 1997- 2013). OGP data indicate that there has been little or no improvement in LTIFR performance over the last few years. One explanation may well be that the oil industry, at least, has not adapted to meet the requirements for further safety performance improvement.

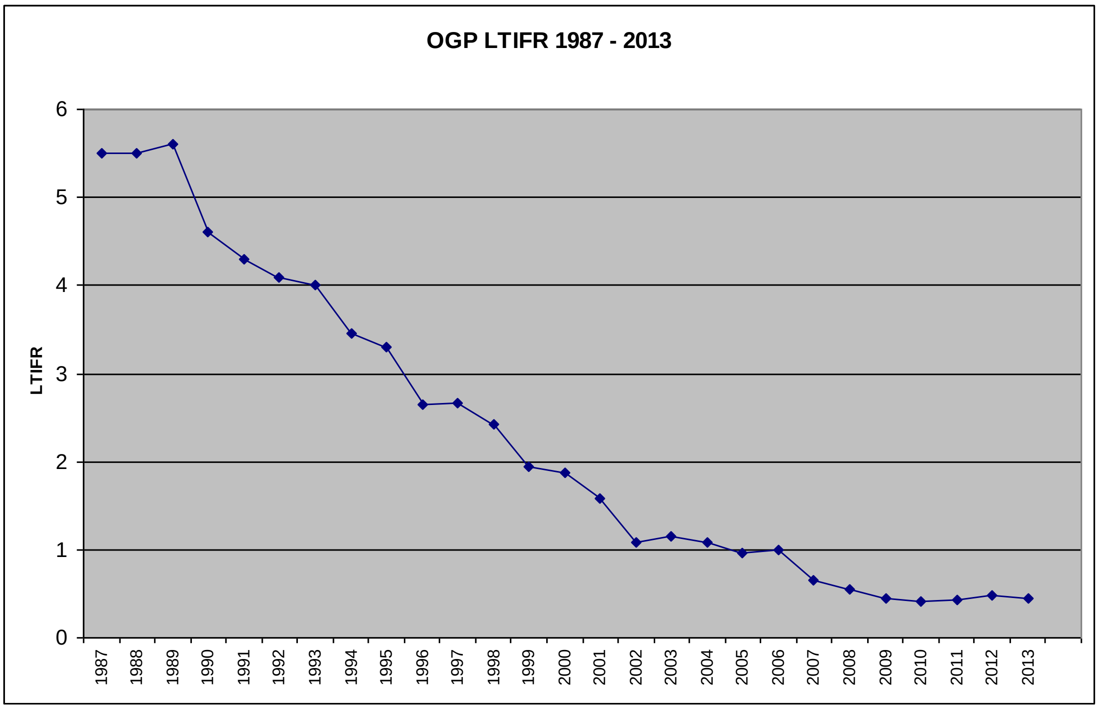

Figure 1.4 OGP Global LTIFR data from 1987 – 2013.

A lack of appreciation by management of the importance of a good safety culture is suggested by the profiles of the professionals being recruited into, or to manage, corporations' safety departments. A review of over 11,000 safety job advertisements conducted over the first 3 years of this project revealed that, remarkably, despite assertions by such august bodies as the United Kingdom Health and Safety Executive of the need for a good safety culture, only 4.9% of the advertised positions were for individuals with skills or knowledge in this particular area. The other 95% of job descriptions require skill sets which map closely to skills that were essential in getting industry to where it is today, rather than those required to achieve the final steps towards achieving 'Culture Alignment' identified by Fennell (2006) and improving

‘Human Factors in Safety’ and ‘Company Culture and Leadership’ as identified in the US Offshore Safety Summit (2012). Clearly, there is a disconnect between the identified needs of industry and the current focus that industry places on safety skills. Unless line management is made more aware of the importance of measuring and understanding safety culture, the current safety performance plateau may well continue indefinitely and the final step will remain elusive.

This research project seeks to address this disconnect by establishing how to evaluate safety culture on a continuous basis and how to improve the training of senior executives in safety culture understanding in order that they might be better placed to improve the culture in their own organisations.

1.4 Objectives

While the report into the Chernobyl disaster (IAEA 1986) referred to ‘nuclear’ safety culture the expression is applicable to any industry operating in high risk environments where good safety culture is equally important. Prior to this mention of ‘safety culture’, the term ‘safety climate’ had already made an appearance in the literature with the original reference attributed to Zohar (1980) in his work entitled – ‘Safety Climate in Industrial Organizations: Theoretical and Applied Implications’ though work had been carried out in the 1970s on what was then termed ‘Organisational Climate’ (James & Jones 1974). As with safety climate and safety culture, the need to distinguish between organisational climate and organisational culture remains.

While not specifically germane to this research project, Schneider et al.'s offering (2013, p. 361) of a definition for both is provided by way of illustration into the difficulties inherent in attempting to distinguish between culture and climate regardless of the specific domain - *"Organizational climate is briefly defined as the meanings people attach to interrelated bundles of experiences they have at work. Organizational culture is briefly defined as the basic assumptions about the world and the values that guide life in organizations."*

In respect of 'safety climate' and 'safety culture', these two terms have entered into common usage and confusion as to their specific meaning has reached epidemic proportions with a variety of researchers, authors and institutions offering their own definitions. Some illustrative/typical examples from the literature are presented in Table 1.2.

Following a review of the literature pertaining to safety culture assessment (presented in Chapter 2), two research questions were formulated –

1. *"How can Health, Safety and Environmental culture be modelled effectively?"*
2. *"How can management be educated in the measurement and evaluation of safety culture of their organisations?"*

Source	Safety Culture	Safety Climate
Health & Safety Executive (HSE 2005, p. iv)	*“The term safety culture can be used to refer to the behavioural aspects (i.e. ‘what people do’), and the situational aspects of the company (i.e. ‘what the organisation has’).”*	*“The term safety climate should be used to refer to psychological characteristics of employees (i.e. ‘how people feel’), corresponding to the values, attitudes, and perceptions of employees with regard to safety within an organisation”.*
Health & Safety Executive (HSE [2] 2013, p. 1-2)	Quoting the Confederation of British Industry *“the safety culture of an organisation could be described as the ideas and beliefs that all members of the organisation share about risk, accidents and ill health".*	*"The term ‘safety climate’ is also used. This has a very similar meaning to ‘safety culture’: and the difference between them is unimportant here.”*
(Goulart 2013, p. 1)	*“Safety Culture is expressed as the summative norms, values, traditions, and behaviours that are tied together in a historical context with respect to Organizational Safety.”*	*“Safety Climate is the fully robust and comprehensive measure of safety for an organization at a point in time.”*
Mearns et al. (2003, p. 642)	Citing IAEA (1986) *“Safety culture has been defined as ‘’that assembly of characteristics and attitudes in organisations and individuals, which establishes that, as an overriding priority, plant safety issues receive the attention warranted by their significance’”.*	Citing Cox and Flin (1998) *“Safety climate is regarded as a manifestation of safety culture in the behaviour and expressed attitude of employees”.*
(Loughborough University 2000, p. 6)	*“The terms safety culture and safety climate may both be used to describe the ways in which members of organisations make sense of the overall safety of their work environment. Safety culture, however, exists at a higher level, relating in part to overarching policies and goals.”*	*“Safety climate, on the other hand, is often used to describe the more ‘tangible’ outputs of an organisation’s safety culture. For example how people perceive and describe the importance given to safety issues by the organisation at a particular point in time, and how local arrangements are seen to reflect this. Safety climate exists at a more localised level, and thus provides a tangible focus for the assessment of some aspects of safety culture.”*

Table 1.2 Various definitions of safety culture and safety climate.

Given the growing acceptance in the literature that traditional questionnaire based surveys were insufficiently rigorous in their approach to understanding safety culture, it was essential, in order to answer research question 2, that a satisfactory answer to question 1 be found. Before that however, there was a pressing need to identify a clear and concise definition of safety culture and safety climate that would serve as the framework around which all modelling and education would be structured.

1.5 Contribution to knowledge

In the early days of this research project, the author contacted Professor Emeritus Andrew Hale formerly of the Safety Science Group at Delft University of Technology, Netherlands to ask for a reference to a paper he had written on safety culture. As a courtesy, this research project was outlined to him and his response is quoted with his kind permission – *"I have always felt that we need a management simulator to help train managers in safety management. I had a few MSc students in Delft look at the issue, but they never got very far."* (personal communication, May 17, 2012).

This research project provides a solution to Professor Hale's belief as well as the challenge proposed by Glendon and Stanton (2000, p. 4) in their rallying call to academia and industry for *"imaginative methods of assessment and analysis".* By addressing the issues surrounding what is meant by safety culture and safety climate, it has been possible to identify and quantify an approach to corporate safety culture and safety climate determination which fits within the general definitions of the two terms.

In addition to the safety culture assessment and analysis challenge, the development of a learning environment containing over a quarter of a million discrete safety related data items enabled the construction of a teaching tool which has greatly improved the education and training opportunities available to line management. This has been borne out through active participation by a broad sample of participants from a variety of industries.

As a consequence of the approach taken to identifying the solutions described above, some new avenues of future research have been opened up. These include new topics such as 'Safety Climate Deficiency Analysis' (Cram & Sime 2014)' and 'Pro-activity Indices' as well as opportunities to examine how individuals interact with information being presented on a data wall.

The original aspects of this research are that it provides –

- An alternative approach to questionnaire surveys for evaluating corporate safety culture on a continual basis
- additional ways of identifying corporate pro-activity in safety related issues
- a new approach to safety related management education
- a mechanism for modelling corporate safety culture using data readily available in most organisations

It should be noted that there is a strong bias toward the oil industry in this research project. This stems directly from the author's circa 40 years' experience in this industry. The research did not, however, exclude other industries operating in high risk environments and the results of this project are equally applicable to all industry sectors wishing to address the issue of safety culture.

1.6 Thesis structure

The thesis itself is presented in 8 chapters including this one. Chapter 2 reviews the current state of the art with regard to safety culture evaluation and addresses the issues faced by all who seek to measure and evaluate organisational safety culture. Problems associated with safety culture questionnaires and the approaches to safety culture surveys are discussed along with a review of some of the most common tools and techniques.

In Chapter 3, data sources which can be used to evaluate safety culture are identified. The chapter continues with the description of a conceptual framework incorporating safety culture, behaviours, safety climate and management influences identified in the first part of the chapter. Combined, these provide the means to model the safety culture of the organisation.

Chapter 4 deals with the methodology that will be adopted for the research project. Different methodologies are discussed ending with a more detailed description and justification of the final selection.

In Chapter 5, the design of a teaching tool to educate management in the measurement and evaluation of organisational safety culture from existing data is presented. This includes a discussion on the corporate model to be developed, its structure, staffing, operational constraints etc. Consideration is given to exactly what kind of tool will be designed and built and where this tool fits within current teaching/instruction/training models.

Chapter 6 describes the development and implementation of the tool proposed in Chapter 5 with examples of each of the modules contained within. In addition to addressing the various components, a brief discussion on the design approach adopted with regard to individual screen layouts, colours and presentation techniques is included.

Chapter 7 presents the results of the data analysis looking, not only at how the participants used the tool, but at how effective the tool was in changing their belief systems. Analyses include: end-of-year culture reports, screen importance perceptions, job description analyses, pre-and post-session interviews, participant e-mail traffic statistics and a thematic analysis of overall participant feedback. The participants are evaluated as members of 3 categories established on the basis of professional experience, industrial background and managerial seniority. The categories are further subdivided into 8 groups which form the basis of the evaluation. These groups are constructed -

- According to profession – (1) HSE, (2) Finance, (3) General Industry
- According to background – (4) Oil, (5) Non-oil
- According to seniority – (6) Senior, (7) Middle, (8) Junior

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When appropriate, such as in the thematic analysis, or for comparison purposes with a larger population, all of the participants are grouped together into a 9th group.

Finally, Chapter 8 discusses the project and its findings and suggests some possible avenues for future research in this area.

Chapter 2 Safety management and culture/climate evaluation

2.1 Brief history of health and safety

The concepts of health and safety, health and safety management and legal compensation date back thousands of years (Johns 1904, pp. 63-84) –

> *"If a surgeon has operated with the bronze lancet on a patrician for a serious injury, and has caused his death, or has removed a cataract for a patrician, with the bronze lancet, and has made him lose his eye, his hands shall be cut off".*

> *"If a builder build a house for a man and do not make its construction meet the requirements and a wall fall in, that builder shall strengthen that wall at his own expense".*

> *"If a builder has built a house for a man, and has not made his work sound, and the house he built has fallen, and caused the death of its owner, that builder shall be put to death".*

Little changed from these early Babylonian times until the industrial revolution. In the United Kingdom, the Health and Morals of Apprentices Act (UK Government 1802) was the first attempt in the UK to try to prevent the abuse and exploitation of young apprentices by addressing their health and working conditions. As a step in the right direction, it was to be applauded though its implementation was lacking and over the next two centuries, a series of more stringent laws were passed, for example, Cotton Mills Act 1819 (limiting working age in cotton mills to 9), Mines and Collieries Act

1842 (women and children under 10 years of age forbidden to work in mines), Explosives Act of 1875 (UK Government 1875) which, along with numerous other pieces of legislation, culminated in the Health and Safety at Work Act of 1974 (UK Government 1974).

A series of major events in various industries around the world, including such disasters as Seveso (Bertazzi et al. 1998) and Bhopal (Broughton 2005) prompted the development of initiatives such as, the Canadian Chemical Producers' Association's global initiative – 'Responsible Care' in 1985. Today, that initiative continues to be driven by the International Council of Chemical Associations (ICCA 2005). Over approximately the same period, in the oil industry alone, the Association of Oil and Gas Producers (OGP), which comprises the largest oil companies in the world, reported 16 major events (non-aviation related) involving 785 deaths (OGP 2010).

These types of events, in the latter half of the 20th century, provided a great impetus to developing the concepts of safety management (Bird & Germain 1989). It is also around this time that the first references began to be made to concepts such as 'safety climate' (Zohar 1980), safety culture (IAEA 1986) and safety management (Cullen 1990).

2.2 Defining safety culture

Unfortunately, the word culture encompasses many disciplines and environments. With such an array of definitions, it is a word replete with different interpretations depending on the individuals being asked. Whether it be safety culture, or any other form of culture, it is influenced by a variety of external factors. In his description of culture as related to pilots, Helmreich and Merritt (1998) identify three differing cultures associated with the profession; national culture, professional culture and organisational culture.

We are all, as individuals, affected by our national culture. This culture influences our belief system, our behaviour and the values we share with other members of the same background. It is instilled in us from an early age. Professional culture encompasses the values and beliefs that individuals bring to the workplace and which is driven by a love of their work and a desire to carry out that work safely and efficiently. A possible downside of this culture, identified by Helmreich and Merritt (1998), is a strong negative component deriving from an almost universal belief (in the case of pilots) of personal invulnerability. This can have an adverse effect on some aspects of safe operations.

According to Helmreich and Merritt (1998) the organisation itself provides the framework within which differing cultures (depending on national roots and professionalism) function and it is at this level that the greatest effect may be achieved, provided that the impetus for such change is driven by senior managers. It is they who can demonstrate their commitment to fostering open communications and actions as opposed to adopting attitudes such as self-denial which can be a reaction to the discovery of risks and other safety culture related issues.

Helmreich and Merritt's 'Rain of error' model (1998) while specifically targeted towards aviation safety is equally applicable to general safe operations and is modified here to illustrate how it fits within general industrial safety culture (Figure 2.1).

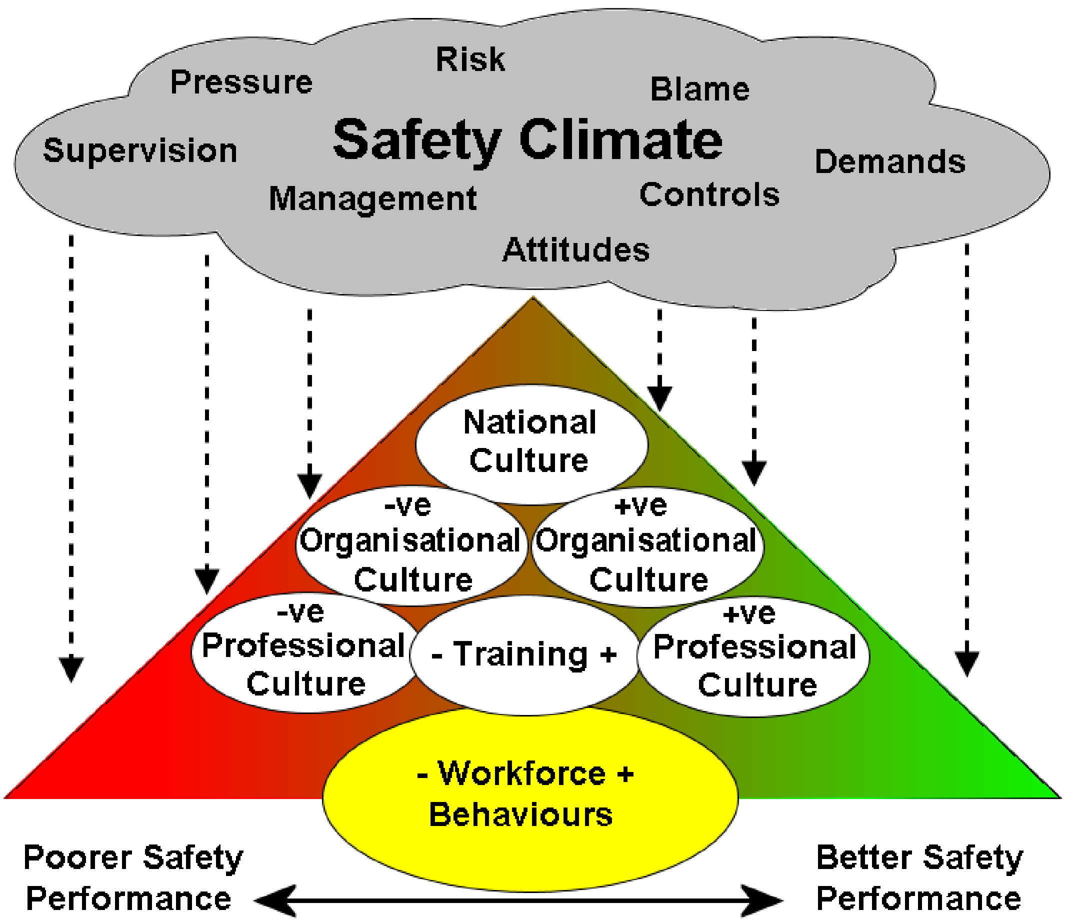


Figure 2.1 Climate of Error.

Modified from Helmreich & Merritt's 'Rain of error'

Another model that has been developed recently comes from CoreSafety (2014), an initiative by the US National Mining Association to produce a 'model for safety culture in mining'. In this model, three core, interlocking elements of Systems, Leadership and Culture are perceived as directly influencing 14 'dimensions' namely: vigilance, trust, reporting, leadership, learning, justice, engagement, empowerment, discipline, competency, communication, awareness, adaptability and accountability.

By the arrival of the 21st century, observations such as that of James Reason (2000, p. 3) at the University of Manchester - *"…….. only a safe culture can provide any degree of lasting protection"* and John Quast (2004, p. 22) of Shell –

> *"You can talk about systems and procedures and you can have all of that in place but if people don't follow them or [they] have a supervisor* that is not *behaving as an HSE leader then you don't have a good HSE culture"*, to which he added, *"accidents would continue to occur due to a poor HSE Culture despite the fact that a company had good safety procedures and standards in place"*

were becoming common and the safety community in both academia and industry was focusing more on the influences and impacts of good safety culture on organisational performance. A natural consequence of this increase in activity and focus was the appearance of a variety of questions not least of which were –

- What is safety culture?
- How can we influence safety culture?
- How can we measure safety culture?
- How do we know if we have a good safety culture?

While the questions are short and succinct, the answers have proven themselves to be extremely complex and elusive. A simple answer to the first question 'What is safety culture' has evaded consensus for over three decades. Table 2.1 presents a collation of safety culture definitions, the majority from Wiegmann et al. (2002, p. 6) with additional contributions from ECAST (2011, p. 2), Hansen (2000, p. 4), INPO (2010,

p. 7), OSHA (2014, p. 1) and a project participant (personal communication, April 16, 2013). Additionally, the International Nuclear Safety Advisory Group's (INSAG) report on safety culture (INSAG-4 1991) was a ground-breaking work which set out to, and succeeded in, clarifying the concept of safety culture. A decade later, the group published a 'next generation' document (INSAG-15 2002) reinforcing the message that the *"first step in promoting a strong safety culture is vital: to obtain visible commitment from the top of the organization."*

What is apparent from all of the definitions is that, while there is broad agreement by most authors on the inclusion of items such as behaviours, values, beliefs, attitudes, opinions, etc., agreement on how to uniformly express safety culture remains elusive.

Source	**Safety Culture**
Hansen (2000, p. 4)	*"Safety culture deals with the "unwritten rules" (clarified by action) that determine if safety really is important in an organization. Safety culture is forged by what executives do (their decisions and actions) more than by what executives say (their policies and proclamations). Tactics most commonly pursued to strengthen safety culture in organizations are: visioning sessions, mission and purpose definition, and values clarification ... and, above all, commitment to high visibility executive participation in the process."*
Carroll (1998)	*"Safety culture refers to a high value (priority) placed on worker safety and public (nuclear) safety by everyone in every group and at every level of the plant. It also refers to expectations that people will act to preserve and enhance safety, take personal responsibility for safety, and be rewarded consistent with these values."*
Ciavarelli & Figlock (1996)	*"Safety culture is defined as the shared values, beliefs, assumptions, and norms which may govern organizational decision making, as well as individual and group attitudes about safety."*
Cooper M.D. (2000)	*"Safety culture is a sub-facet of organizational culture, which is thought to affect member's attitudes and behaviour in relation to an organization's ongoing health and safety performance".*

Cox & Cox (1991)	*"Safety culture reflects attitudes, beliefs, perceptions, and values that employees share in relation to safety."*
Cox & Flin (1998) Lee (1998) Wilpert (2000)	*"The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organization's health and safety management."*
ECAST (2011, p. 2)	*"Safety Culture is the set of enduring values and attitudes regarding safety issues, shared by every member of every level of an organisation. Safety Culture refers to the extent to which every individual and every group of the organisation is aware of the risks and unknown hazards induced by its activities; is continuously behaving so as to preserve and enhance safety; is willing and able to adapt itself when facing safety issues; is willing to communicate safety issues; and consistently evaluates safety related behaviour."*
OSHA (2014, p. 1)	*"Safety cultures consist of shared beliefs, practices, and attitudes that exist at an establishment. Culture is the atmosphere created by those beliefs, attitudes, etc., which shape our behaviour. An organizations safety culture is the result of a number of factors such as: Management and employee norms, assumptions and beliefs; Management and employee attitudes; Values, myths, stories; Policies and procedures; Supervisor priorities, responsibilities and accountability; Production and bottom line pressures versus quality issues; Actions or lack of action to correct unsafe behaviours; Employee training and motivation and Employee involvement or 'buy-in'."*
Eiff (1999)	*"A safety culture exists within an organization where each individual employee, regardless of their position, assumes an active role in error prevention and that role is supported by the organization."*
Flin, Mearns, Gordon, & Fleming (1998)	*"Safety Culture refers to entrenched attitudes and opinions which a group of people share with respect to safety. It is more stable [than safety climate] and resistant to change."*
Helmreich & Merritt (1998)	*"Safety culture: A group of individuals guided in their behaviour by their joint belief in the importance of safety, and their shared understanding that every member willingly upholds the group's safety norms and will support other members to that common end."*
McDonald & Ryan (1992) Mearns & Flin (1999) Pidgeon (1991) Pidgeon & Oleary (1994)	*"Safety culture is defined as the set of beliefs, norms, attitudes, roles, and social and technical practices that are concerned with minimizing the exposure of employees, managers, customers, and members of the public to conditions considered dangerous or injurious."*
Mearns, Flin, Gordon, & Fleming (1998)	*"Safety culture is defined as the attitudes, values, norms and beliefs which a particular group of people share with respect to risk and safety."*

International Nuclear Safety Advisory Group (1991)	*"Safety culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance."*
Project Participant (2014)	*"That attitude to work which if, (and only if), supported by fully visible commitment from the top of a company, issues into a course of action and a confidence among the workforce that whatever is done, (or if appropriate not done), in the name of safety will be upheld at all times, and will in the long term make the company more successful and more profitable."*
Minerals Council of Australia (1999)	*"Safety culture refers to the formal safety issues in the company, dealing with perceptions of management, supervision, management systems and perceptions of the organization."*
Pidgeon (2001)	*"A safety culture is in turn the set of assumptions, and their associated practices, which permit beliefs about danger and safety to be constructed."*
INPO (2010, p. 7)	**Simplest Definition -** *"Making sure people are not harmed is how we do things around here"* **Clear Definition –** *"Professional leadership attitudes in a High Reliability Organization that manage potentially hazardous activities to maintain risk to people and the environment as low as reasonably achievable, thereby assuring stakeholder trust."*

Table 2.1 Definitions of safety culture.

In view of the difficulties in establishing a clear definition of safety culture it is easier to understand why industry as a whole appears to be stuck on the plateau identified by Fennell (2006) and the Health and Safety Executive. Until an effective solution is found to defining and quantifying safety culture, further substantial progress towards achieving the utopian goal of an accident free workplace is unlikely to be realised.

From their research into the differing definitions of safety culture, Wiegmann et al. (2002) synthesised a general definition for safety culture -

> *"Safety culture is the enduring value and priority placed on worker and public safety by everyone in every group at every level of an organization. It refers to the extent to which individuals and groups will commit to personal responsibility for safety, act to preserve, enhance and communicate safety concerns, strive to actively learn, adapt and modify (both individual and organizational) behaviour based on lessons learned from mistakes, and be rewarded in a manner consistent with these values."*

2.3 Defining safety climate

In parallel with the growing references to safety culture, references were also made to safety climate. In common with the safety culture definitions presented in Table 2.1, definitions and opinions on exactly what safety climate is are not hard to find. Indeed, there appears to be as many differences in the perceptions that individuals and organisations have of safety climate as there are diverse definitions of safety culture.

Table 2.2 presents a sample of some of these definitions which reflect a similar confusion to those of safety culture. Once again. the majority are cited in Wiegmann et al. (2002, p. 9-10) with additional contributions from a project participant (personal communication, April 16, 2013), Kines et al. (2011, p. 634), NHS (2010, p. 2) and Singh et al. (2008, p. 1).

Source	Safety Climate Definition
Bureau of Air Safety Investigation (BASI 1996)	*"The procedures and rules governing safety within an organization are a reflection of its safety climate, which is centred around employees perceptions of the importance of safety and how it is maintained within the workplace."*
Cheyne, Cox, Oliver, & Thomas (1998)	*"Safety climate can be viewed as a temporal state measure of culture, which is reflected in the shared perceptions of the organization at a discrete point in time."*
Dedobbeleer & Beland (1991)	*"Safety climate is viewed as an individual attribute, which is composed of two factors: management's commitment to safety and workers' involvement in safety."*
Flin, Mearns, Gordon, & Fleming (1998)	*"Safety Climate refers to the perceived state of safety of a particular place at a particular time. It is therefore relatively unstable and subject to change depending on features of the operating environment."*
Flin, Mearns, O'Connor, & Bryden (2000)	*"Safety climate is the surface features of the safety culture discerned from the workforce's attitudes and perceptions at a given point in time."*
Griffin & Neal (2000)	*"Safety climate should be conceptualized as a higher order factor comprised of more specific first order factors. 1st order factors of safety climate should reflect perceptions of safety-related policies, procedures and rewards. The higher order factor of safety climate should reflect the extent to which employees believe that safety is valued within the organization."*
Hofmann & Stezer (1996)	*"Safety climate is operationalized as perceptions regarding management's commitment to safety and worker involvement in safety related activities"*
Mearns, Whitaker, Flin, Gordon, & O'Connor (2000)	*"Safety climate is defined as a "snapshot" of employees' perceptions of the current environment or prevailing conditions, which impact upon safety."*
Minerals Council of Australia (1999)	*"Safety climate refers to the more intangible issues in the company, such as perceptions of safety systems, job factors and individual factors."*
Yule, Flin, & Murdy (2001)	*"Safety climate is defined as the product of employee perception and attitudes about the current state of safety initiatives at their place of work."*

Zohar (1980) (Manufacturing, including metal, food, chemical and textile, Israel)	*"Safety climate is a particular type of organizational climate, which reflects employees' perceptions about the relative importance of safe conduct in their occupational behaviour. It can vary from highly positive to a neutral level, and its average level reflects the safety climate in a given company."*
Zohar (2000) (Manufacturing, Israel) Group level	*"Safety climate refers to shared perceptions among group members with regard to supervisory practices."*
Project participant (personal communication, April 16, 2013)	*"That sense by the workforce, (based on past experience), of what management reaction is likely to be, in regard to any safety action or inaction they display or enact while carrying out their job, or observing others carry out their job, or while they are walking around their workplace."*
Kines et al. (2011, p. 634)	*"Safety climate is defined as work group members' shared perceptions of management and work group safety related policies, procedures and practices."*
NHS (2010, p. 2)	*"Safety climate refers to the measurable components of safety culture. The terms 'culture' and 'climate' are often used interchangeably, though."*
Singh et al. (2008, p. 1)	*"In broad terms, climate can be seen as the observable/measurable part of culture."*

Table 2.2 Definitions of safety climate.

Wiegmann et al. (2002, p. 10) also provided a synthesised definition of safety climate based on their review. They define safety climate as –

> *"the temporal state measure of safety culture, subject to commonalities among individual perceptions of the organization. It is therefore situationally based, refers to the perceived state of safety at a particular place at a particular time, is relatively unstable, and subject to change depending on the features of the current environment or prevailing conditions."*

The key message from their definition is that safety climate is the 'temporal state' of safety culture and that it is transient, relatively unstable and subject to change depending on the features of the current environment or prevailing conditions.

The synthesised definitions of safety culture and safety climate provided by Wiegmann et al. (2002) were adopted because they represent an 'average' view rather than the diverse definitions derived from the belief systems of individuals expressing their personal opinions. By considering the descriptions of safety culture and safety climate from a variety of individuals and groups across widely differing industries and cultures, Wiegmann et al. have developed a more general definition of safety culture and climate.

2.4 Review of safety culture/climate modelling and evaluation tools

It has been proposed by Apostolakis and Wu (1995) that safety culture can not and should not be separated from other aspects of organisational culture. In their investigation into the safety culture in nuclear installations, they propose that it is impossible to separate any analysis of safety culture from an analysis of power production and that consequently, the broader concept of a quality culture should be adopted. This poses the immediate question of 'why stop at quality culture?' There is a case to be made that organisational culture is simply a composite of all of the different cultural headings: quality, safety, environmental, financial, etc.

There is, however, a danger in trying to persuade industry to run before it can walk by eliminating the concept of safety culture and replacing it with a potentially more obscure term, 'quality culture'. If industry has not yet managed to embrace a common approach to the measurement and evaluation of safety culture, complicating matters further is unlikely to bring success.

There is a risk at this point of straying into a hypothetical debate on whether to separate safety culture from holistic culture. For the purpose of this research, safety culture will be treated as a separate topic though recognition is given to its place in overall corporate culture.

Over the last 30 to 40 years, safety culture and its analysis has been approached from two distinct perspectives. The psychological approach seeks to quantify and understand safety culture by investigating and analysing the beliefs, perspectives, attitudes, values and opinions of the workforce. The management approach looks into the existence or otherwise of policies, procedures, regulations and guidelines and how these are merged into a corporate safety culture through the use of safety management tools such as HSG65 (HSE 1997), BS8800 (BSI 2008), OHSAS 18001 (OHSAS 2007), ILO OSH: 2001 (ILO 2001) and RCMS (ACC 1985).

A great deal of effort by both academia and industry has been, and continues to be, expended in attempting to model and evaluate the safety culture of an organisation. Guldenmund (2010) identifies 3 distinct approaches to evaluating safety culture: academic, analytical and pragmatic.

Normally, entirely qualitative, the academic approach seeks to investigate and understand the organisational safety culture through the use of tools such as interviews, investigations and observations. In light of the mostly non-numerical nature of the information in this type of approach, little opportunity is available to conduct quantitative evaluation. Focusing on revealing knowledge from sources such as historical records the academic approach is backward facing and seeks to understand the organisation's current safety culture by examining how it arrived at its current state.

The pragmatic approach to safety culture research in many aspects mirrors a traditional gap analysis. By seeking to identify what cultural enhancements need to be achieved to propel the organisation to the next level of safety maturity, this approach is more focused on the future. Additionally, by identifying what needs to be done to affect culture change, it has a tendency to be more prescriptive in nature.

The analytical approach is the most common and most popular in evaluating safety culture. Typically, it tackles the identification of safety culture by means of survey questionnaires. In most cases, researchers seek to apply statistical analysis techniques to the responses collected.

Cooper (1997) adapted Bandura's (1977) reciprocal determinism model to attempt to model organisational safety culture. In Cooper's (1997) model, the three elements from Bandura's construct - Person, Situation and Behaviour map on to Safety Climate, Safety Behaviour and Safety Management System (Figure 2.2).

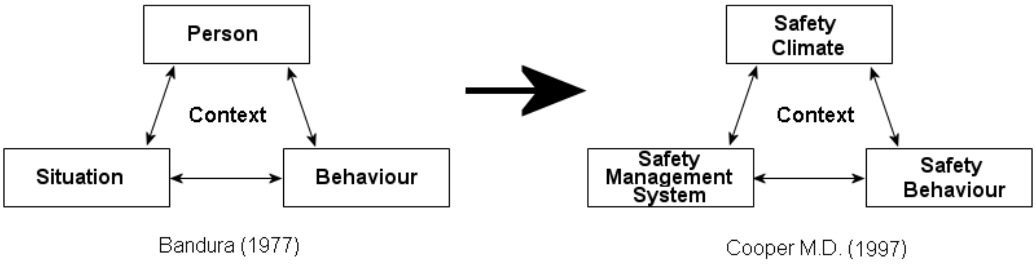


Figure 2.2 Cooper's adaptation of Bandura's reciprocal determinism model.

Cooper (1997) approaches the evaluation of the individual components using different measurement criteria. Safety Climate is measured by a 'perceptual audit' of the beliefs and views of the workforce. Safety Behaviour is assessed through the use of check lists and other behavioural indicators derived from ongoing behavioural safety initiatives and finally, the safety management system is measured objectively using Safety Management System (SMS) audits. Cooper's (1997) view is that since each element of the culture model can be measured both independently and in combination it is therefore possible to arrive at a meaningful evaluation of safety culture.

Hudson (2001) defined 5 discrete stages that define organisational safety culture progress towards the ideal –

- Pathological
- Reactive
- Calculative
- Proactive
- Generative

In the pathological organisation, concern for safety is all but non-existent. The organisation may even be operating in a state of denial where the 'messenger is shot'. A blame culture is prevalent with management seeking to punish and control the workforce. There is no real safety function other than that which is required to comply with legal obligations. Management is focused on profit at the expense of everything else including the workforce whose behaviour is neither regulated internally nor is of interest to the management.

The reactive organisation seeks to learn where appropriate from safety failures. More managed by bosses rather than leaders, information flows downhill and safety communications are characterised by upward incident reporting coupled with safety statistics which reveal little about underlying safety culture. The organisation is galvanised into action following every accident. When accidents do happen, the individual is still viewed as the source of the problem though the organisation does accept a degree of 'no blame'. More training is often the response coupled with additional or modified procedures. The safety function is more of a data processing entity though some attempt may be made to get the safety department to produce procedures to prevent accident recurrence. Management deem(s) the workforce responsible for safety, often exhorting the victim of an accident to 'be more careful next time'. While publicly declaring support for safety, a lack of actions gives the lie to the words in the eyes of the workforce.

The Calculative entity is dominated by management initiatives, including lots of graphs and charts, but follow up is scarce. Conventional information flows down while failure information flows up. There is little feedback and while procedures normally exist, they are not high on the priority list. In the calculative entity, the workforce is involved but has little influence. Management desires to be perceived as committed to safety but in reality does not deliver. The safety function is accepted in an advisory role. Safety reward systems are in place and the organisation has many procedures but little verification on application. Much attention is given to presenting the positive while unrealistic targets are not challenged. The workforce is usually in an excellent state often driven by appropriate reward schemes. Management is seen to ‘care’ but may not ‘know’.

The management of the proactive company looks for opportunities to improve. Safety is included in other meetings and answers to why accidents happened are sought. The workforce is involved to a large extent but is still driven by an organisation pre-occupied with statistics. Safety advisers are to be found in the ‘line’. Safety is also involved at the start of projects rather than as an afterthought and the workforce take control of procedures, development and maintenance. Management is risk aware and is beginning to take safety culture into account. Safety is beginning to take preference to production which can lead to tension within the organisation as line management is held accountable for both. Management wishes to be seen to care about safety and become more involved in accidents and near misses as learning opportunities.

The Generative organisation is at the pinnacle of safety culture. There are no divisions between management and safety. Safety is the priority in all aspects of the company’s operations and is completely integrated into all activities. The need for ‘extracting’ safety as a special topic for discussion/consideration no longer exists and the workforce is completely proactive in terms of safety improvement. Management is seen as the workforce’s partner and is perceived as the first solution to systemic safety issues. The safety department has all but disappeared and safety award schemes have died out to be replaced with a pride in safe working. Safety is regarded as an equal to production and open trusting communications on safety related issues between management and the workforce are common thereby reinforcing a culture of trust. Management not only cares about safety but it knows and understands what is involved in managing safety. Best practices and other learning flows out around the rest of the organisation when applicable.

McDonald et al. (2000) identified sub-cultures within management and technicians in aircraft maintenance organisations while Mearns et al. (1998) identified various sub-cultures within differing groups in a survey of 10 offshore installations. Denison (1996) highlighted the fact that sub-cultures may be of as much interest as organisational cultures and it is interesting to note that the UK Health and Safety Executive (HSE 2006) have identified increasing evidence of the applicability of the term ‘safety culture’ to smaller divisions such as departments or even groups of individuals within similar employment levels in addition to the overall safety culture of the organisation. They go on to note that formal measures of safety culture or safety climate need to be able to distinguish between not only different organisations within industry as a whole but also the individual departments etc. within the organisations themselves.

2.5 Problems with the survey approach to safety culture evaluation

Lord Kelvin (1883) stated that –

> *“When you can measure what you are speaking about, and express it in numbers, you know something about it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be*

the beginning of knowledge, but you have scarcely, in your thoughts advanced to the stage of science."

The International Atomic Energy Authority (IAEA 2012, Ch6, p. 10) states that –

> *"No composite measure of* <u>safety culture</u> *exists. The multi-faceted nature of culture makes it unlikely that such a measure will ever be found."*

If these two observations are correct then achieving improvements in organisational safety culture is certainly one of the most challenging tasks facing today's organisations operating in high risk environments.

Typically safety culture has been, and still is, evaluated using a questionnaire which is sent to a sample of members of the organisation under review. Various analysis techniques are then used in an attempt to quantify the safety culture of the organisation. As will be discussed in this chapter, researchers have begun to express the opinion that it may not be possible to use tools such as safety culture surveys to provide a useful measure of organisational safety culture. Charles Babbage is quoted as saying -

> *"On two occasions I have been asked [by members of Parliament], 'Pray, Mr. Babbage, if you put into the machine wrong figures, will the right answers come out?' I am not able rightly to apprehend the kind of confusion of ideas that could provoke such a question."*

The same 'confusion of ideas' apparently survives today in the domain of safety culture surveying given the observation that the knowledge derived from questionnaires is only, at best, as meaningful as the answers provided (Schwarz & Sudman 1996). It is not only the issue surrounding the quality of data in/knowledge out that is an issue. Friedman and Amoo (1999) examined problems surrounding the rating scales used in an attempt to quantify the responses of survey participants and concluded that there were problems surrounding the selection of these scales which had an impact on how research participants responded. Glendon and Stanton (2000) reinforced the concerns surrounding the survey questionnaire approach to organisational safety culture measurement highlighting the inadequacies of the survey questionnaire techniques while Guldenmund (2000) proposed that consensus had not even been reached on how to describe [safety] culture or climate. Hale (2000) added further support to the debate by suggesting that no researcher could claim that the questionnaires or rating scales which they adopted had been sufficiently validated; a view supported several years later by Guldenmund (2007) who proposed that questionnaires had not been successful in uncovering organisational safety culture.

A variety of factors combine to render the results of a safety culture survey doubtful at best and misleading at worst. Principally, these relate to Question Ordering, (Holbrook et al. 2007, Hyman & Sheatsley 1950, Jordan-Zachery & Seltzer 2011, Keeter 2014, Link 1946, McFarland 1981, Schuman & Ludwig 1983, Schuman & Presser 1981), Culture/Language (Bachman & O'Malley 1984, Cornish 2002, Dolnicar & Grun 2007, Hui & Triandis 1989, Lee et al. 2002, Pan & Fond 2010, Perez 2011, Tellis & Chandrasekaran 2010), Rating Scales, (Friedman & Amoo 1999, Schwarz et al. 1991), Bias (Choi & Pak 2005, Friedman & Amoo 1999, Paulhus, 1991), Sample Selection (Fernandez-Muniz, et al. 2009) and Safety Culture Features (Flin et al. 2000). All have the potential to impact the validity of the typical survey questionnaire approach to identifying safety culture. Each of these is discussed in more detail in sections 2.5.1 – 2.5.5.

2.5.1 Question ordering

The ordering of questions has been shown to influence the results of surveys. Schuman and Ludwig (1983) examined work on the issues surrounding the ordering of questions. They refer to examples which illustrate the influence question order has on participant response; Rugg and Cantrill (1944, cited in Schuman & Ludwig 1983) Hyman and Sheatsley (1950, cited in Schuman & Ludwig 1983), Link (1946, cited in Schuman & Ludwig 1983). An unpublished Gallup poll of 1947 was also presented but has been omitted here.

In the Rugg and Cantrill experiment participants were asked two questions but in different order (Table 2.3). The responses differed greatly, depending on the order in which the questions were put. The reliability of this outcome is, however, open to question as the number of participants was not reported.

	Position		
	1st	2nd	Difference
Should the United States permit its citizens to join the French and British Armies?	49%	43%	-6%
Should the United States permit its citizens to join the German Army?	23%	34%	11%

Table 2.3 Response to questions depending on order (Rugg & Cantrill 1944).

In a similar study (Hyman & Sheatsley 1950), several hundred people (numbers surveyed are in brackets) were asked two questions regarding the rights of reporters from the United States of America and Russia to report news as they perceived it (Table 2.4). As with the Rugg and Cantrill experiment, the responses exhibited large differences in the positive response rates depending on the question order.

	Position 1st	2nd	Difference
"Do you think a communist country like Russia should let American newspaper reporters come in and send back the America the news as they see it?"	90% (635)	66% (567)	-24%
"Do you think that the United States should let Communist newspaper reporters from other countries come in here and send back to their papers the news as they see it?"	36% (581)	73% (635)	37%

Table 2.4 Response to questions depending on order (Hyman & Sheatsley 1950).

Link (1946) proposed two questions regarding the rights of workers to strike. In a national sample, the questions were ordered oppositely. While the majority supported strikes in both instances, the difference was greater when each question was in the 1st position rather than the 2nd.

McFarland (1981) examined the effects of two question orders in a Kentucky state-wide random survey. Their findings indicated that not only did question order affect participant response but that the effects of question order were independent of gender or education level thus reinforcing the message that question order is a concern in restricted populations. Many industries operating in high risk environments tend to be male dominated, e.g. oil and gas, mining, construction, etc.

In their investigation into question order effect, Jordan-Zachery and Seltzer (2011) addressed the issue of affirmative action and whether the question order had an affect on the responses. As in other studies, it was established that the order did indeed affect the response and, in addition, their study highlighted that participants' culture also affected their responses.

The order in which a question is put can also influence the saliency of an issue so affecting respondents' answers to the question over time (Schuman & Presser, 1981).

Keeter (2014) observed that the percentage of people in favour of allowing gays and lesbians to enter into legal agreements akin to married couples was greater (45%) when the question was asked following one asking whether they favoured or opposed gay/lesbian marriage (37%). They also report that more Americans (88%) said they were dissatisfied with the way things were going in the USA when asked following a question regarding their feelings about how George W. Bush was running the country. Removing the question on Bush resulted in a drop of 10% reporting dissatisfaction with the state of the country.

There is strong evidence therefore, from many sources, that the ordering of questions has a significant impact on the responses generated and it follows that this is likely to have major implications in the design of any questionnaire and the analysis of the data subsequently collected. This is especially pertinent where the topic is as emotive as safety in high risk organisations. Safety culture surveys are expensive and time consuming for any organisation and testing the effects of question order on the intended survey population prior to conducting the final survey is likely to prove impractical and potentially disruptive to the organisation. In such an important arena as safety, it is counter productive to consider submitting a questionnaire which may be adversely affected by the vagaries of question order to a workforce already potentially disillusioned with their own safety culture. Insights derived from such a source may very well adversely influence an organisation's initiatives with regard to improving its safety culture.

2.5.2 Culture/language

Industries such as energy and mining are often multi-national and multi-cultural. The global populations and presence of some of the world's largest energy and mining companies is presented in alphabetical order in Table 2.5.

Company	Countries where present	Total staff numbers
BHP Billiton	26	128,800
BP	80	83,900
Chevron	20	61,000
Conoco Phillips	30	17,000
ENI (Agip)	90	78,000
Shell	70	92,000
Statoil	34	23,000
Total Oil Company	130	90,000

Table 2.5 Global presence of some of the major energy and minerals companies.

Source – Corporate public affairs information.

With a highly mobile workforce and with reserves most commonly restricted to the more challenging environments around the world, it is much more 'the norm' for many different cultures, nationalities and backgrounds to be working together on the same project. While it has been commonplace for many decades for diverse cultures to live and work together, the differences have been mostly overcome through shared technical experience. When the focus is on measuring safety culture, research has shown that differences in culture and language may have a demonstrable impact on attempts to evaluate organisational safety culture.

In a study of over 5,500 respondents across 15 countries, Tellis and Chandrasekaran (2010) established that different countries exhibited 'substantial' differences in responses to the same question sets. While their work was not based on safety culture, it is supported by other research all of which combine to reinforce the idea that culture and language play a significant role in affecting survey participants' responses. Dolnicar and Grun (2007) focus on the dangers inherent in drawing conclusions from cross-cultural surveys where there is demonstrable evidence of varying response tendencies which are not related to the original content of the investigation.

In their study of Asians and Asian Americans, Lee et al. (2002) found that Chinese and Japanese respondents selected midpoints more often on items that involved admitting to a positive emotion. Bachman and O'Malley (1984) established that Blacks were more likely than Whites to select extreme response categories. Hui and Triandis (1989) found that Hispanics were more likely to select extreme responses on 5 point scales.

While the simple solution to multi-cultural / multi-lingual survey issues may appear to translate the survey into the respondents' language(s), Perez (2011) cautioned against assuming that linguistic items could be translated and retain their original meaning so reinforcing the view that language itself affects one's experiences and interpretations of the world around us.

It may seem to be stating the obvious but a critical component in carrying out a survey is to get responses. Cornish (2002) highlighted that non-response to surveys can occur simply because of the inability to interact/interview the subjects in their own language and that improved cooperation can be attained by matching the linguistic and cultural backgrounds of both the interviewer and the subject. Progress continues to be made in how to accurately translate surveys into multiple languages (Pan & Fond 2010) but today, there is still scope for translation errors to corrupt survey questionnaire responses.

2.5.3 Rating scales

A common type of question in a typical safety culture survey provides responses such as 'excellent, very good, good, fair, poor' (Likert scales). This type of response is open to intentional or unintentional abuse. Friedman and Amoo (1999) examined the difficulties inherent in research based on rating scales, illustrating the scope for biasing any survey conducted using such an approach. Pollack et al. (1990, cited in Friedman & Amoo 1999) found that scales whose anchor points include strong adjectives such as 'superior' or 'terrible' do not produce the same results as scales with weaker end points such as 'very good' and 'very bad'. Respondents from some cultures seem to be reluctant to select extreme values while the converse is true for respondents from some other cultures as has been referred to in the previous section.

Numerical scales are not immune either. Schwarz et al. (1991) showed that the question "*How successful would you say that you have been in life?*" when asked of 1,032 respondents, elicited responses, when the scale was from 0 (not at all successful) to 10 (extremely successful), of 36 per cent in the range 0 to 5 and when the scale was from -5 to 5 only 13 per cent in the range -5 to 0. Even with the same verbal descriptors in both scale instances, the responses were dominated by the numerical values of the scales.

2.5.4 Bias

Paulhus (1991, p. 17) defines bias in responses as – *"a systematic tendency to respond to a range of questionnaire items on some basis other than the specific item content (i.e. what the items were designed to measure)".* Friedman and Amoo (1999) state that forced-choice rating scales affect the bias of a questionnaire by obliging respondents to actually have an opinion. By omitting the 'no opinion' option, the researcher is making the assumption that every respondent has a valid and valued opinion on the particular topic. This is not necessarily correct and can lead to bias in the data. This, according to Friedman and Amoo (1999) has the dual effect of forcing the mean and the median of responses to the middle as many respondees who hold no opinion will tend to go for the median 'average' or 'fair' values. Additionally it will make it appear that more respondents have an opinion on the particular question topic than may actually be the case.

Choi and Pak (2005) identify 48 sources of bias in how questions are presented to participants. While their examples pertain to medical surveys, 40 examples can be easily translated into the sorts of questions that one would normally expect to find in typical safety culture surveys. Two examples of questions, similar to Choi and Pak (2005, p. 2), which may lead to bias are provided in Table 2.6.

Original Choi and Pak (2005, p. 2) question	**Modified example for safety culture questionnaire**	**Bias**	**Explanation**
"Do you agree that acquired immunodeficiency syndrome (AIDS) can be transmitted by shaking hands with a person with AIDS or through other means of physical contact?"	Do you believe that risk assessment or job safety analysis are important to the organisation?	Double-barrelled	Not possible to know which part of the question is being answered. A response might include both or either of the options.
"How often do you exercise? [ ] Regularly [ ] Occasionally"	How often do you participate in tool-box talks – [ ] Regularly [ ] Occasionally	Vague word	Everyone has a different concept of what words such as Regularly and Occasionally mean.

Table 2.6 Two examples of bias-inducing survey questions (Choi & Pak 2005).

2.5.5 Sample selection

Fernandez-Muniz et al. (2009) provided a detailed description of their sample selection process in their paper on occupational safety management and company performance. It is completely outwith the scope of this research project to explore their research processes in great detail; however, a point of concern with their approach to sample selection is discussed here as it offers an insight into the difficulties associated with identifying an appropriate sample on which to conduct a safety culture survey.

Having reduced the total possible population of 62,146 companies in their survey population down to a final sample of 3,820 by means of convenient selection criteria (company size and industry sector), they then selected the safety officer as being the individual who seemed most likely to be the person with the greatest information and insight into the organisation and who would know most about the difficulties experienced in implementing any safety management system.

There are several reasons why this was most likely an inappropriate choice of individual to represent a company's safety approach. Depending on the particular company and that company's current state of evolution, the safety officer may come from a variety of backgrounds.

- He[1] may be a highly experienced and competent former technical / operational expert who occupies his current position to literally advise the company on what may and may not be done with regard to every aspect of daily operations. As such, his experience of safety is likely to be much more of the 'hands on' approach rather than the management/cultural approach.
- He may be an individual skilled in the science of safety management.
- He may be a line manager on his way up through the organisation and spending a period of time in the safety department/function as part of his overall development.
- He may be a contractor or a member of staff or he may be hired from an outsourced entity.

[1]In her book on Knowledge Acquisition for Expert Systems, Anna Hart wrote *"As in classical languages, the pronoun 'he' is assumed to embrace both genders. I do not consider it necessary to break up sentences by the continual reminder that we were made male and female."* I have subscribed to that view since I read it nearly 30 years ago and have adopted the same philosophy here.

As companies move towards greater safety management as the key factor in improving safety performance, the background and competencies of the safety manager are in a continual state of flux.

Fernandez-Muniz et al. believed that the safety officer’s opinion would be more representative of the organisation and probably less biased. This assumption itself opens up the survey to bias. Safety professionals are the only people in the organisation who are directly paid to be committed to safety. As such, their responses to questionnaires are likely to be biased depending on how effective they perceive their own influence on the company to be. It is quite likely that other members of the workforce hold a completely different view of safety and its management. By selecting a single occupational post from an inexperienced perspective, the results of their (or any other similar) survey may well have been doomed before the survey had even taken place.

2.6 Overlap with existing safety management systems

Setting aside the complex statistical analyses, techniques and metrics which are applied to the participants’ responses to survey questionnaires, much effort has been expended in identifying common features in safety culture/climate evaluation. In their investigation, Flin et al. (2000) identified 18 safety climate surveys. A synthesis of the features from all of these surveys is presented in the right column of Table 2.7 alongside, in the left column, the components of a typical SMS based on the de facto international standard for safety management systems - OHSAS 18001.

Learning Environment Safety Management System Elements	**Synthesised Features from Flin et al. (2000)**
Policy	Attitudes
Strategy	Blame
Risk & Hazard Assessment	Career
Prevention & Mitigation	Communication
Legal & Other Requirements	Competence
Objectives	Control
Line Management	Design
Individuals	Fatalism/optimism
HSE Function	Job satisfaction
Competence	Management
Awareness	Obstacles
Training	Participation
Consult. & Communication	Peer judgement
Documentation	Peer support
Document & Data Control	Personal immunity
Operational Control	Procedures
Emergency Preparedness & Response	Responsibility
Contractor Evaluation Qualification & Selection	Risk
Contractor Management	Role
Contractor Performance	Rules
Performance measuring & monitoring	Safety awareness
Accident reporting	Safety behaviour
Record Management	Safety need
HSE MS Review	Safety reporting
Self-Assessment	Safety reps
Lessons Learned	Safety system
Audit	Scepticism
Results	Sensation seeking
Actions	Speaking up
	Supervision
	Support
	Time independence
	Violations
	Work clarity
	Work environment
	Work practices
	Work pressure
	Work values

Table 2.7 OHSAS 18001 and Flin et al. (2000) safety climate features comparison.

What is apparent is that there is a degree of commonality between the OHSAS 18001 elements and the features from the various safety climate surveys identified by Flin et al. (2000). Creating a new set of themes or factors in order to evaluate safety climate may lead to confusion in organisations which already have a set of factors in place in the form of their SMS. The objective of all safety research endeavours must be to have a beneficial effect on safety performance in the field. With corporate line management already under considerable pressure from day-to-day operational requirements, introducing additional terminology to a group of individuals already inundated with existing safety related terminology, risks confusion. Given that OHSAS 18001 is, to all intents and purposes, a global standard in all but name (it is anticipated that OHSAS 18001 will be superseded by ISO 45001 in 2016) it is suggested that OHSAS 18001 or its successor should be used as the foundation of all safety culture/climate evaluation initiatives.

2.7 Review of existing tools

There is no shortage of publications, especially in the domain of the nuclear industry, on the applications for simulation based training in safety from the perspective of teaching skills to equipment or control room operators (Corcuera 2002, Duncan & Shepherd 1975, IAEA 2004, Myers 2011, Nystad & Strand 2006). On the specific subject of safety culture training simulators however, the literature is extremely sparse. A search of the Lancaster University library for publications relating to safety culture training simulators resulted in only 16 returns of which 15 were directly related to medical treatment and patient safety while the 16th referred to emergency response simulator training within the context of nuclear power plant operation. Returns from both Google and Mendeley produced equally sparse returns and those results which were returned related mostly to simulators designed to teach practical skills within the medical profession.

Jong (1991) describes 4 criteria that identify simulations used in learning and instruction through computer simulations –

- presence of formalised, manipulable underlying models
- presence of learning goals
- elicitation of specific learning processes
- presence of learner activity.

Table 2.8 lists some examples of the safety related training simulation tools which are available today along with other examples of management training games (notably, there are none encompassing safety in this group) and which, to a greater or lesser extent, satisfy the criteria outlined by Jong.

These tools are not directed at safety management or safety culture specifically. For the most part, they are focused on providing operational skills to personnel required to work in either risky environments or with the likes of patients whose health and wellbeing are entrusted into the trainees' hands. Only one tool which sought to teach safety management/safety culture was found; Nuclear Safety Sim. The developers of this tool propose it as a *"management flight simulator"* (Cudlin 2008, p.2) which seeks to inform participants how to develop and practice safety management while juggling issues such as resource allocation, problem resolution, dealing with scheduling priorities, costs and operational issues.

Simulator Type	Interface	Target	Industry	Source
Heavy Equipment Operator Training				
Front-End Wheel Loader Training Simulator	S/C	Equipment Operators	Mining	1
Electric Rope Shovel Training Simulator	S/C	Operators	Mining	1
Aircraft De-icing Training Simulator	S/C	Operators	Mining	1
Digger	S/C	Operators	Vehicle	2
Heavy Goods Vehicle	S/C	Operators	Vehicle	2
Cargo	S/C	Operators	Vehicle/Crane	2
Tower Crane	S/C	Operators	Construction	2
Offshore Crane Training Simulator	S/C	Operators	Oil & Gas	11
Construction Safety				
Construction Safety Training Simulator	O B/M	Workers	Construction	1
Industrial Safety Training Simulation	O B/M	Workers	Construction	1
The Bechtel Safety Simulator	O B/M	Workers	Construction	7
Construction Yards Risk Training Simulation	O B/M	Workers	Construction	12
Emergency Response Training				
Emergency Response Training Simulation Production	O B/M	Fire fighters	General	3
Incident Command	O B/M	Workforce	Oil & Gas	9
Medical Training				
Sim4Life – Human	O B/M	Medical Profession	Medical	4
Laboratory Training				
Starlite Laboratory Safety Training	O B/M	Lab Personnel	Scientific	5
Safety Culture				
Nuclear Safety Sim. Safety Culture Training	O B/M	Nuclear Industry Management	Nuclear	6
Electrical Safety				
HVAC Training Simulator	O B/M	Engineers	General Electrical Services	8
Offshore Safety				
Essential offshore skills	O B/M	Workforce	Oil & Gas	9
Hazard Sims	O B/M	Workforce	Oil & Gas	9
Permit to Work	O B/M	Workforce	Oil & Gas	9
Centrifugal Pump	O B/M	Workforce	Oil & Gas	9
Advanced training simulator for improved HSE in drilling and well operations	S/C O B/M	Drillers	Oil & Gas	10
Management Simulation Training Games				
General Business Management Simulation Game	O B/M	Management	General	13
Marketing Management Simulation Game	O B/M	Management	General	13
Energy Company Business Simulation	O B/M	Management	Energy	13
Mekong e_Sim	R P	Students	General Communications skills	14
Ancient Spaces	3D G T	Students/Public	Archaeology	15

Table 2.8 Selection of safety related training simulators and management games.

Interface –

S/C	- Simulated Controls
O B/M	- On-screen Buttons/Menus
R P	- Role Playing
3D G T	- 3D Game Technology

Source

1 - ForgeFX Simulations	9 - Petrosims
2 - Tenstar Simulation	10- Drilling Solutions / Sintef
3 - Sims U Share	11 -Drilling Systems UK
4 - Zurich Med Tec	12 -Qbit Technologies
5 - US Department of Health & Human Services	13- Cesim SimFirm
6 - Nuclear Safety Sim	14- University of Adelaide
7 - Bechtel Corporation	15- University of British Columbia
8 - Delmar Online Training	

Nuclear Safety Sim is available online for the general public to use though it does require significant knowledge of the nuclear industry to understand what is happening. As a safety culture teaching tool, it lags behind the solution proposed in this thesis. The interface is extremely simplistic. Only five pre-programmed 'issues' regarding work concerns such as maintenance requests and resource allocations are available for selection. The user is required to set initial conditions such as cost goals and backlog goals. The only discernible safety component is a value that is set for each issue by the user between 1 and 10. When the user has set the parameters for an issue, he presses the play button and the plant model advances by 3 months. A graph of some aspect of plant performance updates and the system waits for the next set of inputs.

As a simulator, it is correctly defined though it is difficult to establish how it teaches anything in particular about safety, safety management or safety culture. During discussions with one of the developers of the simulator, he referred to it thus - *" To* *the extent that the overall enterprise is modelled it is to provide a quasi- realistic context for the decision making aspect of the sim"*.

The fact that the authors must have pre-programmed specific direct links between operator input and plant performance (including safety) in order to generate the output brings into question whether it is possible or credible to 'hard-wire' actual safety performance to management inputs.

Apart from this simulator, no other similar type of tool has been discovered. While it was certainly an option to prolong the review of the literature (which had begun to result in a particularly circuitous path) and continue to look for other teaching tools, the observation of Dunleavy (2003, p. 32) was beginning to resonate –

> *"Once you have a good sense of where your interests lie and can relate your question effectively to the research literature, the hard part is to sit down and try to contribute, that is to push ahead knowledge in some particular arena or endeavour. A potent reason why we all tend to overextend literature reviews is that doing so postpones this psychologically taxing moment when we have to think through new ideas for ourselves."*

2.8 Summary of existing safety culture issues

Given the range of problems identified and the lack of existing tools, Glendon and Stanton's call for *"complex and imaginative methods of assessment and analysis"* (2000, p. 4) is one that industry and academia need to address together, and with a degree of urgency, if viable alternatives are to be identified and applied.

The research questions addressed in this thesis are –

1. *"How can HSE culture be modelled effectively?"*
2. *"How can management be educated in the measurement and evaluation of safety culture of their organisations?"*

It is proposed that there is already sufficient knowledge available to the typical organisation operating in a high risk environment concealed within their existing safety related databases and that uncovering and analysing these data will produce sufficient knowledge to provide an answer to the first question.

The second question can be answered if a credible mechanism can be identified which will enable this knowledge to be communicated to management in a manner which facilitates improving their understanding, not only of how to evaluate the safety culture of their organisations, but also how to best champion an effective safety culture. The most likely approach to answering this question will be to construct a training tool which will incorporate the knowledge identified in question 1 and present it in such a way as to satisfy the requirements of question 2.

Chapter 3 Learning environment conceptual framework

This project set out to establish how to model effectively the safety culture of an organisation and how then to pass that knowledge on to the people who have the greatest influence on corporate safety culture; management. It was clear from the review of current approaches to safety culture evaluation described in Chapter 2 that industry in general possesses neither a clear definition of safety culture nor a robust method of evaluation. This lack of insight is further exacerbated by a pervasive confusion as to the differences between the terms ‘safety culture’ and ‘safety climate’.

Following an extensive review of the literature via Lancaster University library services, Mendeley and the internet, it became clear that the existing approach to identifying safety culture, namely survey questionnaires, has been shown to be inadequate and despite calls for a different approach no new solution has been forthcoming.

This chapter discusses the design of a conceptual framework to describe organisational safety culture from the perspective of existing data which could be expected to be available in organisations operating in high risk environments. For simplicity and ease of reference, a fictitious oil company was invented and which was assumed to possess all of the information that one would expect to discover in the typical oil company. The company was called ‘Lancaster Oil Ltd.’ and at the time of writing, no such company is registered in the UK.

3.1 Identification of data sources

Reason (2009, p. 195) suggests the components of a safety culture are that:

- *safety culture should drive the entity in the direction of continuous improvement 'regardless of the leadership's personality';*
- *it collects the right kind of data;*
- *it incorporates a reporting culture;*
- *it has an informed culture;*
- *it has a just culture;*
- *the culture be flexible;*
- *it has a learning culture.*

The Center for Chemical Process Safety put forward a somewhat tongue in cheek observation (CCPS, 2011, p. 1) which suggests that - *"Safety culture is how the organization behaves when no one is watching".*

A closer study of the Wiegmann et al. (2002, p. 8). definition reveals that the CCPS (2011, p. 1) comment may in fact be much closer to the truth than perhaps many in industry have hitherto acknowledged. Concealed within this general safety culture synthesis are strong pointers on where to look within organisations to find quantifiable measures of safety culture.

> *"Safety culture is the enduring value and priority placed on worker and public safety by everyone in every group at every level of an organization. It refers to the extent to which individuals and groups will commit to personal responsibility for safety, act to preserve, enhance and communicate safety concerns, strive to actively learn, adapt and modify (both individual and organizational) behaviour based on lessons learned from mistakes, and be rewarded in a manner consistent with these values."*

Dissecting Wiegmann et al.'s (2002) synthesis highlights a number of key topics which can be developed further to construct the foundations of a safety culture model –

- *"enduring value and priority placed on worker and public safety"*
- *"everyone in every group at every level"*
- *"act to preserve, enhance and communicate safety concerns"*
- *"strive to actively learn, adapt and modify… behaviour"*
- *"lessons learned from mistakes"*
- *"rewarded"*

Data, which are readily available to any organisation, should it choose to collect them, can be used to establish how much or how little the entity may adopt/reflect these characteristics.

"Enduring value and priority placed on public and worker safety" contributes to identifying whether an organisation is 'risk averse' or 'risk tolerant' and whether it positions itself to be 'progressive' or 'prescriptive' in the way it approaches safety.

"*Lessons learned from mistakes"* and *"communicating safety concerns"* to *"every group at every level"* separates the 'open' organisation as opposed to the 'secretive' entity.

"Acting to preserve and enhance safety concerns" has links to whether the organisation looks backwards 'lagging' or forwards 'leading' with regard to its view on safety performance improvement.

Whether an organisation *"strives to actively learn"* can be identified to a great extent not only from the training which it provides to its management and workforce but also what sources of knowledge the organisation embraces in order to learn. Organisations make a deliberate choice as to whether they wish to be ‘informed’ or ‘ignorant’. and this can be identified from such sources as –

- Audits
- Inspection
- Meetings
- Reviews
- Reports
- Alerts

all of which provide useful, sometimes vital, information on safety improvements.

A willingness to “adapt and modify” translates into whether the organisation is one which is ‘amenable’ to change or ‘dogmatic’ in its attitudes and whether it is ‘reactive’ or ‘proactive’ in its adherence to the way things are done today.

An organisation which values safety, not necessarily from a financial perspective only, will almost certainly find ways to ‘reward’ staff for efforts to improve rather than ‘penalising’ them for failures.

A breakdown of Wiegmann et al.’s (2002) synthesis of safety culture has identified 8 safety culture couplets -

- Risk averse versus risk tolerant
- Progressive versus prescriptive
- Open versus secretive
- Leading versus lagging
- Informed versus ignorant
- Amenable versus dogmatic
- Reactive versus proactive
- Rewarding versus penalising

All of these characteristics play directly into the overall safety culture of the organisation which, it is widely accepted, is driven from the top down. Without the support and input from the top managers, a good safety culture is unachievable (Hansell 2008, Leonard & Frankel 2012, National Safety Council 2013, OGP 2013, Ruchlin et al. 2004). Management at the top, therefore, is the key driver of everything safety-related within the organisation whether it be in the domain of safety culture or safety climate. The impetus behind developing a good safety culture is therefore driven, to a large extent, by whether the organisation is managed by a 9th couplet - *Leaders* or *Bosses*.

Support for this approach comes from an analysis by Van Wijk et al. (2008) of 10 major events where they identify 8 characteristics –

- leadership issues;
- operational attitudes and behaviours (operational 'culture');
- the impact of the business environment (often commercial and budgetary pressures);
- oversight and scrutiny;
- competence and training (at all levels);
- risk assessment and risk management;
- organisational learning;
- communication issues.

as being relevant in accident causation. These correlate well with the 9 culture couplets identified by the author from the analysis of Wiegman et al.'s. (2002) synthesis.

The following sections will explore and expand on the nature, source and relationship between data which are (should be?) routinely collected by many organisations and the various safety characteristics derived from a detailed review of Wiegmann et al.'s (2002) definition of safety culture.

3.2 Availability of data

Recalling the observation of the CCPS (2011. p. 1) that safety culture is how the organisation behaves when no-one is watching, it is more than likely in the 21st century that someone is watching most of the time. Many countries, if not the majority, around the world have their own laws requiring companies to record and report serious accidents or dangerous situations. In the UK, this is specified in regulations such as the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR 2013) or the Environmental Reporting Guidelines (DEFRA 2013) . In the USA, OHSA (2001) requires companies to maintain records and report illnesses under the OSHA Injury and Illness Record keeping and Reporting Requirements (29 CFR 1904). In Australia, the obligation is imposed under the Work Health and Safety Act (Australian Government 2011).

Large companies at least usually possess databases on a variety of safety related issues. What use they make of these data is questionable. Over 30 oil and gas companies comprise the Organisation of Oil and Gas Producers and this organisation annually produces a report on global safety performance. The 2012 report (OGP 2012) contained over 100 pages of data relating to safety performance. Notably, these were exclusively historical (lagging) indicators.

Every organisation operating in a high risk environment generates a large quantity of safety related information on a daily basis. Typically, this information is collected from sources such as -

- Accident reports[1]
- Incident reports [2]
- Leak reports
- Pollution reports
- Safety meetings
- Safety inspections
- HAZard and Operability Studies (HAZOPS)
- HAZard IDentifications (HAZID)
- Risk assessments
- Unsafe act/unsafe condition reports

3.2.1 Accident records

The raw data from the typical corporate accident report provide information on date, time, location, injured parties, type of event. While important, it is the subsequent investigation of the accident which produces the most useful insights in respect of corporate safety culture. As investigators drill deeper into the underlying causes and issues which led to the accident, a wealth of knowledge is (or should be) revealed about the actual functioning of the organisation at the time of the event. In addition to these data, actions to prevent recurrence and so improve organisational safety performance in the future are also identified.

1 For the purpose of this thesis, the word accident shall mean an event which resulted in injury to one or more people.

2 For the purpose of this thesis, the word incident shall mean an event in which there was no injury to people but property damage did occur.

Typically, accident reports are kept for legal as well as for reference purposes either in electronic or paper form. It is normal that these reports contain detailed information not only about the accidents themselves but also about the entities experiencing the accidents (i.e. company or contractor). Root cause analysis of each and every event often provides key information with regard to deficiencies in the way safety is being managed both in the organisation and in its contractors. As will be discussed later in this thesis, deeper analysis of the underlying issues which enable accidents to occur in the first place will reveal that much valuable information regarding safety culture is also available from these reports and subsequent investigations.

From the accident reports it is a simple matter to extract the data needed to populate a number of different information sets including: the accident triangle, department/contractor influence, man hours since last accident, accident distribution, accident frequency and total recordable injury rate. From an analysis of the management system failures which allowed the accident to occur in the first place, deficiencies in the implementation of the safety management system can be identified.

3.2.2 Action tracking records

It is more common than not that some form of 'lessons learned' programme exists and usually associated with that is the need for an action tracking system to monitor the implementation and close out of lessons/actions/recommendations generated within the organisations.

Usually, safety improvement actions generated by any organisation originate from a variety of discrete sources. Most commonly, these are: accident investigations, safety inspections, unsafe act/unsafe condition reports, toolbox talks (discussions at the worksite between supervisors and workers which are normally held immediately prior to work beginning), safety meetings and audits being the most common, though not exclusive, sources. When the activities associated with improvement actions are reviewed, of them all, only those generated from accident/incident investigations are reactive. All of the other actions, produced without the need for an accident or incident to provoke them, are proactively generated. In other words, the organisation has waited for an unplanned event before identifying actions to prevent recurrence. This simple division provides a valuable insight into whether the organisation as a whole, or departments in particular, are proactive or reactive in producing safety related actions as part of their continuous safety improvement process.

3.2.3 Training records

Training records are commonplace and usually the property of either a dedicated training department or the human resources department. Numbers of training courses taken are not in themselves a particularly enlightening statistic when viewed in isolation. When combined with other information which is readily available from even a rudimentary training database, the picture which is uncovered has the potential to be particularly revealing especially in the area of management commitment. When a comprehensive safety training programme is made available, management commitment is highlighted in the percentage of training available which both the manager and the manager’s staff have actually undertaken. Examining the amount of training that different departments complete reveals another piece in the safety culture picture.

3.2.4 Unsafe act/unsafe condition records

Assuming that an organisation has even a rudimentary behavioural safety programme in place, for example ‘Time Out For Safety’ - BP, ‘Advanced Safety Auditing’ - BP, ‘STOP’ - DuPont, ‘Care Plus’ – Shell (HSE [2] 2001) then records of unsafe acts and unsafe conditions will almost certainly exist.

Unsafe act/unsafe condition reporting offers management a clear view of the attitude of the workforce towards safety improvement. As a measure of their faith in a ‘just culture’ the level of reporting gives a good indication of the organisation’s trust that management will not persecute or punish individuals for errors which they have had the confidence to report. While total numbers of reports are one measure of overall organisational reporting culture, analysing reports by type or by department or even time of day provides additional information and pointers to management on underlying attitudes in respect of reporting culture and employee confidence.

3.2.5 HSE goals and targets

Many organisations, in an attempt to be more proactive, set safety goals or, in the more advanced cultures, leading indicator targets as part of their drive to improve overall safety performance. Embedded within the progress towards these targets is a treasure trove of knowledge regarding the organisation as a whole and individual departments in particular in respect of their approach/attitude to proactive safety management.

3.2.6 Other information sources

In addition to the common sources mentioned above, there will almost certainly be other data which are available for analysis should the organisation wish, e.g. leak reports. Leak reports provide a window on potential operational integrity issues and are a source of knowledge in respect of the cultural maintenance and repair approaches adopted by the organisation. Other data sources include: staff assessments, meeting reports, audits, reviews, inspections, etc. These sources have not been included as they tend to be particularly industry specific and, while they may be able to provide a degree of additional insight, the learning curve for non-oil industry participants was thought to be steep enough without making life too difficult. It is also anticipated that, when the participants have completed the training, they will be more receptive to using data from more diverse sources such as those highlighted here to further inform them of their own organisations' safety culture.

3.3 Base data groups

In this section, the individual data groups used to examine organisational safety culture are discussed and the justification for their inclusion presented. A complete description of exactly how the modules were constructed and incorporated into the learning environment is presented in section 6.5.

The initial analysis of the safety culture definition developed by Wiegmann et al. (2002) described in Section 3.1 identified 8 'culture couplets' plus an additional one introduced by the author, which, when considered together, provide an overview of the safety culture of the organisation. These couplets were used as the foundation of the conceptual model on which the learning environment was constructed. The next step in the process was, therefore, to identify the data which could be used to gain insight into the status of each component. As discussed in Section 3.2, these can most commonly be found in the typical databases retained by many organisations operating in high risk environments. An in-depth review of the typical databases which would normally be available, resulted in the identification of 12 individual data groups which could be used to assess an organisation's safety culture.

A 13th module, independent from these data sources that can be derived from an analysis of existing accident data, was included and labelled 'Loughborough Safety Climate' to differentiate it from the Safety Climate referred to in the conceptual model. This module is discussed in greater detail in sections 3.3.8 and 6.5.14. The 12 individual data groups and 13th module are presented in Figure 3.1.

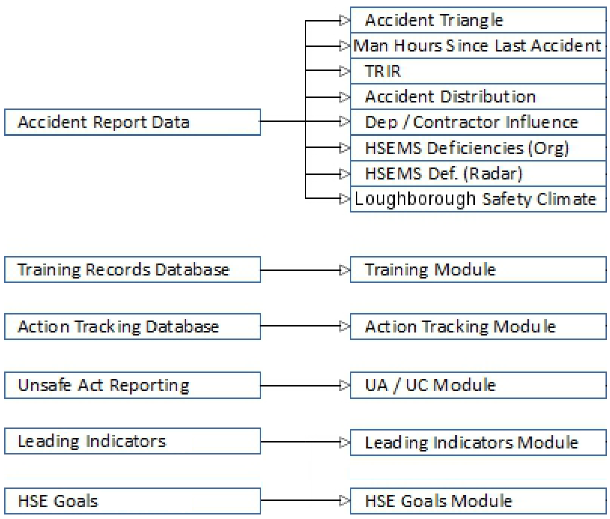


Figure 3.1 Data from typical safety databases.

On the left side of the diagram are the different data sources as described in sections 3.2.1 – 3.2.5. From these the data groups shown on the right hand side of the figure were identified. Proceeding on the basis that these groups could be populated with accurate information from the corporate databases underlying them then they have the capacity to provide a mechanism for identifying organisational safety culture without the need to resort to safety culture questionnaire surveys. Each of them is discussed in greater detail in sections 3.3.1–3.3.13.

3.3.1 The accident triangle

3.3.1.1 Discussion

H. W. Heinrich's research (Heinrich 1941, cited in Oladejo & Macauley, 2014) into the fundamental issues of occupational safety resulted in what has become known as Heinrich's Law or subsequently, more commonly, as Heinrich's Triangle. After examining thousands of records, Heinrich observed that for every accident that causes a major injury, there are 29 accidents that cause minor injuries and 300 accidents that cause no injuries. Nowadays, this is most commonly depicted as shown in Figure 3.2.

Figure 3.2 Classic Heinrich triangle.

Subsequent work by Frank Bird (Bird & Germain 1989) reinforced the triangular nature of accident / incident ratios but with different ratios. (Figure 3.3).

Figure 3.3 Bird triangle.

Numerous other organisations and individuals have published similar triangles (Bord Gáis 2009, Commonwealth of Australia 2012, Nichol 2012, OGP 1997-2013, Sutton 2011, Williamsen 2012). In recent years, criticism of Heinrich's Triangle has begun to appear. Manuele (2011) has questioned Heinrich's original research as it is not available for confirmation. In addition, he questions the definitions of what constitutes major and minor accidents. Quite correctly, he observes that there is no reason to assume that it requires the occurrence of 29 *before* the occurrence of a major injury.

Wayne Pardy accuses some consultants of practising what he terms *"parrot-based safety",* (quoted in Ashley 2011, p. 2), referring to his opinion that *"[some consultants] repeat unproven numbers based on Heinrich's work to promote their solutions."* Other professionals (Judith, Howe & LoMastro, quoted in Ashley 2011, p. 1), have reservations or concerns with the use of Heinrich's triangle claiming it to be misleading or harmful to the cause of effective safety management.

Over the decades, many different versions of the triangle have emerged (Nichol 2012, Sutton 2011, Williamsen 2012). Many entities have also added different layers such as: catastrophe, multiple fatalities, single fatalities, days away from work >3, days away from work <=3, near misses, unsafe acts and unsafe conditions. One issue is the classification of accidents. Some triangles have multiple fatalities at the apex with subsequent layers representing progressively less severe accidents, descending down into behaviours and management issues underpinning everything. A summary of different accident classifications commonly found in accident triangles including the ones referenced above is shown in Figure 3.4.

Figure 3.4 Accident severity triangle.

What is immediately apparent is the variety and complexity of approaches to accident classification. Indeed, the only real link with the original work of Heinrich is the triangular nature of the ratios. If this number of layers were to be used in industry, the scope for disagreement/argument would be enormous without a rigorous, and universally accepted, definition of exactly what constituted each classification. The author has suggested in the past that classifying accidents on the basis of severity is not a useful exercise (Cram 2007). Notwithstanding, there is one important benefit to producing an accident triangle based on event severity and that is its ‘triangularity’ as discussed. A simplified triangle is, however, more suitable to achieving this objective and is discussed in more detail in section 6.5.1.

3.3.1.2 Justification for module inclusion

An important component that all of the criticisms in the previous section overlook is that the triangle is a triangle; it is not a square, an oblong, a circle, a diamond or an arrow. Every year, the International Association of Oil and Gas Producers publish global safety statistics for the international oil and gas industry. Included in these statistics is the accident severity triangle. From 1997 until 2013, the ratio of fatalities to lost time injuries to recordable injuries has been triangular (Figure 3.5). It is an accurate observation that none of the annual ratios are either the same or similar to Heinrich's ratios. Nevertheless, there is not a single instance where the ratios are anything but triangular.

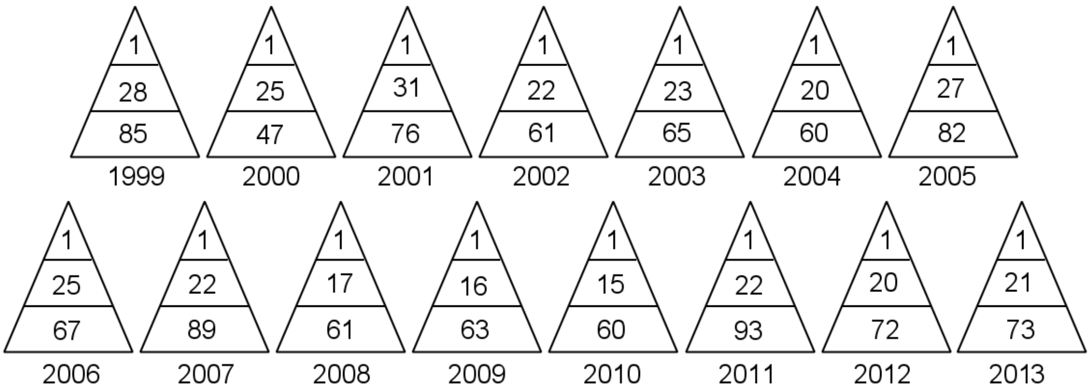


Figure 3.5 Accident triangles from OGP since 1999.

The provision of an accident triangle will offer the opportunity for participants to evaluate whether reporting within the learning environment demonstrates any inconsistencies in terms of the ratios of event severities.

3.3.2 Man hours worked

3.3.2.1 Discussion

One of the most common lagging indicators of safety performance is the count of man hours worked since the last lost time accident. The number appears at worksite gates; it is often included in any safety bonuses paid to the workforce; it appears in tender documents as an attestation to a potential contractor's superior safety performance; it even finds its way into annual reports.

3.3.2.2 Justification for module inclusion

The module is included for two reasons. Firstly, managers are used to seeing it. Secondly, its inclusion offers the opportunity to discuss with the participants during the training period the value/relevance of this type of metric.

3.3.3 Total recordable injury rate

3.3.3.1 Discussion

Total Recordable Injury Rate (TRIR) is calculated from the number of accidents requiring medical assistance, multiplied by 200,000 (approximation of the number of hours worked by 100 men in 1 year) and divided by the total number of man hours worked in the organisation.

3.3.3.2 Justification for module inclusion

The module is included to reinforce the fact that, even though the actual number provides no useful information in terms of either understanding safety culture or formulating future strategy, it is an accepted international measure of safety performance and to exclude it from the model would be to its detriment.

3.3.4 Accident distribution

3.3.4.1 Discussion

There is much to be gained by management focusing its efforts where they will be most effective rather than adopting a broad brush approach throughout the entire organisation. By reviewing incidence of accidents, both by contractor and by company department, a manager can obtain a quick overview of which areas need attention with regard to operational safety.

3.3.4.2 Justification for module inclusion

Being aware of the distribution of accidents across departments and contractors does not, in itself, provide much information about the underlying culture of the organisation. When the data are considered in conjunction with other pages of information, the cultural 'big picture' becomes clearer.

3.3.5 Department and contractor influence

3.3.5.1 Discussion

Individual departments are staffed and managed by people with different skills and experiences and, occasionally, different work cultures. Evaluating the safety performance of an organisation on a departmental basis (HSE 2006) can provide valuable insights into where the organisation may or may not be exposed, and hence, help in putting together a more complete picture of organisational safety culture. Similarly, in light of the fact that many businesses employ contract companies, with the inevitable, and possibly large, number of contract personnel, management of these organisations is potentially even more important than internal management when it comes to safety culture. The contractors' safety performance and attitudes towards safety can have dramatic consequences on the safety performance of the client (DHSG 2011, DuPont 2014)

3.3.5.2 Justification for module inclusion

Understanding who is affecting safety performance is a key component of understanding the underlying safety culture of the organisation. By analysing the data in accident reports, the impact that individual departments and contractors have on overall safety performance can be isolated for review either with the departmental manager or the contractor management or both as deemed necessary.

3.3.6 Safety management system deficiencies (organigram)

3.3.6.1 Discussion

The Lancaster Oil Health, Safety Management System (Appendix 1) is the system by which all aspects of HSE in the learning environment are managed. The modern management system began in 1991 with ‘Successful health and safety management’ more commonly referred to as HSG 65 published by the Health and Safety Executive in the United Kingdom. Its goal was to convey the message that - *“organisations need to manage health and safety with the same degree of expertise and to the same standards as other core business activities, if they are effectively to control risks and prevent harm to people.”* (HSE 1997, p. 5)

In 1996, the British Standards Institute published BS8800 which was revised in 2004. BS 8800:2004 was subsequently superseded in 2008 by BS 18004:2008 (BSI 2008). This standard (BS 18004:2004, p. 1) - *“is applicable to any organisation that wishes to establish an Occupational Health and Safety (OH&S) management system to* *control risks to personnel and other interested parties who could be exposed to OH&S hazards associated with its activities, facilities, processes or plant."* The Occupational Health and Safety Advisory Service published OHSAS 18001 in 1999 (updated in 2007) which specified (OHSAS 2007, p. 11). – *"requirements for an occupational health and safety (OH&S) management system to enable an organisation to control its OH&S risks and improve its performance."* In 2001, the International Labour Office (ILO) published 'Guidelines on occupational safety and health management systems. ILO-OSH-2001' with the stated objective of providing (ILO 2001, p. 10) – *"a practical tool for assisting organizations and competent institutions as a means of achieving continual improvement in OSH performance".*

Of these, the greatest acceptance around the world has been that of OHSAS 18001. A quick estimate of the acceptance of each can be obtained from a simple internet search. For HSG 65, Google returned 15,600 hits; for BS 18004, the number of returns was 6,680 and for ILO-OSH-2001 the number was 299,000. Despite only being launched in 2008, OHSAS 18001 returned over 3 million references. There are currently processes in place which are expected to see the emergence of OHSAS 18001 as ISO 45001 (BSI 2014) in 2016. Despite the fact, therefore, that OHSAS is not yet an ISO standard, it does not appear to have diminished its international standing as the de facto standard for HSE management.

In view of the almost global acceptance of OHSAS 18001 as the vehicle for development of health and safety management systems, a Lancaster Oil safety management system based on OHSAS 18001 was produced for inclusion in the learning environment.

3.3.6.2 Justification for module inclusion

An OHSAS 18001 management system is intended to provide a structure into which organisations can insert their own supporting policies, procedures, processes and systems.

The Lancaster Oil SMS comprises seven different components –

- Policy
- Planning
- Implementation and Monitoring
- Checking and Control
- Review
- Continuous Improvement
- Audit.

Combined, these elements encompass twenty-eight sub-elements providing high level guidance on the measures which, if correctly designed and implemented, will result in improved management of safety within the business.

If the assumption is that an effective, well designed and correctly implemented safety management system will produce a safer operation, then the converse should also be true. This element of the learning environment is, therefore, based on the premise that every accident is the result of a failure in the safety management system.

3.3.7 SMS deficiencies (radar plot)

3.3.7.1 Discussion

Using the same data as that driving the SMS Organigram screen, this page presents the participants with SMS related information in the form of a radar plot. Arranged around the plot are the twenty eight sub-elements of the Lancaster Oil SMS grouped into the seven top level elements: policy; planning; implementation and monitoring; checking and control; review; continuous improvement and audit. Instead of presenting the information in the form of a hierarchical display, this page displays the data by individual SMS element rather than SMS category.

3.3.7.2 Justification for module inclusion

Presenting the information in this format provides participants with the option to view all of the elements of the SMS as a whole. In this manner, participants can see at a glance which individual elements of their SMS require remedial attention and whether any particular patterns are developing within the data.

3.3.8 Loughborough safety climate

3.3.8.1 Discussion

The conceptual model underlying this project is formulated on the synthesis of Wiegmann et al. (2002) that safety climate is a temporal state of safety culture and that it is subject to constant change. As such, the model does not place any particular emphasis on the need to focus significant resources on safety climate. The safety climate module was designed around the work carried out at Loughborough and is described in more detail in section 6.5.14.

The Loughborough Safety Climate Assessment Toolkit (LSCAT) was selected as the foundation for this module based on a review of safety climate tools carried out by the Health and Safety Executive (HSE [1] 2001). The HSE evaluated 6 different safety climate survey tools. These are presented in Table 3.1 along with the key issues which influenced acceptance or rejection for the safety climate module.

Safety climate tools evaluated by the Health and Safety Executive		
Title	**Developer**	**Key Issues**
Health and Safety Climate Survey Tool	Health & Safety Executive	A generic tool. No oil and gas industry specific items. 71 item questionnaire.
Offshore Safety Questionnaire	Robert Gordon University Aberdeen University	No longer used in complete form by the developers. 153 item questionnaire.
Offshore Safety Climate Questionnaire	Aberdeen University	Use of the tool requires permission from Aberdeen University. Not readily available. 80 item questionnaire.
Computerised Safety Climate Questionnaire	Robert Gordon University	The company has not continued to use the tool following completion of the project. It is understood that the tool has not received widespread use. 49 item questionnaire.
Loughborough Safety Climate Assessment Toolkit	Loughborough University Offshore Safety Division of Health and Safety Executive Chevron UK Chevron Gulf of Mexico Mobil North Sea Oryx UK	The overall process could be applied in other industry sectors, subject to industry-specific modification. The toolkit can be downloaded free from the Internet. By January 2000, over 600 cases in the database. 43 item questionnaire.
Quest Safety Climate Questionnaire	Quest Evaluations and Databases Ltd.	The questionnaire was developed specifically for offshore drilling-related use. 319 item questionnaire.

Table 3.1 Comparison of safety climate survey tools.

With 153 and 319 questions respectively, the Offshore Safety Questionnaire and the Quest Safety Climate Questionnaire were rejected as being unnecessarily complex for the task at hand, which was to create a simple safety climate module. The Health and Safety Climate Survey Tool, while having significantly fewer questions, was generic and so, as the tool was to be designed around the oil industry specifically, it was rejected. Aberdeen University's Offshore Safety Climate questionnaire was not readily available and though permission to use the tool may have been provided, with 80 questions, it was considered excessively complex for adoption. Robert Gordon University's Computerised Safety Climate Questionnaire, while having a manageable question set had been discontinued by the organisation which originally funded the research and the tool was described in the HSE report (HSE [1] 2001) as having had little widespread use.

The LSCAT was readily available as a free download from the Internet. It had been developed in conjunction with distinguished organisations including the Offshore Safety Division of the Health and Safety Executive and major oil companies and it had the lowest number of questions, making it the optimum choice for the foundation of the safety climate module.

3.3.8.2 Justification for module inclusion

As the participants progress through the training, their focus is on understanding the safety culture. It was felt that, given the widespread use of the term 'safety climate' in industry, some form of safety climate tool should be made available to the participants should they wish to avail themselves of any insights such information would provide.

Implementing this facility certainly offered an opportunity to monitor the actual use participants made of the module during the training session.

3.3.9 Training

3.3.9.1 Discussion

Under the Health and Safety at Work Act all employers are required to provide (UK Government 1974, p. 6), - *"such information, instruction, training and supervision as is necessary to ensure, so far as is reasonably practicable, the health and safety at work of his employees".* Typically, companies either hire external training experts of which literally hundreds if not thousands exist in the UK alone. Alternatively, if they are large enough, companies may have their own internal training department and expert staff who provide the same input. If a training department exists then they may provide reports on such topics as: numbers of personnel who have received training, the course subjects, if tests were involved then possible the number of passes, etc.

3.3.9.2 Justification for module inclusion

While useful as a performance metric and as evidence that an organisation has discharged its training obligations, the underlying knowledge regarding the training culture of an organisation's safety culture does not appear to be widely investigated. Including this module and sensitising the participants to the sort of knowledge available to them with regard to how different departments embrace the training opportunities afforded by the company, provided a deeper insight into yet another piece of the organisational culture jigsaw.

3.3.10 Action tracking/lessons learned

3.3.10.1 Discussion

A common initiative in organisations exposed to workplace risks is to implement an action tracking system. A wealth of information has been published on the importance of such initiatives and many organisations have implemented programmes to capture and track actions/lessons. Sometimes, results fall short of expectations (Patton 2001), nevertheless useful knowledge is often available within an action tracking/lessons-learned initiative which can, if correctly managed, reveal important insights into corporate safety culture. For example, many companies proclaim in such documents as their annual reports that they are committed to learning the lessons from accidents to ensure that they do not happen again (Bord Gáis 2009, BP 2013, Petrofac 2013, Premier 2012, Tullow Oil 2012). By declaring that the organisation is dedicated to investigating every accident and learning the lessons from these events to prevent recurrence, organisations may inadvertently be stating that they are reactive towards their safety improvement programmes. It is much more preferable to learn the lessons prior to the first accident.

3.3.10.2 Justification for module inclusion

Remedial actions originate from a variety of sources including; accident/incident reports, safety meetings, inspections, audits, risk assessments, HAZIDs, HAZOPs and unsafe act/condition reports to name the most common. Of these, actions generated from the investigation of accident/incident reports are the only reactive ones. Actions generated from every other activity are proactive in that they were identified and logged (and possibly completed) before any accident happened.

Presenting the data captured in the typical action tracking database affords participants the opportunity to evaluate how proactive or reactive their organisation is in respect of taking actions to improve safety performance. When these data are collected at a departmental level, a clear picture emerges as to which departments are more or less proactive than others: a valuable insight for the senior manager seeking to motivate his direct reports to embrace the concept of positive safety improvement. Additionally, the ability to observe departmental performance addresses the issue of departmental culture raised by the Health and Safety Executive (HSE 2006).

3.3.11 Unsafe acts and unsafe conditions

3.3.11.1 Discussion

Much has been written both for and against the direct link between unsafe acts and accidents (Heinrich 1941, Krause 2005, Manuele 2011, Reason 2009). It is beyond the scope of this project to support or otherwise the issues surrounding the debate over the relationship between unsafe acts and accident occurrence other than to say that, while there may be many other issues which encourage individuals in the workplace to commit unsafe acts, there does appear to be a relationship between the number of unsafe acts recorded in an organisation and the safety performance of that organisation (Cram & Sime 2011).

3.3.11.2 Justification for module inclusion

Examination of the data pertaining to unsafe acts and conditions reveals much about both the reporting culture of the organisation and its proactivity with regard to improving safety performance. Both unsafe act and unsafe condition reports are often illustrated on the typical accident triangle and the data available for inclusion in the learning environment in the unsafe act/unsafe condition (UA/UC) element have the capacity to provide valuable insights into the behavioural safety programme(s) implemented within Lancaster Oil.

3.3.12 Leading indicators

3.3.12.1 Discussion

Industry is accustomed to being presented with lagging indicator statistics (OGP 1997 – 2012). In addition to their limited applicability in evaluating historical safety performance, lagging indicators provide little, if any insight into prevalent safety culture other than to provide a very broad assessment as to whether the safety culture of the organisation is good or otherwise. Adoption of leading indicators and close monitoring of progress towards achieving leading indicator targets can provide another piece of the organisational safety culture jigsaw picture. There is no definitive list of appropriate leading indicators, thus organisations will need to select indicators that are most relevant to their particular operational parameters. A selection of typical leading indicators has been adopted for this particular module, based on the author's past experience.

3.3.12.2 Justification for module inclusion

The objective of this module is to sensitise participants to the wealth of insight that is available by judicious monitoring and analysis or progress towards achievement of leading indicator goals. Whether the actual leading indicators used in this module are identical to the ones participants might encounter in their own organisations is largely irrelevant. It is the concept that is being presented, not the value or otherwise of the individual indicators.

3.3.13 HSE goals

3.3.13.1 Discussion

Many organisations set targets for a variety of topics and a series of safety goals is also very common. Research has shown that setting goals results in improvements in both personal and corporate performance (Locke 1996, Latham & Locke 2006) as long as the two are not in conflict (Seijts & Latham 2000). Within the confines of the learning environment, setting personal goals for individual managers would have been both impractical and unrealistic. A suite of corporate HSE goals can, however, be set and used to evaluate how well or otherwise the organisation is progressing towards achieving the targets set.

3.3.13.2 Justification for module inclusion

This module reinforces the message that the setting and conscientious monitoring of safety goals is a useful exercise in terms of evaluating organisational safety culture. While the module does not, in itself, provide direct information on safety culture, when used as a 'piece in the culture jigsaw', it provides valuable additional input to safety culture assessment.

3.4 Additional resources

In addition to the data screens derived from typical organisational databases, two other sources of information were included as important contributors to enhancing managements' understanding of safety culture. These are a Poisson distribution and a suite of typical e-mails which might be encountered by any manager working in a high risk environment.

3.4.1 Poisson distribution

3.4.1.1 Discussion

This particular screen does not derive from the typical data collected and retained by companies but was included as the direct result of the author's experience in analysing safety performance data (Cram 2007).

In his book 'The Law of Small Numbers', Bortkiewicz (1898) first noted that events with low frequency in a large population follow a Poisson distribution even when the probabilities of the events varied. This is an accurate description of accident frequency. Accidents are low frequency events, they occur in a large population; and the individual probabilities vary widely. Bortkiewicz (1898) used the Poisson distribution (Poisson 1837) to illustrate that the numbers of soldiers killed and injured in the Prussian army followed (with remarkable accuracy) the Poisson distribution. The participants learn from the presentation that their data too follows this distribution and, as such, they are better positioned to both understand their organisations' safety performance and also formulate a credible response to the 'board'.

3.4.1.2 Justification for inclusion

Understanding what the data are signifying is critical for the executive charged with the safe running of his organisation. The Poisson distribution screen teaches participants that the obvious answer to an issue is not necessarily the correct answer and that they need to look beyond ill-founded interpretation of the data if they are to understand what is really happening in their organisation.

3.4.2 E-mail traffic

3.4.2.1 Discussion

While not sourced from any database, corporate communications have the potential to provide executives with insights into the safety culture of the company.

3.4.2.2 Justification for inclusion

A suite of e-mails delivered to the participants at appropriate times during the session gives them a flavour for how various personnel (mostly managers) regard safety and safety culture within the company. In addition, a continuous flow of information provides participants with an ongoing series of issues which need to be addressed thereby maintaining their activity levels during the 8 hour session.

3.5 Yin and Yang of safety characteristics

With all of the required data sources identified, the next step was to build the model of safety culture as it applied to Lancaster Oil Ltd. Few factors in safety culture are binary concepts. If all of the inputs to the safety culture model were clear ‘yes’s’ or ‘no’s’ the task of defining and measuring safety culture might be considerably more simple than it has proven to be in the past. By way of illustration of the variance and flexibility of describing different safety characteristics, the classic ancient Chinese symbols of Yin and Yang were adopted (Figure 3.6).

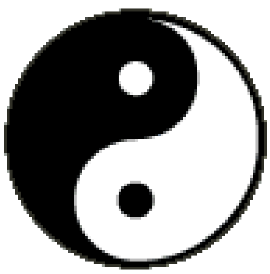


Figure 3.6 Yin and Yang.

Recalling the 9 culture 'couplets' identified in Section 3.1 which were distilled from Wiegmann et al.'s (2002) synthesis of safety culture -

- Leaders versus bosses
- Reactive versus proactive
- Open versus secretive
- Risk averse versus risk tolerant
- Rewarding versus penalising
- Progressive versus prescriptive
- Amenable versus dogmatic
- Informed versus ignorant
- Leading versus lagging

these do not represent binary opposites, rather, they represent a continuum leading from one state to another.

With the foundations of the safety culture model identified, the next step in the development of the model was to establish which of the data sets described in sections 3.3.1 – 3.3.13 would provide input into determining the overall safety culture of the entity. These are discussed in sections 3.5.1 through 3.5.9.

3.5.1 Leaders versus bosses

Whether an organisation has a leader or a boss (Figure 3.7) at the helm is a key

Figure 3.7 Leader versus boss.

"The boss drives people; the leader coaches them. The boss depends on authority; the leader on good will. The boss inspires fear; the leader inspires enthusiasm. The boss says 'I'; The leader says 'WE'. The boss fixes the blame for the breakdown; the leader fixes the breakdown. The boss says, 'GO'; the leader says 'LET'S GO!'"

– H. Gordon Selfridge

component in the development, implementation and maintenance of an effective safety culture. The UK HSE (2012, p. 1) describe a transformational leader as one who –

"makes a positive impact on attitudes, behaviours and organisational performance. They transform, energise and motivate their workers to:

- *view their work from different perspectives*
- *be aware of their organisation's vision*
- *reach their full potential by challenging themselves*
- *work to benefit the team rather than just themselves"*

The original definition of the term transformational leadership is attributed to James MacGregor Burns and recognises that there is a duality to the improvement involving both the leader and the led - *"Such leadership occurs when one or more persons engage with others in a way that leaders and followers raise one another to higher levels of motivation and morality."* (Burns 1978, p. 20)

Barling et al. (2002, p. 492) proposed a model linking transformational leadership to occupational injuries. A modified version of their model, which recognises the influence of safety culture on safety awareness and safe behaviours, is presented in

Figure 3.8. The results of their study concluded that – *"safety-specific transformational leadership provides an opportunity for enhancing occupational safety that goes beyond ergonomic design or regulator approaches."*

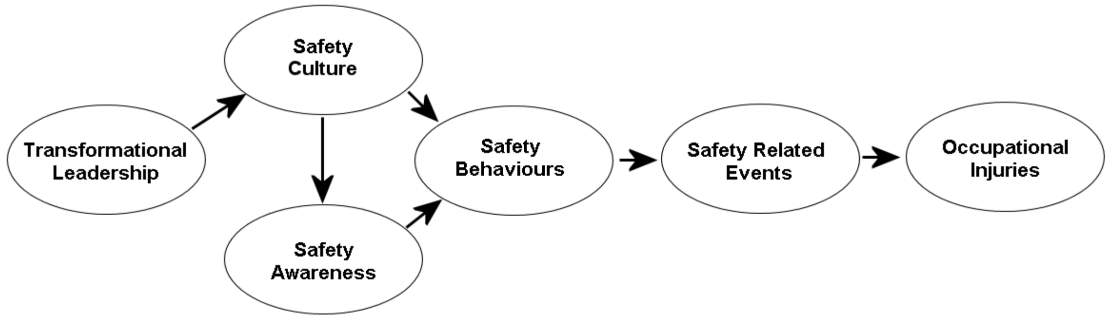


Figure 3.8 Modified Barling et al. (2002) model linking transformational leadership and occupational injuries.

Leadership in safety can be demonstrated in a variety of ways. The more effective the leader, the more likely their area of responsibility will be to deliver improved safety performance. Good leaders will require full reporting from their subordinates, they will set an example to their staff by ensuring that they have personally completed all of the safety training available. Actions required to improve safety in their areas will be addressed as appropriate, in line with the priority assigned to the actions and they will be completed on time. The effective leader will ensure that safety goals are delivered and that leading indicator targets are achieved. By analysing the data typically available from the various sources described in section 3.3, it is possible to build a picture of how leadership is affecting the overall safety culture of the organisation (Figure 3.9).

Figure 3.9 Contributions of different data sets to identifying leaders versus bosses.

3.5.2 Reactive versus proactive

All organisations exhibit reactive or proactive characteristics in the domain of safety culture (Figure 3.10).

Figure 3.10 Proactive versus reactive.

"The wind shield is bigger than the rear view mirror." – Tom Daschle

Many claim that they investigate every accident to learn the lessons to prevent recurrences in the future. On initial consideration, this appears a laudable sentiment and commitment, but it may obscure an underlying reactivity in its safety culture.

Claiming to be committed to investigating the causes of a fatality to prevent a recurrence could be interpreted as the organisation waiting for the first accident before learning the lessons that will prevent the second. Clearly, whether an organisation is reactive or proactive is an essential characteristic of its safety culture.

Accident investigation is not the only area where organisations demonstrate their pro-activity. Other arenas such as action tracking, training, goal achievement also illustrate effectively an organisation's pro-activity or reactivity.

Actions to improve safety originate from a variety of sources in addition to accidents; inspections, audits, unsafe act and unsafe condition reports, safety meetings and employee suggestion schemes to name a few, all have the potential to produce valuable improvement actions. The difference between them, however, is that actions following accidents are reactive whereas actions from other sources are proactive. The sources of actions in the corporate action tracking database are, therefore, a good indicator of a proactive approach to safety versus a reactive approach.

Other indications of an organisation's pro-activity can be found in how it delivers on targets such as leading indicators, HSE goals or how much it avails itself of safety related training (Figure 3.11), not only in the workforce but including managers as well.

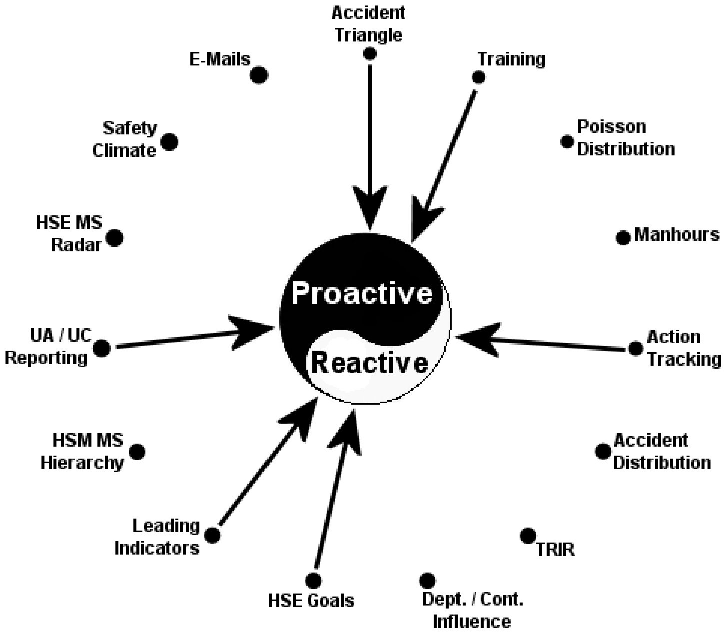


Figure 3.11 Contributions of different data sets to identifying pro-activity versus reactivity status.

3.5.3 Open versus secretive

Some organisations may exhibit a tendency to conceal safety related issues in the hope that ignorance of the problem may absolve them from responsibility in the future should something go wrong (Figure 3.12) or in the hope that they may appear safer than they are to staff, clients or the general public.

Figure 3.12 Open versus secretive.

Actions are visible though motives are secret. – Samuel Johnson

Many others are of the belief that an open culture is one in which improved safety can flourish (Jubin 2011, NHS 2014, Queensland Government 2014). In addition, from a financial perspective alone, it is far more cost effective to minimise the risks rather than attempt to minimise legal liabilities in any subsequent litigation (Hopkins 2005). Empirical evidence shows that organisations which adopt a more open approach to safety related issues have improved their internal safety management as a direct consequence (IAEA 1998).

The fact that organisations report openly, that they generate actions to improve safety and acknowledge that such actions are necessary and do not seek to hide deficiencies, that they communicate frankly throughout the organisation, that they do not seek to censor communications are all good indicators of an entity with an open culture towards safety (Figure 3.13).

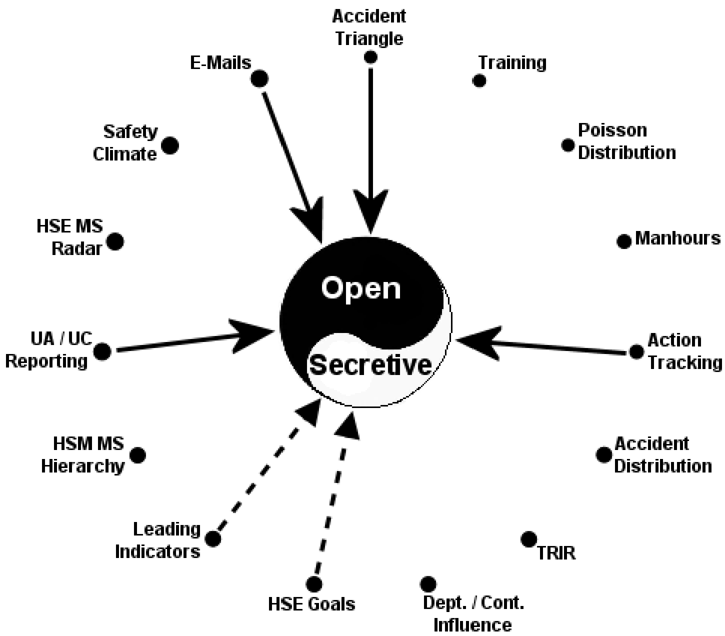


Figure 3.13 Contributions of different data sets to identifying open versus secretive safety culture.

3.5.4 Risk averse versus risk tolerant

Risk tolerance is defined by Hunter (2002, p. 6) as *"the amount of risk that an individual is willing to accept in the pursuit of some goal".* With an organisation potentially comprising hundreds or even thousands of individuals, the risk tolerance or aversion of the entity (Figure 3.14) as a whole becomes extremely difficult to evaluate.

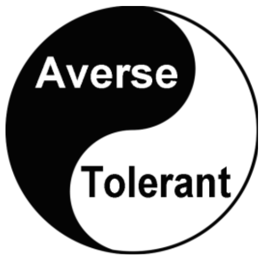


Figure 3.14 Risk aversion versus risk tolerance.

"One is not exposed to danger who, even when in safety, is always on their guard." - Publilius Syrus

Adding to that complexity is the revelation that safety training may not achieve the intended goal of increasing risk aversion. Rather, research by Lehmann et al. (2009) suggests that safety training by itself is insufficient to reduce workers' tolerance of risk in the workplace. Further support for the risks of training resulting in impaired safety is provided by Rosness et al. (2014) who conclude that – "*Drift into failure may be viewed as a learning process rather than a failure to learn."* The degree of risk tolerance versus risk aversion plays a key role in the organisation's safety culture and hence safety performance. By way of example, the following extract from the final report into the Macondo disaster (DHSG 2011, pp. 5-6) paints a damning picture of BP's acceptance of risk in a culture of cost cutting –

> *"At the time of the Macondo blowout, BP's corporate culture remained one that was embedded in risk-taking and cost-cutting – it was like that in 2005 (Texas City), in 2006 (Alaska North Slope Spill), and in 2010 ('The Spill'). ……… It is the underlying 'unconscious mind' that governs the actions of an organization and its personnel. Cultural influences that permeate an organization and an industry and manifest in actions that can either promote and nurture a high reliability organization with high reliability systems, or actions reflective of complacency, excessive risk-taking, and a loss of situational awareness."*

Identifying an organisation's pre-disposition to risk tolerance can be evaluated by considering a variety of data sets. At the most basic, communications between staff will offer an opportunity to establish how risk is perceived. Data from the sources highlighted in Figure 3.15 can be evaluated to provide a picture of risk perception. For example, is the organisation proactive about improving safety; does it have demanding yet achievable improvement goals in place; and is progress towards achieving these goals/targets monitored closely? Does the prevalent safety climate indicate issues or otherwise with risk tolerance? Are safety management system failures synonymous with poor levels of risk tolerance? Are actions to improve safety derived from reactive or proactive sources? All of these and others can be addressed to provide the 'big picture' view to the Chief Executive Officer.

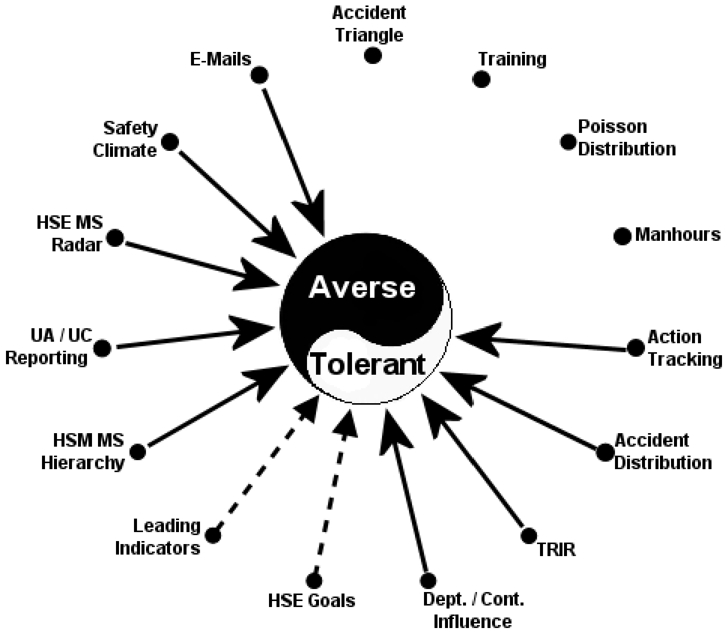


Figure 3.15 Contributions of different data sets to identifying risk aversion versus risk tolerance.

3.5.5 Rewarding versus penalising

Reason (2009, p. 195) puts forward the argument that a 'no-blame' culture is *"neither feasible nor desirable"* and that a "*blanket amnesty* [on unsafe acts] *would lack credibility in the eyes of the workforce".* This approach has the potential to undermine an effective reporting culture. The Heinrich (1941) triangle, still widely used in a multitude of guises around the world, highlights the large number of unsafe acts at the base of the triangle none of which, by definition, actually led to the occurrence of an event with an undesirable outcome. There has been no cost to the organisation, no accident, no-one injured, yet it is here that the bulk of learning is available to the organisation at an extremely low cost. Penalising on the basis of reporting unsafe acts (Figure 3.16) has a high potential to undermine a successful reporting culture where it is most important, at the base of the accident triangle.

The issue with requiring some form of punishment within the confines of a 'just culture' is that meeting out punishment will undoubtedly lead to concealment of the unsafe act. Who is going to report an unsafe act which did not have a bad outcome for the organisation and so will never be discovered if they know that they may end up being punished for their commitment to openness and reporting? A no-blame, unsafe act reporting, culture can be achieved and has been shown to produce significant improvements in safety culture and performance (Cram & Sime 2011).

Figure 3.16 Rewarding versus penalising.

"When a man is penalised for honesty he learns to lie." - *Criss Jami*

Another approach to rewarding the workforce for good safety performance is the safety award schemes that many companies operate. Opinions on whether safety award schemes actually do result in improved safety performance remain divided. A study by Goodrum and Gangwar (2004) suggests that safety award schemes do appear to bring benefit to the organisation while the UK Health and Safety laboratories study (Hopkinson & Gervais 2006) concludes that evidence to support the benefits remains too scarce to be able to make a judgement on the subject. Cram and Sime (2011) found that an appropriate reward scheme applied to the right topic did bring demonstrable benefits to the organisation in terms of improved safety behaviours while Sims (2013) draws attention to the tendency in recent years to regard safety incentive schemes in a negative manner and the ongoing debate surrounding worker attitude versus behaviour.

What does not seem to be in debate is the opinion that the organisation which seeks to reward proactive activities (Figure 3.17) that help improve safety culture will achieve more than one which seeks to punish accidents or unsafe behaviours etc.

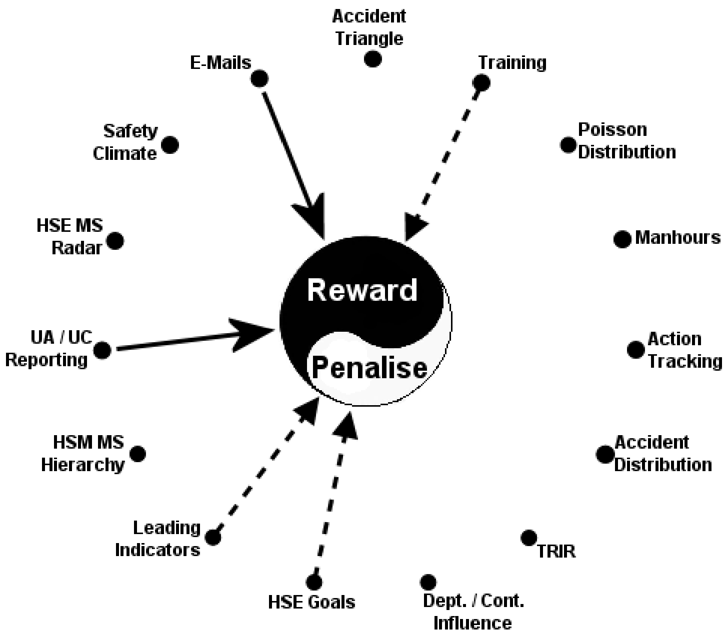


Figure 3.17 Contributions of different data sets to identifying whether the organisation is rewards or penalises.

3.5.6 Progressive versus prescriptive

Prescriptive – *"You shall install a 1m high rail at the edge of the cliff"*

Goal-based – *"People shall be prevented from falling over the edge of the cliff"*

(Penny et al. 2001).

Prescriptive safety regulations place the organisation in the position where compliance with the regulations means that in any subsequent event, as long as the organisation can demonstrate that it has complied with the rules and regulations, it is not the organisation itself which is at fault but the rules/regulations themselves (Penny et al. 2001); as such, organisational liability is reduced if not eliminated. While this may be appealing to entities operating in litigious national environments, the nature of prescriptive regulations, which tend to be developed as the result of past experience, places potential limits on the ability of the organisation to develop and implement innovative or 'best practice' solutions to safety related issues (Hoppe 2005). There is even the possibility that prescriptive standards may rapidly become deficient as they are overtaken by best practices and that the prescriptive approach may, in fact, prevent an organisation from adopting current industrial best practices (Becht 2011).

Progressive organisations continually seek to improve (Figure 3.18). They recognise that the workforce is a crucial resource and that senior management is in a position to send out strong messages about the importance of safety (HSE 2008).

Figure 3.18 Progressive versus prescriptive.

"Rules are not necessarily sacred, principles are".- Franklin D. Roosevelt

Within the data routinely collected by many companies are key pointers (Figure 3.19) to whether they are prescriptive or progressive in their approaches to safety and safety management.

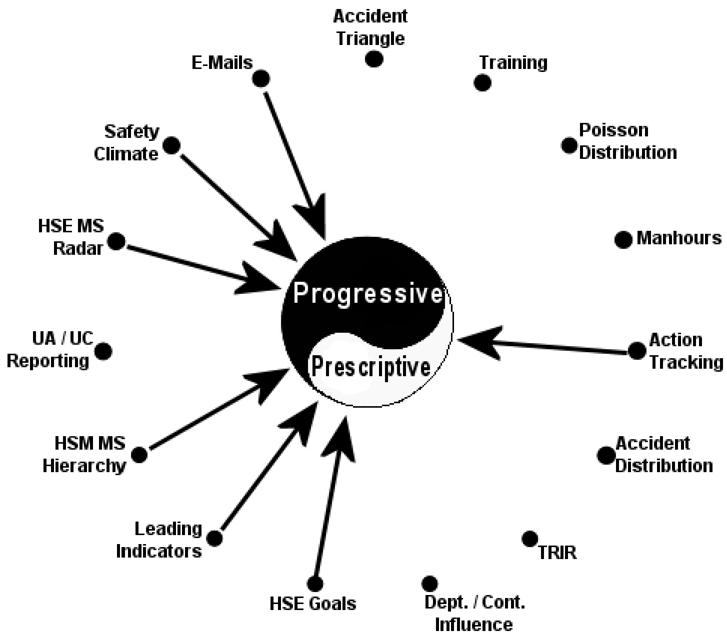


Figure 3.19 Contributions of different data sets to identifying whether the organisation is progressive or prescriptive.

3.5.7 Amenable versus dogmatic

Underpinning all effective safety management and included in all safety management systems is the need for continuous improvement. Only by rejecting existing approaches and being open to learning new and better solutions to safety related issues will organisations be able to deliver on their obligations to drive down accident rates.

Dogmatic management, whether through belief or expediency, renders the organisation susceptible to repeating history and so undermines any attempt to introduce important initiatives such as lessons-learned programmes. Improving safety performance depends on learning lessons and encouraging people to change their views/behaviours (Figure 3.20). Dogmatic responses on the other hand may work to distance the workforce from the process of improving behavioural safety (Cooper D.C. 2000).

Figure 3.20 Amenable versus dogmatic.

"Nothing is more dangerous than a dogmatic world view - nothing more constraining, more blinding to innovation, more destructive of openness to novelty". - Stephen Jay Gould

Indications (Figure 3.21) as to whether the organisation is amenable to change can be found in: corporate communications; changes in management system issues in connection with accidents; increases in reporting of non-accidents; changes in how the organisation regards, sets and delivers leading indicator and HSE goals targets; and how it changes its views regarding actions to improve safety.

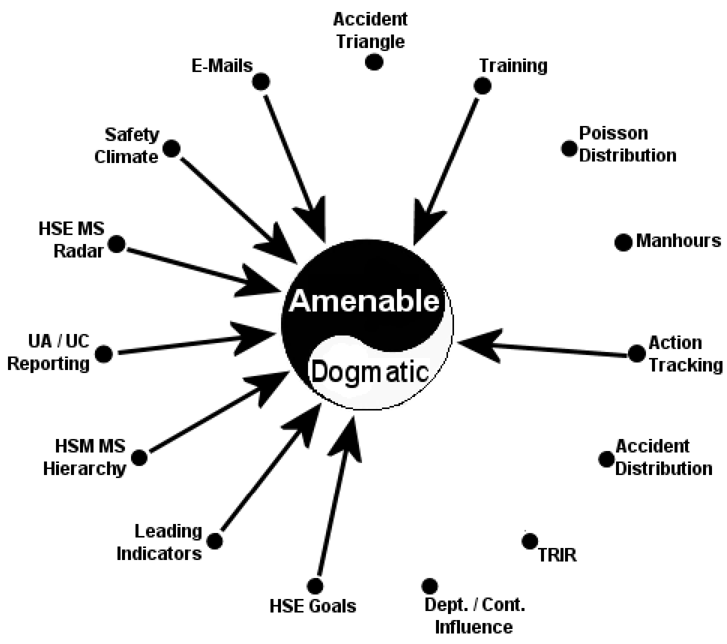


Figure 3.21 Contributions of different data sets to identifying whether the organisation is amenable to change or dogmatic.

3.5.8 Informed versus ignorant

Companies that truly seek to improve can not afford to ignore the importance of an informed safety culture (Figure 3.22).

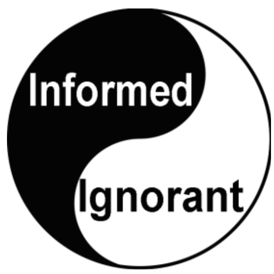


Figure 3.22 Informed versus ignorant.

"A great deal of intelligence can be invested in ignorance when the need for illusion is deep". – Saul Bellow

Reason (2009, p. 194) stresses - *"The critical importance of an effective safety information system – the principal basis of an informed culture."*. Dependent on an effective reporting culture, without which the lessons can not be identified, an informed culture (Figure 3.23) ensures that the workforce and the management receive the maximum information in respect of the organisational safety risks facing them on a continuous basis (CANSO 2013).

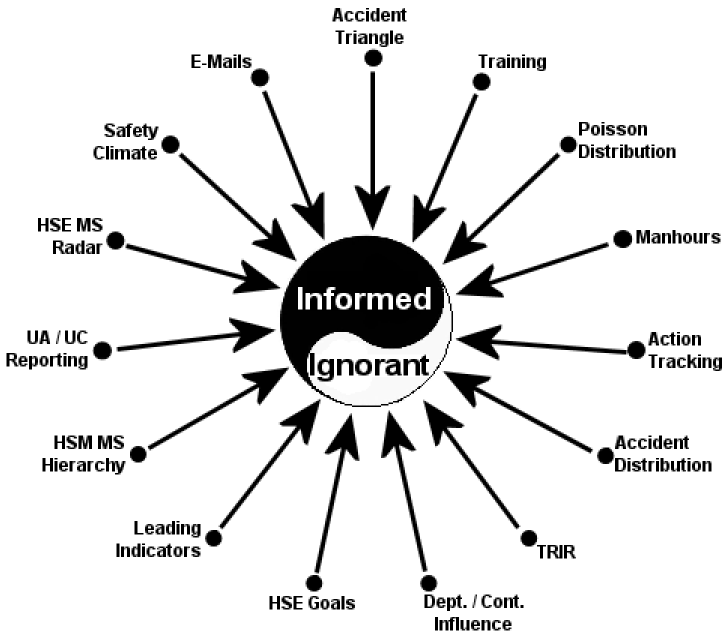


Figure 3.23 Data sets to identifying whether the organisation is informed or ignorant.

Information on whether an organisation is 'informed' or 'ignorant' can be found in almost every aspect of its operations and the data it collects or communicates. Figure 3.23 above reflects the fact that simply by wishing to record and evaluate as many sources of information as possible about safety within the organisation is an indication of an organisation which seeks to be informed.

3.5.9 Leading versus lagging

Companies have the choice as to whether they wish to be motivated by adopting positive approaches to health and safety management or whether they chose to learn from history (Figure 3.24). Leading indicators provide organisations with an opportunity to improve their safety performance, while at the same time, minimising the percentage of learning which results from unplanned actions resulting in harm to people, environment or plant.

Figure 3.24 Leading versus lagging.

"If you do not change direction, you may end up where you are heading". – Lao Tzu

According to Step Change in Safety (2000, p. 3) leading indicators provide – *"information that helps the user respond to changing circumstances and take actions to achieve desired outcomes or avoid unwanted outcomes".* Any organisation that focuses on the past may know where they have come from but the questions of 'where they are going?' and 'how they will get there?' remain unanswered.

Lagging indicators tell the organisation nothing about what to do to improve. They are a backward facing view of historical safety performance and unfortunately still at the forefront of much of today's view of safety. Indications of whether the organisation is driven by leading or lagging indicators is available from a variety of sources (Figure 3.25). Whether the organisation seeks to educate and inform its personnel indicates a willingness to adopt a leading approach to safety.

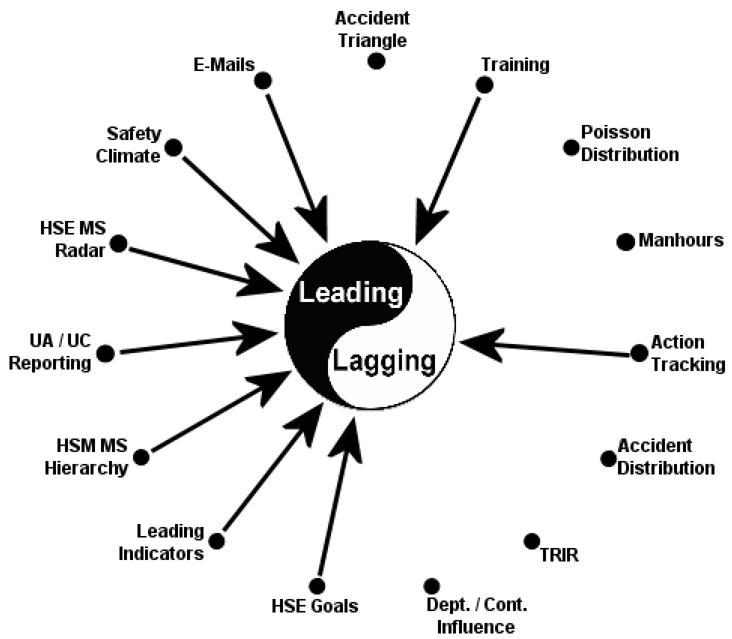


Figure 3.25 Contributions of different data sets to identifying whether the organisation leads or lags.

General communications between the various management teams and/or staff reveal the organisation's approach to taking the lead. Adoption of leading indicators and safety related goals as drivers of safety performance highlight clearly the position of the organisation with regard to whether it leads or lags. A strong UA/UC reporting culture indicates a willingness to learn before the accident has happened. Evaluation of safety management system issues (both HSE MS radar and hierarchy in Figure 3.25) contribute to clarifying the overall picture of the organisation's implementation of effective safety management.

3.6 Relationship between safety culture and safety behaviour

There is much evidence in the literature that safety culture and safe behaviours are linked in some form of reciprocal manner (Cooper D.C. 2000, Hopkins 2002). In his Safety Culture Application Guide, Lardner (2003, p. 26), concludes that –

> *"A reciprocal relationship exists between safety culture, behavioural safety and team working. Behavioural safety and team working both can support the development of a mature safety culture with high levels of employee involvement. Similarly a strong safety culture allows team working and behavioural safety to flourish".*

Exactly how this relationship functions is unclear, not least because of the inability of industry to agree a common definition of what safety culture actually is. Nevertheless, there is general agreement that culture and behaviour form a pairing that influences the safety performance of the organisation. For the purpose of this thesis, however, the focus is constrained to the safety culture element alone.

3.7 Conceptual model for the construction of a safety culture learning environment

With the data sources identified and their relationships to the various characteristics of the organisation established, it is possible to construct a model of organisational safety culture which can be used to train management in how they can adopt the same approach, and thereby identify the safety culture in their own organisations. The last piece to be put in place is the role and position of senior management. Senior management encompasses every aspect of corporate culture and behaviour. It is pervasive throughout the organisation, and brings enormous influence to bear on the various elements of the safety climate of the organisation on a day-to-day basis.

In an ideal world, encouraged and directed by senior management, an organisation demonstrating total commitment to safety and with the entire workforce working together the model of safety culture would appear as Figure 3.26.

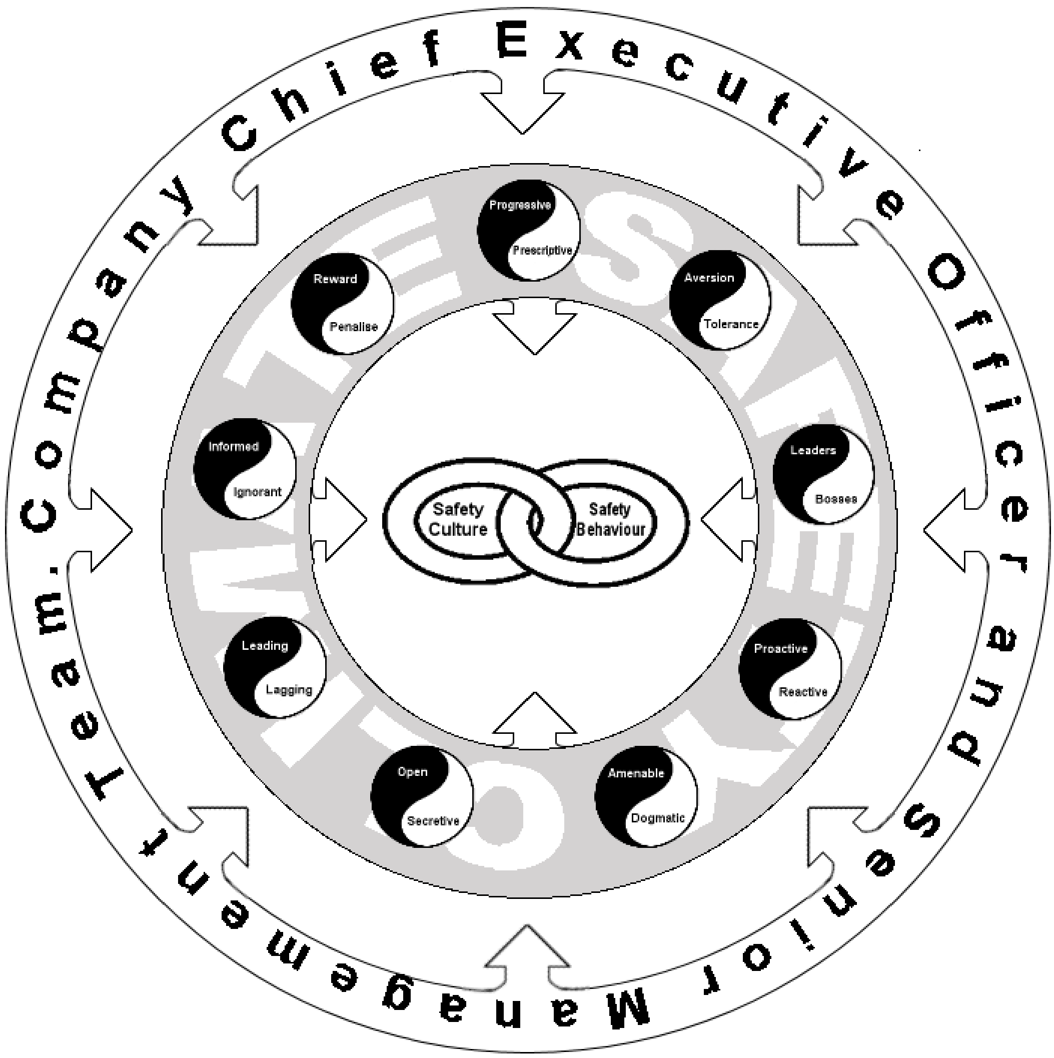


Figure 3.26 Elements in organisational safety relationships.

In this ideal situation, the safety management system (SMS) is fully communicated, implemented and monitored with the workforce and all management is aligned according to the visible commitment message that is being delivered from the top. All policies, procedures, standards and guidelines are rolled out and in force across the entire organisation. All systems and processes are functioning at peak performance levels. Management throughout the organisation is demonstrating its commitment to the same set of safe operating principles and safety performance is consequently maximised (Figure 3.27).

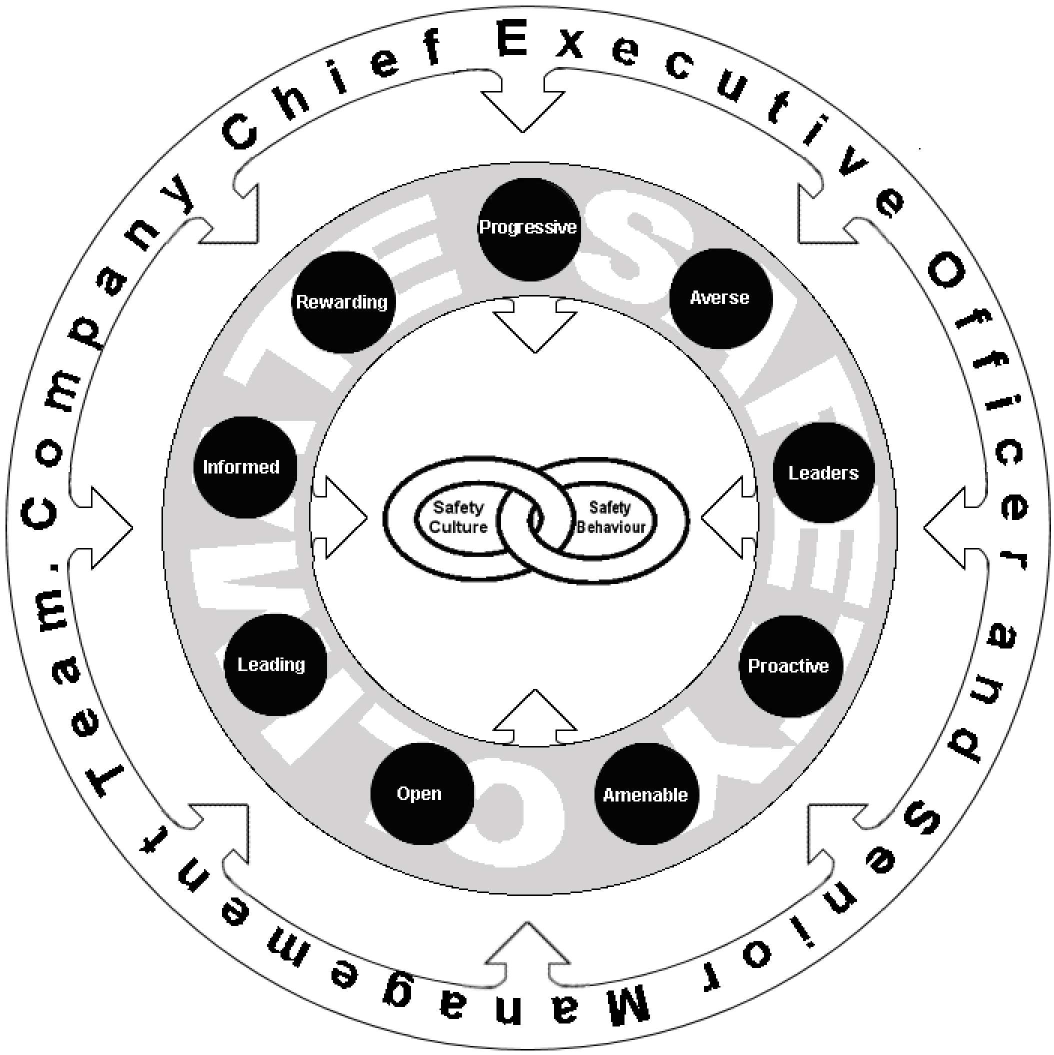


Figure 3.27 The ideal safety culture.

Alternatively, a company in complete disarray with regard to safety culture would exhibit the completely opposite state (Figure 3.28). Dogmatic, tolerant of risk, dominated by bosses who preferred to conceal true safety performance, ignorant of reality, overseeing a workforce subdued by fear. This is the antithesis of a corporation where safety is a priority.

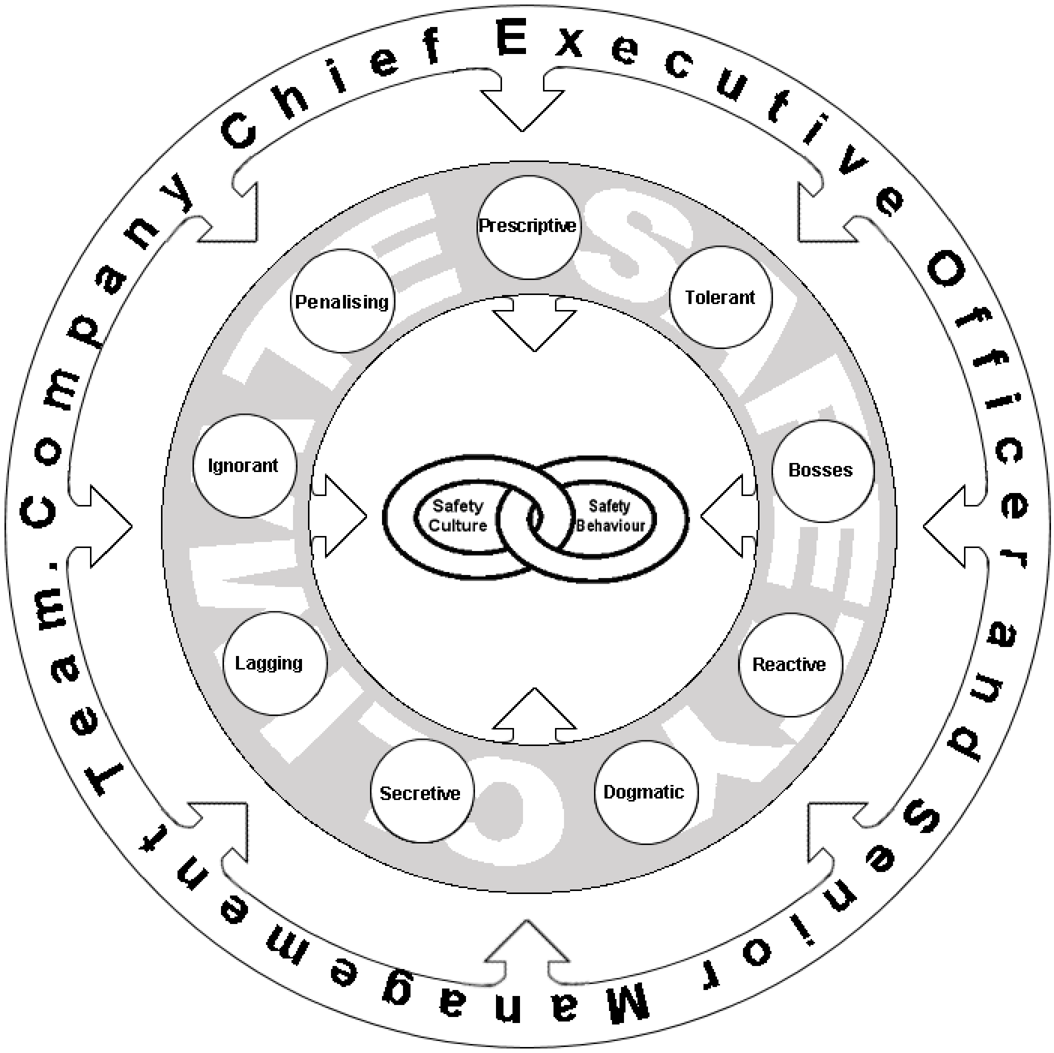


Figure 3.28 Worst case scenario for corporate safety culture.

The reality is that most, if not all organisations, lie somewhere in between (Figure 3.29). Each has its own safety personality which fluctuates with changes in management, workforce, changes in circumstances, the individual components therefore are in a continual state of flux. This is typical of the type of organisation that management is obliged to evaluate, interpret, understand and, ultimately, manage.

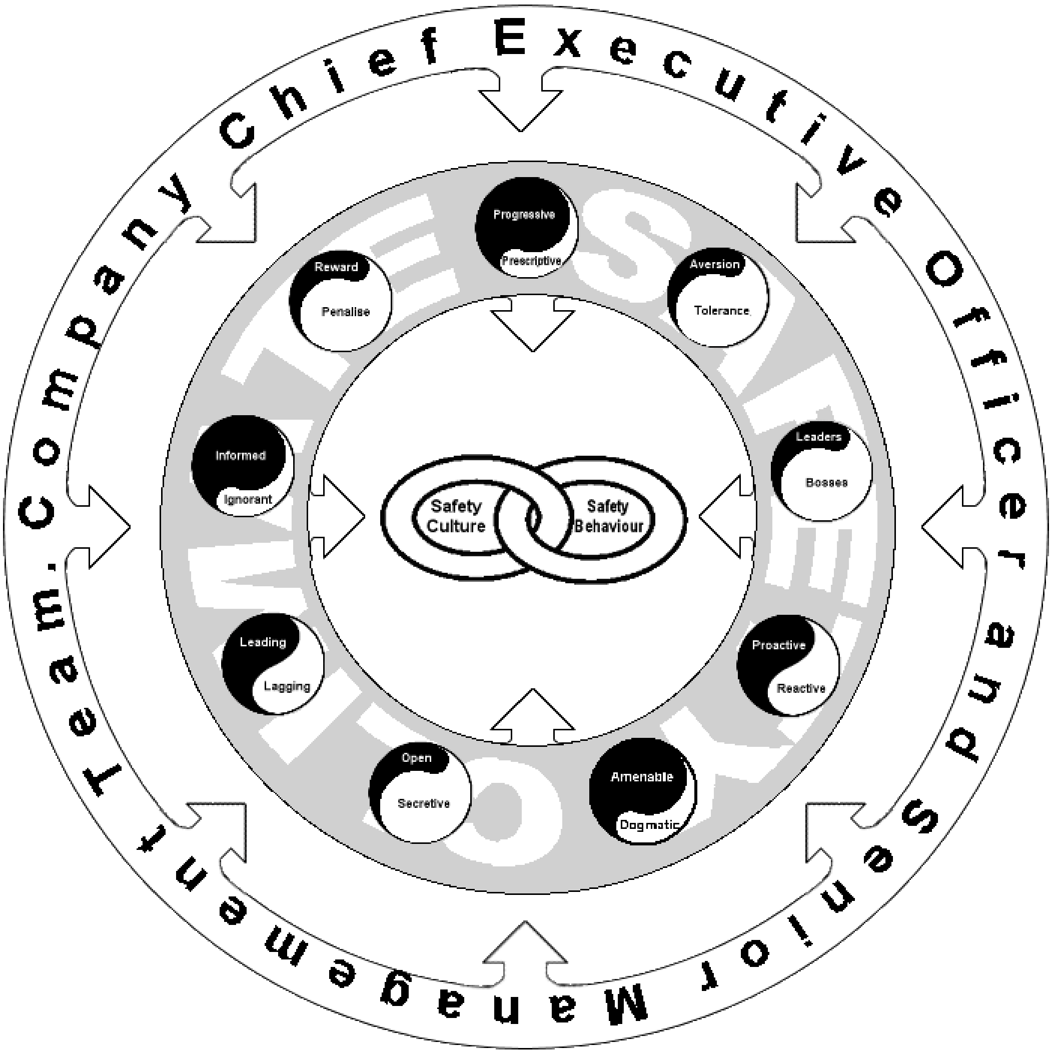


Figure 3.29 Temporal state of organisational safety culture.

3.8 Summary

In this chapter, the definitions of safety culture and safety climate synthesised by Wiegmann et al. (2002) were broken down into discrete components. The resulting analysis of these individual components was then used to construct a model linking the relationships between safety culture, safety climate and the role of management in influencing both. Based on this model and the identification of the required data sources to construct an effective safety culture learning environment, the next step was to identify the best approach to evaluating the effectiveness of the proposed tool.

Chapter 4 Research methodology

In this chapter, reference will be made to the Safety Culture Learning Environment (SCLE) or, more simply, ‘learning environment’, which will be described in detail in Chapter 5. The term is used here to avoid having to refer to the ‘tool’ rather than its final description solely for the sake of historical continuity.

This research project investigated: a diverse group of safety culture related concerns as discussed in Chapters 2 and 3; mechanisms for evaluating the questionnaire approach to safety culture surveys and their inherent problems; means for identifying a solution to the issues surrounding surveys as an appropriate measure of organisational safety culture; the design and implementation of the proposed solution both from the conceptual and practical perspectives; the design of a knowledge transfer approach and finally the measurement and evaluation of the effectiveness of the model and knowledge transfer approach.

All of these combined to produce a complex solution to defining what organisational safety culture really is; how it can be modelled and what will be passed on to any participants in the education process in the form of knowledge, belief or experience.

4.1 Epistemology

From an epistemological perspective, there are interesting aspects regarding what is, and what is not, knowledge with respect to the information being presented to the participants.

A common definition of knowledge states that

S knows that P if, and only if -

(i) P is true,

(ii) S believes that P, and

(iii) S is justified in believing that P.

This is often represented in an Euler diagram as shown in Figure 4.1.

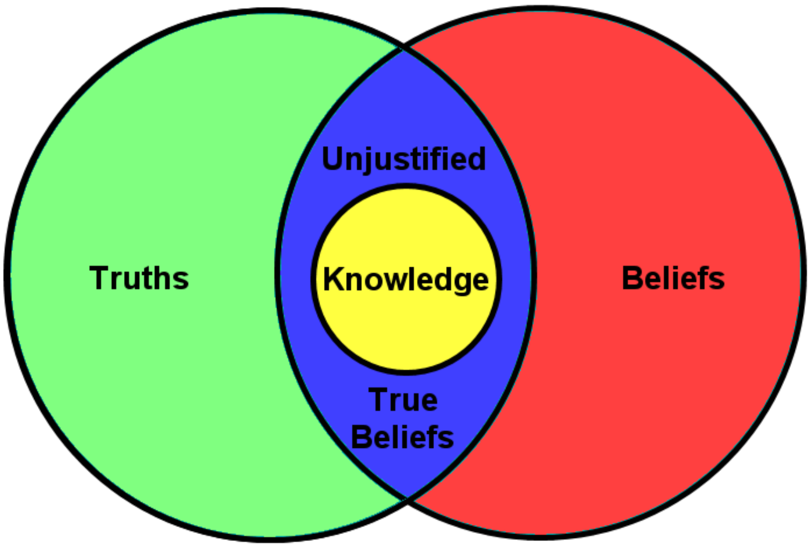


Figure 4.1 Typical definition of knowledge as 'justified true belief'.

Gettier (1963) contests the claim that 'justified true belief' is, in fact, knowledge and, using two different examples, proceeds to illustrate that the definition above is not in fact sufficiently rigorous to accurately define knowledge. To delve deeper into this philosophical debate, while interesting in itself, would require an additional thesis. There are however, pertinent issues worth addressing with regard to the nature of the information being passed to the participants.

Much of the information being presented to the participants is not, in itself, necessarily a truth. For example, while the number of accident reports submitted may result in a pattern which indicates that the organisation is failing to report all events, it is not in actual fact an established truth that this is the case. It may simply be that the organisation is currently experiencing a particular distribution of accidents and that, over time, this may adjust in favour of a closer match with established industrial norms.

Similarly, other data may be the result of errors or omissions. For example, management uptake of available training courses. If the data is not accurately collected and managed by the organisation then this may result in patterns within the data which are not representative of the true state of affairs.

Strictly speaking, according to the philosophical definition of ‘knowledge’, what is being imparted to the participants might more accurately be described as ‘insight’ rather then ‘knowledge’ though it is unlikely that this subtlety would have a significant impact on the participants who simply wish to establish what the situation is within their organisations. Indeed, ‘insight’ is possibly the more accurate description as the output from the SCLE is a number of pointers to where management might be most likely to discover the factors which are adversely affecting their organisational safety culture.

For the rest of this thesis however, wherever the term ‘knowledge’ is used, it will be to describe the information being provided to the participants.

4.2 Review of possible methodologies

The multi-faceted nature of the project complicated selection of the most appropriate research approach. A review of the most common methodologies identified: mixed methods, cultural, ethnographic, evaluation, experimental, correlation, descriptive, historical, surveys and sampling, phenomenology, grounded theory, design science, action, and case studies. Most of these were not applicable to the project and so were immediately dismissed. Three remaining methodologies did, on initial review appear to have merit and so justified closer examination as discussed briefly in the following sections.

4.2.1 Action research

Action research has many definitions. Punia (2009) highlights 17 different descriptions while Park (1999, p. 4) states - *"There is general understanding in action-oriented research that the people who are to benefit from the research should participate in the research process"*, while Denscombe (2010, p. 6) writes that the purpose of action research is to *"solve a particular problem"* and to *"produce guidelines for best practice"*.

This research project certainly falls within the domain described by Denscombe in that the problem of measuring and evaluating safety culture remains a challenge to industry and that there is a need to help management acquire the skills to effectively manage and improve safety culture within the organisations they control.

Notwithstanding differing definitions of exactly what action research is, incorporating action research into the evaluation process initially appeared to have the potential to address the issue of treating people as active agents rather than passive subjects

(Reason 1999). Following the action research model proposed by Kemmis and McTaggart (2005), an initial outline of the intended steps would be as shown in Figure 4.2.

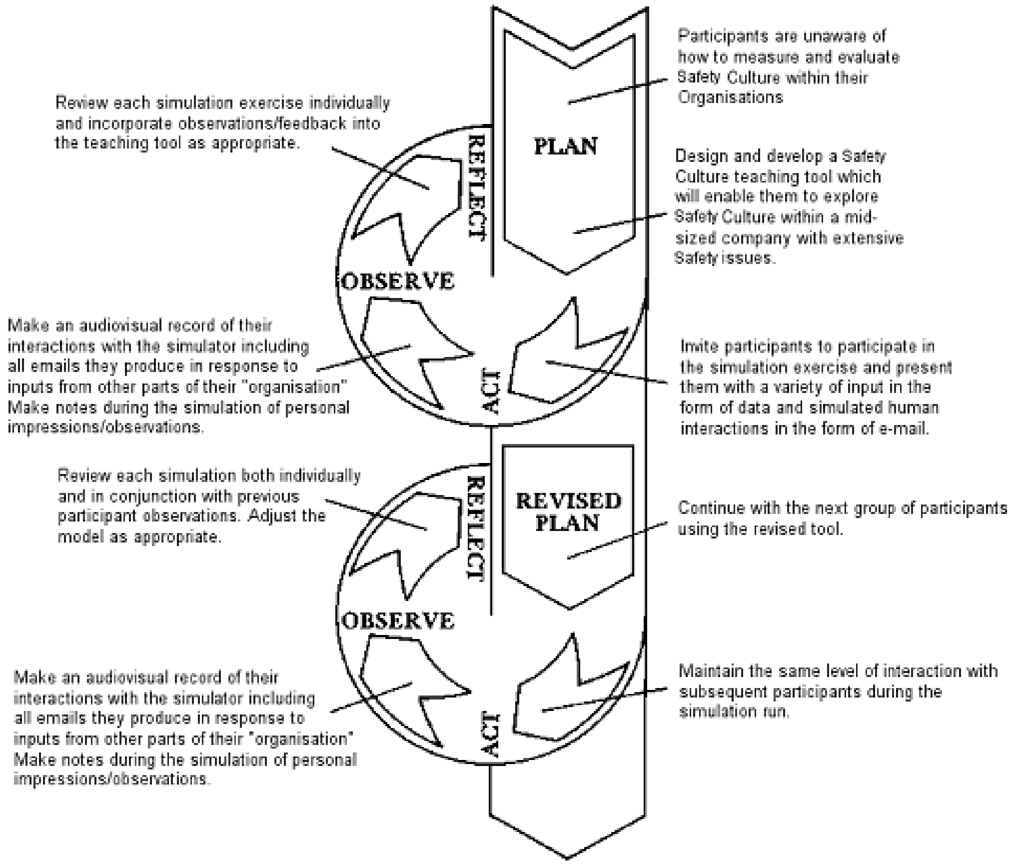


Figure 4.2 Preliminary approach to action research methodology.

A consistent theme running through most of the published material on action research is the cyclical nature by which revisions are made to the 'plan' phase of the model process. It is here that the action research approach fell short of what was required in respect of this research project.

Every participant requires a full 10 hours to complete the learning experience. This comprises an introduction to the day and the nature and structure of the company modelled within the SCLE. The introduction is followed by 8 hours of interaction within the SCLE and finally, a post-SCLE review. Certainly, there are observations, comments and suggestions for options and improvements; however, if these were to be developed and implemented following completion of the learning experience by each participant then the option to evaluate the learning environment from a common perspective would be lost.

It is certainly possible that, should the tool find widespread application in industry, an action research approach could be used in the future over an extended time frame with large numbers of participants with the objective of fine tuning the learning environment. Managing to get a large number of people over the highly constrained timetable of this project was simply not going to be possible due to logistical, financial and time constraints.

4.2.2 Design science

On initial review, a design science methodology also appeared to have potential as an appropriate methodology for this project. As a solution oriented approach (Wieringa 2013), design science requires that a new artefact be created and tested to establish whether it has successfully solved an existing problem from a novel perspective. This was precisely what this research project set out to achieve; in the first instance to identify how to model safety culture and then, having identified how to construct the model to produce an information technology solution for subsequent evaluation.

Takeda et al. (1990) describe a design science research process model which, on first assessment, appears to exactly describe the appropriate approach for this research project. A modified version of their 5 step process that is more applicable to this project is presented in Figure 4.3.

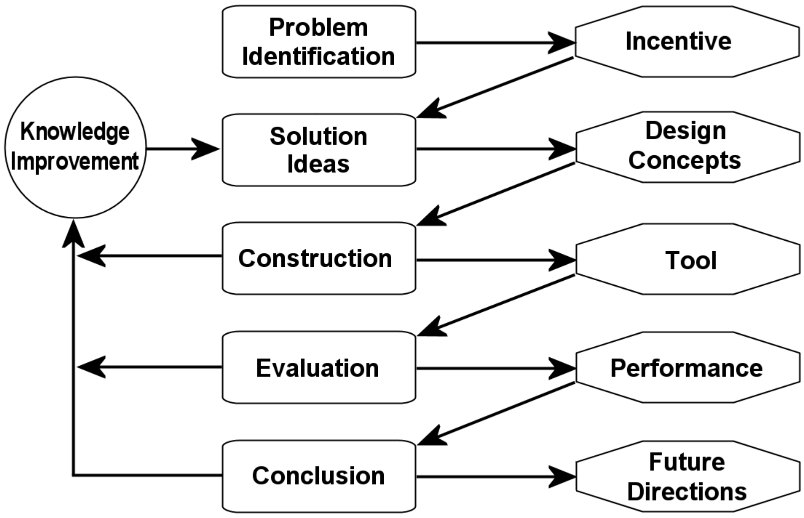


Figure 4.3 DSR process model adapted from Takeda et al. (1990).

As with the action research methodology described in section 4.2.2 however, the need for a continuous feedback loop excluded this approach.

4.2.3 Evaluation methodology

The evaluation methodology approach is typically used to determine the quality (or otherwise) of a particular performance, product or skill (Baehr 2004). This project certainly involved all three of these factors. Participant performance was to be assessed in terms of their ability to use the information and subsequent analytical skills to determine and report on the safety culture of their organisation.

Evaluation methodologies typically involve distinct parties with clearly defined roles and responsibilities, the most commonly identified being those of client/stakeholder and evaluator (Baehr 2004, IEG 2007). Skolits et al. (2009) highlight the lack of clarity in the definition of precise roles for the evaluator and point out the relationships which exist between the evaluator and the stakeholder(s). Kushner (2005) stresses the importance of the evaluator setting aside his personal judgements and values in preference to those of the participants. He goes on to express the concern that some may view this as optimistic given the inability of evaluators to suppress their own subjectivity.

In this particular research project, there are significant problems with the varying roles, responsibilities and relationships described in the literature. Not only is the researcher the creator of the artefact being studied, he also participates to a large extent by adopting three different roles (educator, member of staff and participant's boss) during the learning experience. Given such intimate involvement with the project and the participants' learning processes, it was decided that there was too much of a potential conflict with the requirements of an evaluation approach to adopt this methodology for the project.

4.2.4 Case study

Stake (1995) defines a case study as an exercise which is conducted with the objective of capturing the complexity of a single case while Ghauri (2004) describes it as a choice of object to be studied which is applicable to both quantitative and qualitative research. It is selected when researchers wish to improve their understanding of a particular problem. Yin (1994) recommends that case study is the appropriate research methodology when the research questions being answered fall into either 'How' or 'Why' categories. In this research project both of the research questions are of the 'How' variety. Yin's latest definition of case study (2014, p. 16) is presented in two parts. In the first part, he defines the scope of a case study:

"1. A case study is an empirical inquiry that -

- *investigates a contemporary phenomenon (the 'case') in depth and within its real-world context, especially when*
- *the boundaries between phenomenon and context may not be clearly evident."*

What Yin intends to convey from this first part of the case study is that the researcher would want to do case study research because they seek to comprehend a real-world case with the assumption that such an understanding is likely to involve important contextual conditions pertinent to the case under study.

The second part of Yin's definition of a case study recognises that phenomenon and context are not always clearly distinguishable. For this reason, other methodological characteristics come into play as the relevant features of the case study approach.
Part 2 of his definition continues -

A case study inquiry -

- *"Copes with the technically distinctive situation in which there will be many more variables of interest than data points"* and consequently,
- *"Relies on multiple sources of evidence, with data needing to converge in a triangulating fashion",* which leads on to the statement that it
- *"Benefits from the prior development of theoretical propositions to guide data collection and analysis."*

In this definition Yin proposes that case study research adopts a holistic approach incorporating design, data collection and subsequent analysis. This is very close to the actual situation in respect of evaluating the applicability and effectiveness of the safety culture learning environment that is proposed as a solution to Glendon and Stanton's (2000, p. 4) call for *"complex and imaginative methods of assessment and analysis will be required to evaluate safety culture."*

Case studies involve data collection using a variety of sources including but not limited to: written reports, verbal reports, interviews, observation, audio visual records or other such materials. Walton (1992, p. 129) proposes that –

> *"The processes of coming to grips with a particular empirical instance, of reflecting on what it is a case of, and contrasting it with other case models, are all practical steps toward constructing theoretical interpretations. And it is for this reason, paradoxically, that case studies are likely to produce the best theories."*

Ridder et al. (2009) propose the use of case studies as detailed empirical investigations which emphasise the individuality of the case. They believe that their work has contributed to knowledge and that, in strategy and management research, case studies are good for identifying the relationships between constructs. They propose that the case study can be used to not only develop propositions but also to confirm propositions and draw attention to sampling strategy and research setting as components of study design that help build the framework for theoretical contributions.

Flyvbjerg (2006) proposes that the optimum form of understanding occurs when the researcher is placed within the context being studied. From this vantage point, the opinions and perspectives of the units of observation may be more closely studied. The nature of the case study which entails a close evaluation of the case itself provides support for the observation by Beveridge (1957, p. 105) that *"More discoveries have arisen from intense observation of very limited material than from statistics applied to large groups."*

A frequent criticism of case studies as a valid research methodology is that it is not possible to extrapolate from a single case to the more general population (Denscombe 2010). What is common to many of the proponents of the case study approach is that case studies per se offer the opportunity to gain valuable insights into real world artefacts through empirical research. This is precisely what the current research project seeks to achieve. My thesis is that all of the knowledge already exists (or should do if management are committed to safe operations) within the typical organisation operating in a high risk environment and that this knowledge can be used to replace an existing, but flawed, technique, namely safety culture survey questionnaires, as a valid, and more accurate mechanism for evaluating organisational safety culture.

In his defence of the case study as a valid research tool, Flyvbjerg (2006) highlights 5 misunderstandings that are common –

1. Theoretical knowledge is more valuable than practical knowledge
2. It is not possible to generalise from a single case
3. The case study facilitates generating a hypothesis rather than testing one
4. Case studies are inherently biased towards the researcher's desires
5. It can be difficult to summarise case studies

4.2.4.1 Theoretical knowledge versus practical

In the 'cowboy days' of expert system research, knowledge engineering was making an attempt to establish itself as a rigorous scientific approach where every aspect of the expert's knowledge could be coded into the form of an expert system that would liberate the knowledge thus making it available to all. A particular example dredged from the author's memory of a lecture nearly 30 years ago recalls an attempt to produce an expert system that could be used to identify when cheese was ready for the marketplace. The expert whose knowledge was being used to develop the expert system typically inserted a long sample tube into the cheese and then examined the cheese it contained carefully before making his decision. The knowledge engineers worked with him to identify parameters such as texture, temperature, colour, age, humidity, elasticity, etc. in an attempt to quantify how he arrived at his conclusion. It was only after much effort had been expended that they (and the expert apparently) realised that the expert's decision was driven primarily by the smell of the cheese and not by the physical parameters they had been seeking to quantify. One form of knowledge is not more important than another. All knowledge is important in its own right and this is equally true of knowledge gained through a case study.

4.2.4.2 Generalisation

The criticism that one can not generalise from a single case is, to a large extent, dependent on the case. Flyvbjerg refers to the famous lead and feather case which finally debunked Aristotle's theory on gravity. Through the judicious use of lead and a feather for the test, the hypothesis that if it was true for these two extremes then it was probably true for everything in between was strongly supported.

4.2.4.3 Generating versus testing hypothesis

The third observation that case studies are more useful for generating hypotheses rather than testing them is refuted by Flyvbjerg (2006, p. 229) who proposes that *"The case study is useful for both generating and testing of hypotheses but is not limited to these research activities alone"* while Eckstein (2000, p. 129) suggests that *"case studies are not only equal alternatives at the testing stage, but, properly carried out, a better bet than comparative studies."*

4.2.4.4 Bias

The risk of biasing the results of the analysis was something which the author was concerned about from the start of the project. There is a natural tendency to want the project to succeed and, with a qualitative study, the possibility for personal bias to creep in is real. Three precautions were identified to mitigate the risks of personal bias. Where possible, closed questions would be asked requiring a simple binary response. Secondly, where a subjective interpretation/analysis was required, this would be carried out, where practical, according to a pre-defined marking template to ensure consistency. Finally, a random sample of subjective analyses would be peer reviewed (section 4.4). While not 100% guaranteed to remove all bias tendencies, these precautions were felt adequate, in conjunction with the author's recognition of the risk of bias to ensure that the interpretation of the results would be as impartial and unbiased as reasonably achievable.

Flyvbjerg (2006, p. 237) concludes his refutation of undesirable bias in case studies by proposing that it has been shown that case studies contain a greater bias towards the *"falsification of preconceived notions than towards verification"*

4.2.4.5 Summarising

The tendency for case studies to generate large quantities of subjective narrative has contributed to the belief that it is difficult to summarise case study material. This was certainly seen as an issue in this project as it was anticipated that large quantities of narrative data would be generated. Flyvbjerg points out that it is more likely to be the property of the study itself rather than the methodology which is the real issue in summarising the study. The volume of data to be collected by this project was certainly acknowledged as a potential issue but, as Flyvbjerg states, this is not a reflection on the suitability of the case study methodology to the project. It is merely a reflection on the magnitude and scope of this research project and is certainly not a reason for rejecting the appropriateness of the case study methodology.

4.2.5 Methodology review

The objective of this research was not to justify the organisational model which had been created in terms of its relationship or otherwise to an actual operating oil company. The model presented to the participants was deemed to be valid and fit for purpose by its mere existence as an expert model designed around the author's circa 40 years' experience in the industry. The objective of the research was to establish whether such a model could provide a solution to the dual issues concerned with identifying organisational culture and training managers in how to evaluate this culture. This immediately eliminated both the action research and design science research methodologies from consideration. The evaluation research approach was dismissed as unsuitable because of the potential for a conflict of interest given the requirement for the evaluator's impartiality and the unavoidable dual roles of client and evaluator.

The case study methodology was selected as the most appropriate approach reinforced by its close correlation with Stake's (1995) defining characteristics of qualitative research. Namely that it should be –

- Holistic
- Empirical
- Interpretive
- Empathic

This project has a clearly defined context, is case oriented and definitely seeks to understand the object (SCLE) rather than comparing it with existing similar objects. It is wholly field oriented and the bulk of the data is observable. Much of the data is in the form of natural language interaction. Most of the process relies on the intuition of the observer and deliberately seeks to maintain a high level of researcher-subject interaction. Finally, it is by nature empathic. For all of the reasons described above, the case study methodology was adopted as the optimum approach for evaluating this project.

4.3 Case study design

There is a number of different suggestions for the various steps involved in conducting case studies. Examples include - Government of South Australia (2010, p. 1) – 11 steps, Yin (1994, p. 20) – 5 steps, Soy (1997, p. 2) – 6 steps. These, consistent with others, are fundamentally similar in their approach to case study research and generally differ significantly only in the degree of detail incorporated into each of the recommended steps. The South Australia Government version (2010) with its 11 steps ends up as more of a checklist as it seeks to lead the researcher by the hand to a conclusion. After reviewing a sample of case study approaches, the following 7 steps were selected as offering a concise and simple approach –

- Determine and define the research questions
- Identify the type of case study
- Select the participants
- Determine data gathering procedure
- Design session and timetable
- Collect data
- Analyse data

4.3.1 Determination and definition of research questions

Many researchers, as previously mentioned, have concluded that the accuracy of traditional safety culture/climate surveys and their ability to truly represent the prevailing organisational safety culture, is open to doubt. Entities such as the UK Health and Safety Executive (HSE, 2006, p. 80) when commenting on safety culture surveys observe – *"In our view, the absence of a more fundamental methodological breakthrough means that the psychometric approach seems likely to continue"*. Hence a different and new approach to safety culture assessment is required. As the collection of new data through the traditional survey questionnaire route is inadequate and the CCPS (2011, p. 1) observation is that safety culture is what is actually happening in the organisation when no-one is watching then a solution to the culture evaluation problem might be found by examining existing information. It is proposed that the requisite data can be found in most organisations operating in high risk environments either as a result of legal obligation or through proactive efforts. This leads to the first research question -

"How can safety culture be effectively modelled from existing data?"

Extracting knowledge regarding organisational safety culture and presenting this in an effective manner to a selection of research participants is critical if the answer to question 1 is to have any practical benefit to industry, rather than remaining an academic exercise which does not make the jump into the operational environment. Assuming, therefore, that it is possible to identify a positive response to the first research question, then it follows that the next important step is to communicate this knowledge to the people to whom it will be most beneficial, i.e. organisational management. This produces the second question of this research project -

"How can management be educated in the measurement and evaluation of safety culture of their organisations?"

4.3.2 Type of case study

Yin (1994, p. 39) identifies 4 different types of case studies –

Type 1 - Single case, single unit of analysis (holistic)

Type 2 - Single case, multiple unit of analysis (embedded)

Type 3 - Multiple case, single units of analysis (holistic)

Type 4 - Multiple case, multiple units of analysis (embedded)

The selection of the correct type was essential to achieving an accurate evaluation of the research. Identifying the appropriate type of case study required the answering of three different questions –

- What is the case to be studied?
- What is/are the unit(s) of analysis?
- What is/are the unit(s) of observation?

A cursory review of the project might suggest that it was a single case study of a teaching tool using a number of individuals (units of analysis) each participating in a similar experience and assessing the results of their outputs/interactions. More careful consideration of the nature of the case concluded that it was, in reality, the answer to research question 1 which was the artefact being studied. The learning environment itself was merely the delivery mechanism.

The instinctive assumption that the participants themselves were the units of analysis did not align with Murray's (1998, p. 105) definition – *"A unit is the unit of analysis for an effect if and only if that effect is assessed against the variation among those units."*

Organisations comprise many individuals and these individuals do not operate in isolation. They are grouped according to the different inputs they provide to the overall functioning of the organisation. The learning tool was intended for a specific group (management) within the typical organisation and for that reason the participants were selected and grouped according to specific criteria: professional discipline, experience in the oil industry or not and managerial seniority during their careers. The unit of analysis according to Murray's definition was, therefore, the 'group' as it would be the different groups comprising different arrangements of participants that would be analysed and compared. Support for this approach is apparent when the data showing 'culture reporting improvement' for each of the groups in Figures 7.8, 7.9 and 7.10 are compared with the same improvement chart for individuals as shown in Appendix 7. Finally, the individuals themselves, being the empirical unit on which data were collected, fitted well into the category of 'units of observation' (Mills et al. 2010).

Based on the above, the type of case study to be undertaken fell into the Type 1 (Holistic) domain as described by Yin; a single case (the answer to research question 1) with a single unit of analysis (the groups). It should be noted that the existence of multiple groups did not make this a Type 2 (embedded) case study having multiple units of analysis as each group was simply another instance of the same units of observation and not a completely disparate entity.

4.3.3 Participant selection

Following on from the design, implementation and testing phases of the learning environment, the final step required to answer research question 2 was to source an appropriate participant sample to test the system.

While it may appear self-evident, the choice of participants needed to be appropriate to the objective of the research and answering the second research question (Saunders 2012). Given the nature of the research project, a sample of the target population was the only practical approach to the evaluation phase. Denscombe (2010) describes two sample types – ‘representative’ and ‘exploratory’. The key attributes of the representative sample described by Denscombe (2010) are that it:

- Includes all relevant factors/variables/events and
- Matches the proportions in the overall population.

For this type of project, it was never feasible to consider obtaining a representative sample for the entire industrial management population around the world.

The second sample type described by Denscombe (2010), Exploratory, is much better suited to the type of research being undertaken in this project. Exploratory samples are used as a way of discovering new ideas or theories and are based on the need to gather new insights. Given the novel approach that this project brings to organisational safety culture understanding, this is clearly within the scope of the exploratory sample approach.

The next step in identifying an appropriate sample group addressed the issue of ‘probability’ and ‘non-probability’ samples. Probability sampling is intended to be based on completely random selections from the population being studied and is most applicable to large, known populations. This approach is often associated with large scale surveys (Denscombe 2010). Non-probability sampling applies when the researcher deems it unsuitable to select random sample entities and when it is not feasible to select a large sample population.

Further guidance on the nature of sample selection is provided by Saunders (2012) in his paper 'Choosing research participants.' Here too, Saunders addresses the issues of probability versus non-probability samples and presents the essential characteristics inherent in both types. With the choice of the sample being based on the researcher's judgement rather than random selection, using a relatively small sample size, and most importantly, with the aim of the study being of an exploratory nature intended to elicit 'rich understandings', the criteria identified by Saunders in determining whether a probability or non-probability sample should be used clearly point to the non-probability sample as being the most appropriate.

With the decision made that an exploratory, non-probability sample was most appropriate to answering research question 2, attention focused on identifying the appropriate technique to determine the most relevant sample. Many approaches to non-probability sampling have been identified by a number of different authors (Chaturvedi, 2012, Denscombe 2010, Trochim 2006). Some of the most commonly referred to approaches include –

- Quota sampling
- Convenience sampling
- Theoretical sampling
- Snowball sampling
- Purposive sampling

4.3.3.1 Quota sampling

The key concept in quota sampling is that this technique seeks to ensure that the sample proportions accurately reflect the distribution in the wider population. Given that the tool developed as part of this project is intended to be applicable to all senior management in all industries where high risk is an integral component of organisational day-to-day activities, then this sampling technique was not appropriate.

4.3.3.2 Convenience sampling

The convenience sampling approach did at first glance appear to be a good candidate for sampling technique. The idea of selecting candidates which suited the convenience of the researcher was immediately appealing especially given the limits on time and expenditure. The approach was dismissed, however, as it was simply 'too easy' and would almost certainly have resulted in a participant list that did not satisfy the real need to establish whether senior management from a diverse range of background could actually benefit from the learning experience.

4.3.3.3 Theoretical sampling

Theoretical sampling had no application to the problem. As a sampling technique, theoretical sampling seeks to modify or confirm a particular theory as each instance of the sample adds additional information to the research. In this project, there was no theory to test and so selecting sample instances based on the need to confirm or otherwise a particular theory was not applicable.

4.3.3.4 Snowball sampling

There did seem to be some merit in applying this technique to the sampling issue. By selecting a suitable initial participant, it was very likely that this individual may be in a position to identify other participants who would be ideal candidates to participate in the research. Certainly, it could go a long way to solving the problem of finding sufficient participants to validate the research. There were several drawbacks, however, which consigned this approach to the reject pile. In the first instance, the snowball technique exposes the project to the possibility of bias on the behalf of the initial participants. No two people interpret any requirement in exactly the same way and the possibility that the participant might be influenced in their nomination(s) by how they might perceive the research was not deemed acceptable. In addition, just because other participants had been nominated, would not ensure that these people would be either willing or available within the research time frame. Finally, while this technique is useful in building up a sizeable sample in a short time frame, logistical constraints associated with the management of the project meant that a large number of people could not be accommodated in an acceptable period. For these reasons, the Snowball approach was discarded.

4.3.3.5 Purposive sampling

Described by Denscombe (2010, p. 35) as *"Hand picked for the research"*, this approach to sampling results in a relatively small sample comprising people who have normally been selected for their knowledge of the topic. For this study, however, it was also essential to include participants who had no knowledge of the subject. Research question 2 refers to the 'education and training' of managers. Selecting a sample who already knew about the topic in depth would be unlikely to demonstrate the effectiveness of a teaching tool intended for people with no significant knowledge of the topic. The purposive sampling approach was, however, the most appropriate and the 'hand picked' population were subsequently selected using a 'diagonal slice' approach.

4.3.3.6 Diagonal slice

A diagonal slice approach (Figure 4.4) seeks to identify participants from every organisational level and across multiple disciplines (Brooks 1987, Girling 1999, Zoeckler 2010).

Strictly speaking, the term diagonal slice is misused as, in practice, the intent is to gather a group of people from as many levels and disciplines as is practicable. It might be more accurate to describe it as a matrix sample. For the purpose of this project, three levels of management were identified; Senior, Middle and Junior. As far as disciplines were concerned, three classifications were defined; HSE, Finance and General Industry.

HR	**Finance**	**Production**
Senior	Senior	Senior
Middle	Middle	Middle
Junior	Junior	Junior

Figure 4.4 Organisational diagonal slice.

4.3.3.6.1 Health, safety and environment specialists

Although the purpose of the teaching tool is not to educate/train HSE professionals, these are nevertheless the individuals with the greatest knowledge of the subject and as such, they served a dual function. In addition to being subject matter experts whose feedback would be vital in assessing the value of the tool, they also provided a ‘baseline’ against whose performance the other two groups could be assessed.

4.3.3.6.2 Finance professionals

Participants from the finance discipline were included to provide a reference to the effectiveness of the education/training on a small group of individuals who would not normally in the course of their work come into contact with the issues surrounding safety and safety culture, though they certainly come into contact with the financial consequences of poor safety.

4.3.3.6.3 General industry

Finally, the remaining participants were selected from a broad range of industrial backgrounds. This was done deliberately. Despite the Safety Culture Learning Environment (SCLE) being developed from knowledge of the oil industry, OHSAS 18001 was developed for use in all organisations which need to manage the business of safety. So while the data used to develop the learning environment are based on a typical oil company, the fact that the participants are not required to possess in-depth knowledge of this industry in order to benefit from the learning experience lends support for the statement that the SCLE is applicable to oil and non oil-experienced individuals regardless of their particular industrial background.

4.3.3.7 Sample size

The final decision that needed to be made was the size of the sample that would participate in the learning environment evaluation. In his extensive review of sample size Mason (2010) identifies that 80% of the total proportion of qualitative studies examined adopted Bertaux’s (1981) minimum size of 15 participants for a non-probability sample. This is supported by Saunders (2012) who summarised 8 different authors' work on sample size for differing study types (including Bertaux 1981). Of the 8, 5 identified sample sizes less than or equal to 15 across several different study types.

While a high number was naturally desirable, the practical constraints of cost and time meant that numbers would need to be limited if the objectives of the project were to be realised. A target of 15 was set as a minimum, given not only the support in the literature but also the constraints imposed on the project by cost, time and logistics. Any more than 15 was considered a bonus and in the end, 17 participants managed to travel to site and engage in the learning experience. The final participant selections are displayed in Table 4.1.

	HSE	Finance	General Industry
Senior Management	XX	X	XX
Middle Management	XXX	X	XXX
Junior Management	X	X	XXX

Table 4.1 Distribution of participants.

4.3.4 Data gathering procedure

The project required that a diverse group of individuals participate in a learning experience which would be alien to all of them given the novel approach that was being adopted. In addition to their probable lack of familiarity with safety management/safety culture (excluding the safety specialists), the technological aspects of the delivery mechanism were also likely to be unfamiliar.

Well before the time for the first case study, it was obvious that getting any volunteers at all was going to be a difficult task. Primarily, this was due to the sheer scale of the project. While willing volunteers had expressed their desires to assist with the research during the initial phases of the project, these individuals were spread thinly across the UK, Continental Europe and the Middle East. In almost every case, they were working professionals and the likelihood of being able to get them all to a single location even at discrete locations such as Aberdeen, Madrid or Abu Dhabi within a few days of each other was effectively zero. Additionally, with an equipment list which included -

- 18 x computers (2 as spares)
- 14 x monitors
- 3 x video wall stands
- 1 x 16 port video switch
- 1 x video projector
- 1 x computer rack
- c. 120m of cabling

transporting the physical equipment would have been a major, and costly, task. Given the need for a total of 2 days set-up time, 1 day system testing, 1 day participant evaluation and 1 day dismantling time, a minimum of a full working week would have been required at each evaluation location, possibly for as little as a single participant. With a lot of participants at diverse locations this could have resulted in several months of work as well as very high transport, accommodation and office space rental costs. In the case of space rental, this assumed that there would be a suitable office space available for equipment set-up at the testing location. Taking the SCLE to the participants was, therefore, infeasible and the decision was made to bring the participants to the learning environment in order to facilitate data collection at a single location.

4.3.5 Session design and timetable

All participants in this project were clearly informed of the nature and content of the research and what would be done with the information collected in accordance with Lancaster University's ethics policy and all agreed with those requirements and signed the requisite documents consenting to the collection and use of data pertaining to the study. In addition to satisfactorily addressing the ethical aspects of the project, it was essential to bring the participants to a point where they could begin to interact meaningfully with the tool from the moment the session began.

The preparation of the participants described here relates to the pre-session familiarisation that each was required to undergo. This was done to enable them to be able to respond appropriately to the information in the numerous pages of charts and diagrams that would be presented to them via the video wall and the e-mail traffic they would begin to receive from their line managers together with other elements of Lancaster Oil Ltd. from start-up.

All of the participants understandably brought their actual working life experiences with them. They were not being asked to role play to the extent that they were being asked to forget this experience, rather they were being encouraged to bring whatever background or experience they had in safety culture to the day. In order to identify what experience they possessed or what opinions they held in the area of safety culture, a short interview was conducted before the session to establish -

- their previous exposure to safety culture
- their beliefs about the importance or otherwise of various items of information in establishing their understanding of corporate safety culture

On completion of the session some 8 hours later and after their final safety culture report to the board of directors, the participants were again interviewed using the same question set to establish which, if any, of their opinions had changed. In addition, 4 further questions were included in the second interview relating to their experience during the session and their thoughts on various aspects of their interaction with the SCLE. An analysis of the results of the two questionnaires is presented in Chapter 7.

The SCLE was designed to start automatically at a pre-programmed time and to run for a total of 8 hours to cover the 5 years of the life of the fictitious company it modelled. Given the diverse nature of the participants' experiences across a broad spectrum of industries, it was not clear at the outset of the project how much time would be required to bring each participant to a satisfactory start point in terms of their personal knowledge that would position them appropriately to interact knowledgeably with the teaching tool. This research project breaks new ground in the approach to educating/training individuals in how to measure and understand safety culture. While the use of simulations in education is not new (Lombardi 2007, University of Adelaide 2006, University of British Colombia 2006), there does not appear to be a similar tool to the SCLE at present for comparison. Consequently, there were no real guidelines on how to prepare participants for the experience they were about to have. To accommodate the individual variability that seemed inevitable from the start, a degree of flexibility was designed within the tool to allow the automated start time to be varied in hourly increments. This enabled more time to be devoted to individual awareness and orientation, before the event, as required.

The tool was designed and developed with the intent that it should be applicable across all industries so while the organisation which had been modelled for teaching purposes was that of an oil company, it was important that participants' experiences provided them with the skills to address safety culture in any industry and not specifically in the oil industry. Key factors which were of some note with regard to participants' profiles included –

- Their familiarity with the oil industry in very broad, general terms
- Their familiarity with safety management in high risk operations
- Their expertise with computers in general and e-mail systems in particular

Of great importance in extracting the most benefit from the session was bringing the participants to the point where they –

- Understood the structure of their organisation
- Understood their role and position within that organisation
- Understood what information would be given to them during the 8 hours until the end of the session
- Understood the importance of 'exercise unreality'
- Understood the complex relationship they would have with the researcher who was playing three different roles during the learning process –
    - Educator
    - Participant's HSE manager
    - Chairman of the board

- Understood the need to think and behave as if they really were the managing director of an operating oil company and not a participant in a research project.

Note: 'Exercise unreality' is a term the author has adopted over 25 years' designing and running oil industry emergency response exercises. It is never possible to accurately replicate the events/stresses/emotions/interactions, of a major emergency, in the training room. If trainees in emergency exercises wish to gain the maximum benefit from their experiences, then they need to suspend belief for the duration of the training and accept that there are constraints that are unavoidable in preparing a viable training scenario.

Each session was conducted according to the same timetable as shown below -

07:15 Read and sign Lancaster University research ethics documents
07:30 Conduct interview number 1
08:00 Induction
08:45 Participant presents 2019 safety performance data to chairman of the board
09:00 Learning environment components begin automatically
10:36 Preparation of 1st annual safety culture report by participant
12:12 Preparation of 2nd annual safety culture report by participant
13:00 Presentation of mid-session safety review
13:48 Presentation of 3rd annual safety culture report by participant
16:24 Presentation of 4th annual safety culture report by participant
17:00 Poisson distribution presentation given to the participants
18:00 Presentation of 5th annual safety culture report by participant
18:15 Second interview
19:00 Wash-up and review
19:30 Finish

Lunch and comfort breaks were taken as required though the SCLE did not pause for these activities. Given that even an uninterrupted session lasted over 10 hours, avoidable delays were deemed unacceptable if participant concentration was not to fail. In one case, a participant did reach the point in the final interview where he declared that he could no longer think and that he could not answer any further questions. This was the only actual such case. Others did, however, confide that they ended the session feeling completely drained of energy and emotion by the end of the 10 hours.

4.3.6 Collection of data

Yin (1994, p. 80) identifies 6 sources of evidence applicable to case study research: Documentation, Archival Records, Interviews, Direct observation, Participant observation and Physical artefacts. This is a case study of a novel solution to a problem and, as such, neither archival records (pertaining to the case itself) nor physical artefacts are available. The other four sources of evidence were straightforward in terms of acquisition. This resulted in a slightly simplified convergence of multiple sources of evidence for a single study as shown in Figure 4.5.

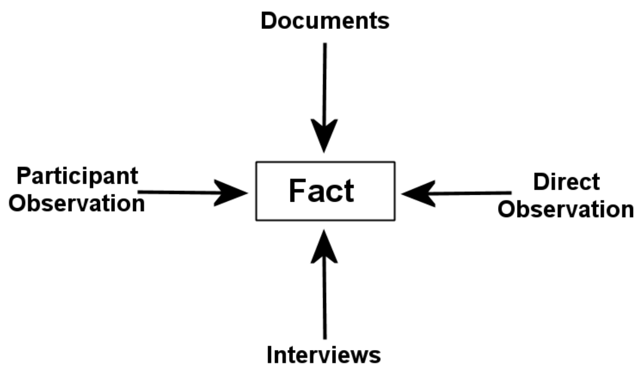


Figure 4.5 Simplified conversion of multiple sources of evidence (single study).

In order to capture the maximum amount of data from each of the teaching sessions, several collection mechanisms were established –

- Audio-visual record
- E-mail traffic
- Pre-session interview
- Annual reports
- HSE manager job specification analysis
- Post-session interview

4.3.6.1 Audio-visual record

Being in the one room for the entire session meant that audio-visual recording would be the simplest approach to collecting a full history of participant action. Recording began with the pre-training interview, and captured every data screen access, every conversation held with the educator and every presentation made to the board of directors. In total, for each participant, approximately 10 hours of audio-visual material was generated. A separate, simultaneous audio record was also made as backup in the event of loss of the audio-visual records. Full details of how the audio-visual material was examined including the frequency and duration of individual data page accesses are presented in Chapter 7.

4.3.6.2 General e-mail traffic

In order to both maintain participant interest and to collect data on their changing levels of ability to evaluate their organisation's safety culture, a combination of requests both for intervention in particular safety topics and mandatory reporting to the board was conducted using the SCLE's inbuilt e-mail system. During the 8 hours it took to run through the entire data set, pre-programmed e-mails arrived at the appropriate time in the participant’s inbox. Most were accident reports which did not individually require specific action by the participant. Others, however, were e-mails from ‘direct reports’, members of the workforce and the chairman of the board. The participant was required to address these communications and respond accordingly. All e-mail traffic sent out by the participant ultimately arrived in the educator’s inbox for future analysis.

4.3.6.3 Pre-session interview

A copy of the interview schedule is presented in Appendix 2. Typically, the interview occupied around 30 minutes. Its purpose was to elicit specific information from the participants regarding their opinions on various aspects of safety culture. It was not the intention to enter into any discussion or debate relating to their views on other safety topics such as safety management, safety engineering, occupational safety, etc. The information obtained from the first interview was intended to be the baseline for comparison with the results of the second interview, scheduled for the end of the session, to evaluate how the participants’ views had changed over the course of the day.

Kvale and Brinkmann (2009) discuss a variety of interview classifications. Of the different structures and formats they present, one, the focused interview, most accurately reflects the intended interaction. It was essential to structure the interview as the subject matter was a narrow, highly specialised theme, namely that of the participants’ experiences and opinions on safety culture and the contribution, they believed, various factors brought to their overall understanding of said culture.

The interview was designed to be more of an interactive questionnaire rather than a two-way discourse. It was divided into 3 sections. The first section established whether the participants had ever been involved in a safety culture survey and their opinions on what they perceived organisational safety culture to be. Section 2 asked specific questions regarding the participants' perception of the importance of the various elements of the SCLE and finally, the last section, which was only asked in the second interview sought feedback from the participants on their feelings and opinions regarding their experience during the day, their thoughts on the data and time scales involved and their opinion of the SCLE as a useful teaching tool.

Sections 1 & 2's questions are common to both pre- and post-session interviews to provide an opportunity to quantify changes in beliefs as a result of their experience. Interviews are commonly criticised as valid research source because of - *"Different interpreters finding different meanings in the same interview, the interview is not a scientific method"* (Kvale & Brinkman 2009, p. 211). For this reason, each question in Section 2 was asked in both open and closed fashion. Participants were asked to respond in the first instance with a simple 'Yes' or 'No'. Regardless of their answer, they were then asked to explain why they felt that way. By keeping the question tightly focused on the subject and not allowing the interviewee to stray from topic, it was expected that opportunities for misconstruing responses would be minimised.

The first interviews were carried out after the induction and before the training began. Some of the screens and the data displayed are novel within industry so there would be little benefit in interviewing participants with regard to their thoughts on these topics without first informing them what the topics actually were and what the screens were going to display.

4.3.6.4 Annual safety culture reports

The SCLE began on the 1st of January 2020 and ran until the 31st of December 2024. At the end of every 'year' in the SCLE, the participants were required to submit their annual reports on the safety culture of the organisation, as they perceived it from the available data, to the board of directors. This report was a major source of information regarding the effectiveness of the SCLE as it provided powerful insight into how much progress participants had made in their abilities to evaluate and interpret the information being presented to them.

4.3.6.5 Replacement HSE manager position

At the start of the session, one of the first e-mails that the participants receive is a note from the human resources manager advising that the new HSE manager (second role played by the author) has started in his position. Attached to this e-mail is the job description for the new hire. Shortly before the end of the session (8 actual hours later and 5 years in simulated time) the participant receives notification that the HSE manager has resigned and that they need to hire a replacement. The same copy of the job description is attached and the participant is asked if they wish to make any modifications. The modifications that the participants make is a reflection on how they now perceive the role of their HSE manager in the light of the new experience they have gained.

This requirement was incorporated into the learning environment in response to the research mentioned in Section 1.3 where, of 11,000 HSE jobs advertised over the last 3+ years, only 4.9% of them have been looking for professionals with the skill sets to help organisations down the last step toward the ultimate goal of an accident free workplace. An analysis of the modifications that the participants make to the original job specification provides an insight into their new appreciation of the role of HSE manager and the skill sets of individuals they would wish to fill this role.

4.3.6.6 Post-session interview

On completion of the training session, participants were again asked the questions posed from sections 1 and 2 of the interview template (with the exception of the question on whether they had ever conducted a safety culture survey before). The differences in their answers enabled an evaluation of changes in their belief system with regard to safety culture and provided direct input to the answer to research question 2.

Johnson (1997, p. 283) in his description of ‘Strategies used to promote qualitative research validity’ identifies participant feedback as important to providing ‘verification and insight’ – *“The feedback and discussion of the researcher's interpretations and conclusions with the actual participants and other members of the participant community for verification and insight”* and so a 3rd set of questions was asked at the end of the session to determine how the participants themselves felt about how useful they had found the experience and what, if any, changes they would like to see in order to develop the tool further.

As well as the continuous interaction with the participants during the session which was evaluated during the video wall analysis, each participant was asked to provide feedback on their experience, their thoughts on the usefulness of the SCLE as a teaching mechanism and their views on how it could be migrated to industry.

4.3.7 Data evaluation and analysis

Analysis of the data was carried out in 5 distinct categories –

- Video wall analysis
- Annual report
- Pre- and post-session interviews
- Job description
- Participant feedback

Data evaluation was carried out within the overall case study approach. The European Commission (2006) identifies 4 components of a case study (Figure 4.6) which match closely the approach adopted in this project.

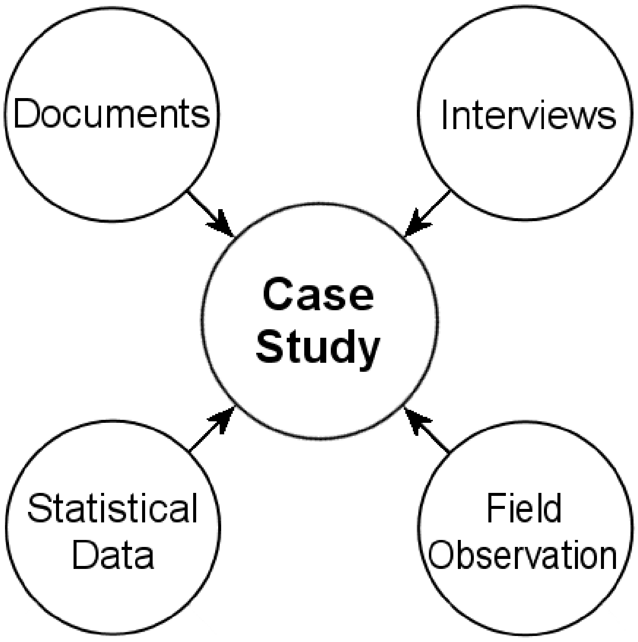


Figure 4.6 Case study components.

All of the data collected during the individual participant sessions were classified into one of the components in Figure 4.6.

4.3.7.1 Video wall analysis

Video wall analysis looked at the interaction the participants had with the 250,000 plus data items that built on the monitors during the session. By making an audio-visual record of the entire session, it was possible to evaluate participant actions down to the nearest second. Details are presented in section 7.1.

4.3.7.2 Annual report

The annual report was included as a principal indicator of changing abilities and beliefs in evaluation of the safety culture of the organisation presented in the SCLE. With 5 reports submitted to the 'board of directors', the participants' assessment on the safety culture of their organisation changed every year. Analysis of these reports was expected to provide a picture of their changing abilities in evaluation safety culture.

In order to eliminate bias and to enable consistent scoring, a marking template was produced. This was applied to each of the annual reports produced by each participant. Such a template would also facilitate peer review (the results of which are presented in section 4.4) of a sample of the reports as a check.

4.3.7.3 Pre- and post-session interviews

The interview questionnaire provided an opportunity to introduce a degree of quantitative analysis by way of the inclusion of a set of closed questions. The data obtained from the closed questions could be easily graphed while the responses to the open questions on the same topics would provide support to any claim that there had been a change to their belief systems.

4.3.7.4 Job description

Analysing the participants' modifications to the initial job description with which they were provided for their HSE manager would give additional support to the evaluation of how the participants viewed the need for appropriate skills in their organisations in regard to establishing and evaluating safety culture.

4.3.7.5 Participant feedback and thematic analysis

Feedback from participants was obtained from 3 sources: an audio-visual record of the entire session, the post-session interviews and written feedback provided by each participant on completion of the full learning experience. A thematic analysis (Braun & Clarke 2006) incorporating all of the feedback was also carried out.

4.4 Data quality assurance

Where analysis of data involved an assessment of subjective textual information, a peer review was conducted by a safety specialist from the oil industry. This individual brought almost 40 years' experience in both the upstream and downstream oil and gas industries, which included refinery process operations, process and safety engineering design, management training and auditing, and consultancy. For the past 16 years he has been working in various HSE management and advisory roles mostly specialising in setting up management systems, including ISO and OHSAS standards. In addition to being a Registered Safety Practitioner (RSP), he is also a Chartered Member of the Institute of Occupational Safety and Health (CMIOSH).

The results from the peer review indicated a reasonably good level of correlation. While the total scores on the marking template (Appendix 3) ranged from 79.5% to 95.5% agreement, what was of most satisfaction was the fact that the peer review agreed with the author's analysis that there was continuing improvement (annual scores) in the participants' abilities to evaluate and report on their organisation's safety culture. Although individual years may have had slightly different scores, in 100% of the cases, both the author and the reviewer were in agreement that there had been similar levels of improvement through the 5 years of the learning environment timescale.

4.5 Summary

The case study, as a mechanism for evaluating particular phenomena approaches the subject by way of a narrative supported by data most commonly presented in the form of graphs and tables. Unlike strictly quantitative approaches, the case study has the potential to combine both the quantitative and the qualitative data thereby enhancing the understanding of the subject being evaluated.

The use of quantitative data alone in this study, while it might have provided similar conclusions with regard to the answers to the 2 research questions, would most likely have missed the essential feedback from the open-ended interview questions, the large volume of e-mail traffic including participants' reports and the verbal feedback from the participants regarding their experiences. Without this feedback, establishing the magnitude of the usefulness of the SCLE as a teaching tool would have been much more difficult.

While the action research methodology and the design science research methodologies offer much in the way of evaluating the SCLE, they are not aligned with the true objective of this project which is not how to design such a tool but whether the solution proposed serves the purpose for which it was designed and developed. The independence and impartiality demanded by the evaluation methodology meant that the researcher with his intimate involvement in all aspects of the SCLE development needed to be excluded. For these reasons, the case study methodology (Yin - Type 1) was adopted as the basis for this project.

Chapter 5 Considerations in the design of the safety culture learning environment

5.1 Identifying the appropriate learning experience

The goals of the project were to develop and evaluate solutions to the contemporaneous problems of measuring and evaluating corporate safety culture and communicating the knowledge and ability to senior management. To achieve this objective, a model of a typical oil-producing organisation operating in a high risk environment needed to be designed and constructed. Incorporated into the model would be data which, at the basic level, provided the participant with superficial insights into the culture of the entity he was managing but which, with the benefit of greater understanding, could be analysed by the participants to reveal the true picture of the underlying safety culture. There were many questions which needed to be answered before the design phase could begin –

- Should the tool be interactive?
- What form should the organisational model take?
- How should management be represented?
- Should the tool be classified as education, training, learning or development?
- What interaction should there be with the educator?
- Should role players be involved and, if so, in what capacity?
- What would be the optimum time-scale to incorporate into the model?
- How long should the process take to complete?
- What would be the source data for the corporate culture?
- How would the participants' performance be measured?
- What would be the profile of the intended participants?
- Should the education/training be on a one-to-one basis only?
- How should the information be presented to the participant?

Finally, when all of these questions had been resolved satisfactorily, the last and most important question which had to be answered was –

- Could a model be built and validated both from a time and cost perspective?

5.2 Tool interaction

In her paper 'What Are Simulations? – The JeLSIM Perspective' - Ruth Thomas (Thomas 2003) highlights the differences between simulators, emulators, viewers and other types of learning environments (Figure 5.1).

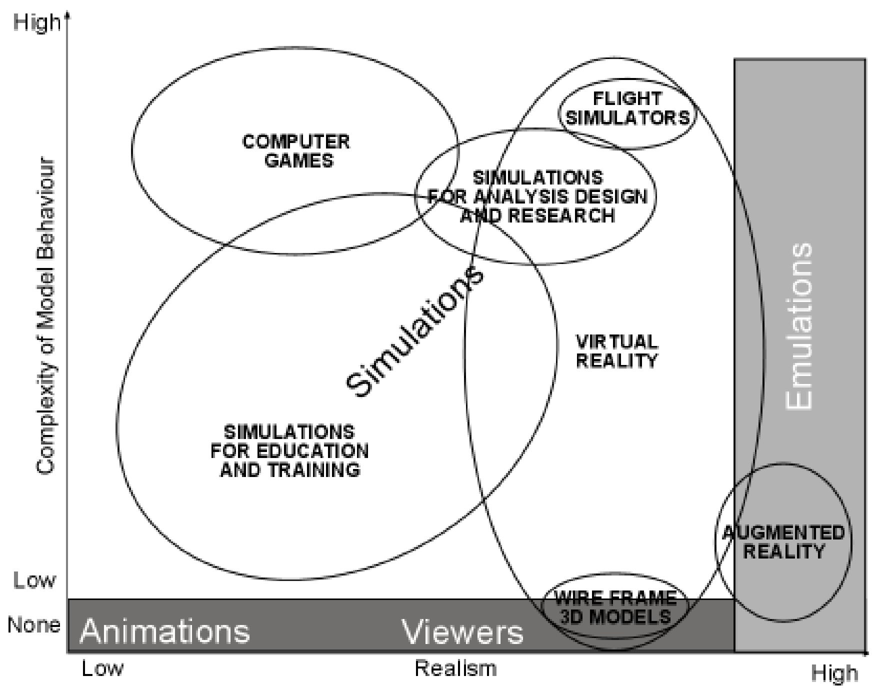


Figure 5.1 Relationship of simulations to emulations and viewers. Reprinted with permission.

It was clear that tools such as animations, viewers, flight simulators, virtual reality, wire frame 3D models and augmented reality tools were not contenders as effective training delivery mechanisms.

5.2.1 Simulator

Two possibilities still remained and each was considered. At first glance, the design and construction of a simulator might be seen as the most applicable approach. Fishwick (1995, p. 1) defines simulation as - *"The discipline of designing a model of an actual or theoretical physical system, executing the model on a digital computer, and analyzing the execution output. Simulation embodies the principle of 'learning by doing'"*.

Certainly, a model of a theoretical entity was going to be designed and subsequently executed on a digital computer and analysis would be carried out on the 'output'. In addition, there would be a significant quantity of 'doing'. Fishwick's definition, at first, appeared to be appropriate to defining the tool as a 'simulator'. There remained a question, however, relating to what Fishwick meant by 'doing'.

Thomas (2003, p. 1), describes the -

> *"broad agreement from both simulation experts and educational users of computer simulations that the key features of simulations are:*
>
> *1. There is a computer model of a real or theoretical system that contains information on how the system behaves.*
>
> *2. Experimentation can take place. i.e. changing the input to the model affects the output."*

Thomas's criterion 1 is relatively straightforward to fulfil with the appropriate data, the 2nd criterion poses significant issues in both credibility and viability. This issue was equally applicable to Fishwick's 'doing' in terms of model interaction.

The net effect of a good safety culture versus a poor safety culture is fewer accidents as put forward by both Quast (2004) and Reason (2000) in section 2.2. It is here that the major problem associated with developing a simulator is most clearly manifested.

If the opportunity is provided for users to make inputs to a corporate simulator then the effects of these inputs have to be modelled. In response to participant input, the simulator output has to be a decrease in accident frequency, an increase or no change. In the former case, participant inputs will have had a positive impact on the safety performance of the organisation while the opposite is true in the event of an increasing accident frequency. This gives rise to two problems. In the first instance, in order to produce a credible response by the model to user inputs, a direct link will have to be established between actions by management and a corresponding direct affect on the frequency of accident occurrence. It is unlikely that such a direct link could be made.

While external conditions such as weather, age, gender, etc. contribute to accidents, the occurrence of a specific accident is completely random (Elvik et al. 2009). In addition, the severity of an accident is an ‘act of God’. By way of a simple example, consider horse riding accidents. According to the British Horse Society (2012), the Hospital Episode Statistics Online 2010–11 reported 3,935 horse related accidents. Of these, 52 resulted in serious injuries and 8 fatalities. (The reader’s attention is drawn to the triangular nature of these numbers – 8 : 52 : 3935.)

What is never possible to know in advance is which of the 3,935 episodes is going to have a fatal outcome. Literally thousands of people fall from horses every year yet only a few are seriously injured and only a very small minority are killed. In the simulator world, as in the real world, there is no way to know beforehand which of the people in the process of falling off the horse is going to die as a result of the fall. An interactive simulator would, through necessity, need to incorporate the facility for the participant to effect changes to the simulator inputs which would manifest themselves in a corresponding increase or decrease of accident frequency and severity. As already mentioned, in the real world, no such direct link can be shown to exist. Deciding in advance which accidents to add or delete from the simulation would expose the tool to valid criticism of its relationship to real life.

In addition to the credibility aspect of designing a simulator, there is hidden knowledge built in to the data which the participant learns to interpret. By exposing the internal database to modification through user interaction, it is entirely possible that this knowledge, which is derived from data patterns resulting from daily operational events, could be lost. This would effectively render any simulator useless as a teaching tool as it would no longer be able to reasonably reflect the real world situations about which the participant is learning. For these reasons, the option of designing and constructing a simulator was discarded from the available options.

5.2.2 Emulator

Constructing a passive emulator was relatively straightforward. Both the Harcourt, Academic Press Dictionary of Science and Technology and the Dictionary of IT Terms define ‘emulation’ as –

> *“1. the imitation of one computer system by another so that each can accept the same data or programs and produce the same results.*
>
> *2. the use of a program to simulate functions of hardware or another program.”*

The second definition does appear to be a contradiction as the definition of an emulator is not exactly a simulation. In addition, both definitions relate to computer systems emulating computer systems. Thomas (2003, p. 6) offers a more succinct definition - *".... an emulator could be seen as an accurate simulation where no approximation has taken place and all features of the original are present in the emulation"*. In her paper Thomas describes a variety of categories from simulators to emulators within a framework bounded by degree of model behaviour on the Y-axis and realism on the X-Axis. Within these boundaries, any safety culture emulator would occupy the section of Figure 5.1 defined by low to no model behaviour but with high realism.

High realism is definitely critical in the case of any tool being developed to teach safety culture measurement and evaluation. If, however, the exercise remained completely passive through the training episode, it is likely that participant attention would decline markedly. Any attempt to deal with the 'attention problem' by participant actions that impact the model's behaviour would result in the same issues in terms of adversely altering the underlying database which was the principle reason for dismissing the simulator approach.

5.2.3 Learning environment

The research questions are -

1. *'How can HSE culture be modelled effectively?'*
2. *'How can management be educated in the measurement and evaluation of safety culture of their organisations?'*

While the answer to question 1 is relatively straightforward providing good data is available, the answer to question 2 is much more complex.

Industry is replete with financial indicators that managers use to gauge how well their companies are operating and which provide them with pointers to the areas where they need to focus their efforts if they wish to improve corporate financial performance. Table 5.1 presents some examples of these ratios and a list of 125 such indicators is provided in Appendix 5 to illustrate how seriously management takes knowledge of financial performance.

Financial Ratio	Explanation
Acid Test Ratio	An indication of the company's liquidity.
R&D Ratio	The ratio of expenditure on Research & Development versus sales revenue.
Debt Equity Ratio	A measure of the relationship between capital provided creditors and that contributed by shareholders.
Price Earnings Ratio	The relationship between price per share and revenue per share.

Table 5.1 Example of typical financial ratios.

The list is certainly not exhaustive, nor is it a list with which every manager would be expected to be intimately familiar, but the fact that it was compiled in only a few minutes of searching on the internet (Ready Ratios 2013) is a good indicator of how plentiful and widely accepted such indicators are in the management world. Managers for the most part want the knowledge that these indicators provide because it helps them do what they consider themselves paid to do, i.e. run a financially successful company.

When it comes to safety, the list is somewhat shorter (OGP 1997 - 2012) –

- Fatal accident rate
- Lost time injury frequency rate
- Total recordable injury rate
- Fatalities by category and activity
- Lost work day cases by category and activity
- Injury severity

Entirely backward looking and conveying no information at all about what to consider for future improvement much of the time, the information available in respect of safety management is lamentably scarce. The questions as to why this is the case are perhaps a few rocks that need to be turned over.

- Is it possible that there is a surfeit of financial indicators because managers are only really interested in, and want to run, financially successful companies?
- Is it because managers are not really interested in knowing about safety?
- Is it because the calibre of safety professionals has hitherto not provided management with better information that they [management] would like, and need, to know?
- Is it because managers are not as likely to be fired for poor safety performance as they are for poor financial performance?
- Is the pressure applied to management from the stakeholders all about profit and less about safety?
- Has society been prepared to accept lower standards for safety in order to have access to cheaper products?

Regardless of the answer or combination of answers, it was clear that attempting to solve question 2 through traditional simulation/emulation approaches was unlikely to succeed.

What was required to deliver the solution to question 2 was a tool which faithfully recreated the operational behaviour of a company with a significant number of staff on a day-to-day basis. As the intended audience for the tool may include individuals with decades of entrenched views and opinions, the primary goal of the tool would be to alter participant attitudes with regard to safety culture awareness and acceptance. The tool needed to be built on accurate data foundations to eliminate any credibility issues and, ideally, incorporate the knowledge of the educator as part of the learning process. It would introduce the participants to the sorts of information and knowledge that can be derived from the examination of safety related data in much the same way as they are accustomed to deriving financial knowledge by examining the underlying financial data. In short, it would be aimed at changing their entire philosophy regarding safety management and hence safety culture.

These requirements align closely with the theory of ‘Transformative Learning’ first postulated by Mezirow (1975). A concise definition by Mezirow himself is that - *“Transformative Learning is the process of effecting change in a frame of reference.”* A frame of reference is that body of experience which individuals have acquired over their lives and which shapes and directs their perceptions of life and the world around them. Mezirow (1975) identified ten phases of transformational learning (Kitchenham 2008) -

1 - A disorienting dilemma
2 - A self-examination with feelings of guilt or shame
3 - A critical assessment of epistemic, sociocultural, or psychic assumptions
4 - Recognition that one’s discontent and the process of transformation are shared and that others have negotiated a similar change
5 - Exploration of options for new roles, relationships, and actions

6 - Planning of a course of action
7 - Acquisition of knowledge and skills for implementing one's plans
8 - Provisional trying of new roles
9 - Building of competence and self-confidence in new roles and relationships
10 - A re-integration into one's life on the basis of conditions dictated by one's perspective

How these might manifest themselves in the case of a senior executive faced with the need for a radical perspective change can be illustrated by the example below -

1. A disorienting dilemma. (A senior manager of a company is faced with criminal charges over poor safety in his organisation. Suddenly and without any prior experience, he finds himself potentially about to be branded a criminal and facing possible prison time (France 24 2012, UK Health & Safety Executive 2008).

2. Self examination with feelings of fear, anger, guilt or shame. (The realisation that it could have been avoided had the appropriate safety precautions been in place within his organisation.)

3. A critical assessment of assumptions. (The manager re-evaluates his historical approach to safety in relation to production and other operational objectives. He wonders why he had not paid more attention to the risks inherent within his type of business.)

4. Recognition that one's discontent and the process of transformation are shared. (Through discussions with other peers, family, professionals or friends, he

discovers that others have had similar concerns but may have been more proactive in addressing them prior to the ‘eye-opening event’ or ‘disorienting dilemma’.)

5. Exploration of options for new roles, relationships and actions. (The manager considers new approaches to move forward. Much of this is through discussion with peers, colleagues and close friends and family.)

6. Planning a course of action. (He plans an approach that will see safety being given a higher profile, with the intention of placing himself and his management in a position where they all share the big picture view of safety culture within the organisation.)

7. Acquiring knowledge and skills for implementing one’s plan. (The manager seeks to improve his own knowledge through different training and/or interactions with peers and other professionals.)

8. Provisional trying of new roles. (The manager seeks to incorporate his newly discovered insights into his own company.)
9. Building competence and self confidence in new roles and relationships. (As more insights and greater understanding are forthcoming, the manager’s self confidence and competence in handling his new knowledge increases.)

10. A re-integration into one’s life on the basis of conditions dictated by one’s new perspectives. (Irrevocably changed, the manager fully rejoins his previous role but

now with a completely new set of perspectives on how safety can be measured, understood and managed through his actions and perspectives.)

Of the 10 phases of Mezirow's (1975) transformative learning paradigm, steps 3 and 7 are the ones the SCLE is intended to address. By creating an environment where the participant can acquire the knowledge and skills to measure and evaluate his organisation's safety culture he will be best placed to assess what needs to be addressed in his own company's operation in order to formulate and implement any plans for improvement. (The manager seeks to improve his own knowledge through different training and/or interactions with peers and other professionals.)

5.3 Organisational model form

The first decision that had to be made was what kind of company to use as the basis of the model. This was perhaps the easiest decision given the author's background and experience in the oil industry. In addition to this experience, the fact that oil companies operate in high risk environments make them ideal candidates on which to model safety performance and culture. For that reason, an oil company was selected for the model. It has been mentioned before but it is important to reiterate that the choice of an oil company as the basis of the model does not preclude the use of the SCLE in any industry.

If maximum benefit were to be derived from the learning experience then it followed that the tool should mirror as far as reasonably possible the structure of a real organisation engaged in the exploration and production of oil and gas.

While it was not essential that participants be upstream oil and gas managers themselves, the tool needed to be believable to professionals in that domain or there would always be a high risk of loss of credibility from participants with regard to the model resulting in a likely rejection of the learning experience as being unrealistic and built on inaccurate foundations.

A typical, self-contained, oil and gas company operating in a remote location, most likely comprises many departments: drilling, production, well operations, logistics, finance, information technology, human resources, health, safety and environment, accommodation and catering, construction, reservoir engineering, maintenance and transport being the most common. Each of these carries its own operational risks and, to a certain extent, has its own internal version of corporate safety culture as a consequence of its particular discipline and management style. To model each of these departments would have been neither practical nor useful.

For the sake of simplicity, the decision was made to assemble all non-operating departments into a single group called Support. This group included: Logistics, Finance, Information Technology, Human Resources, Health, Safety and Environment, Accommodation and Catering and Transport. While not one hundred percent representative of an actual company, this grouping encompassed all of the departments with the lowest operational risks and their amalgamation did not detract from the credibility of the structure of ‘Lancaster Oil Ltd.’ as the company was to be known.

With the support functions taken care of, the remaining departments: Drilling, Production, Well operations, Construction and Maintenance were credible departments in their own right. Construction was renamed ‘Infrastructure’ to avoid participants imagining a typical building/factory construction scenario. A notional Field HSE department was included in name only to facilitate communications issues during the education/training activities.

Finally, the board of directors was established to provide the participants with an entity to which they were entirely responsible in respect of taking direction and reporting back as required.

In terms of numbers of staff, selecting the correct size of organisation was important from both data generation and credibility perspectives. Too small an organisation would be unlikely to generate sufficient data either in the form of accidents or other ‘culture-revealing’ communications. On the other hand, too large an organisation, while certainly producing sufficient data, might inadvertently lead to confusion in the mind of the participant with regard to the scope of the project and the management issues that are all too prevalent in large companies. A figure of circa 1,000 personnel was selected primarily because of the need for large numbers of ‘man hours worked’ in some of the model’s calculations. One of the most common calculations requiring this number is that of the total recordable injury rate which is calculated as –

$$\frac{\text{Total number of recordable accidents x 200,000}}{\text{Man hours worked in company}}$$

A small number of man hours worked in the denominator will produce large fluctuations in the result while the opposite is true of a company with a lot of workers and hence a high man hour count. The 1,000 personnel count also included all contractor staff working in the 11 contractor companies which were included in the model and which are discussed in detail in section 5.3.7.

Lancaster Oil Ltd. (LOL) is a fictitious oil company created to deliver the daily operational safety input that any managers might be expected to encounter in the course of their normal activities. Due to the varied nature of risks associated with its operations, a land-based oil company was selected as the most suitable type of entity. Such a company provides the opportunity to develop diverse managerial scenarios in a variety of differing risk environments. While a real oil company comprises many different departments as already mentioned, LOL is composed of six plus the board of directors –

- Board of directors
- Drilling
- Production
- Well operations
- Infrastructure
- Maintenance
- Support

5.3.1 Drilling department

The drilling department is normally the most autonomous department within the company. Drilling operations begin long before any permanent corporate infrastructure exists with the exploration phase. After an oil company has secured the license to explore a lease, the drilling function begins to explore for oil. At this point they are usually the only players involved. The typical drilling department comprises one or two senior managers, several highly educated engineers and one or two support staff.

Few oil companies own and operate their own drilling rigs and crews. There are many specialist companies who hire out the rigs, crews and management. Typically, the oil company places a single staff member on the drill site who acts as the client representative and this individual has the final say on all matters pertaining to drilling operations on site. For the most part, departmental staff carry out white collar activities.

Assuming that oil or gas is discovered, the next phase involves appraisal drilling where the extent of the field is determined. Concurrently, project plans are begun, once sufficient knowledge is available, to design and build a production facility.

As the construction phase of the project gets under way, more departments begin to take shape. Drilling in the meantime continues with the third phase of a typical field life cycle which is the development phase where production (and possibly injection) wells are drilled into the reservoir at locations identified by specialist reservoir engineers.

While the drilling operations are fundamentally the same throughout the life of the field, the risks associated with each phase of the operations tend to decline. During the exploration phase, other than seismic data, little is known about the area. Drilling operations move slowly as there is no accurate information on whether they may encounter shallow high pressure gas pockets, weak formations, etc. During this period, wells can take several months to drill.

As the evaluation phase continues and moves into development, much more is known about the geology and the risks are better understood. Consequently, drilling progresses faster. This can, however, introduce new risks in the form of financial pressures to save time wherever possible. Shifts in attitudes are possible as crews, and managers alike, may begin to exhibit 'familiarity breeds contempt' attitudes and behaviours further into the development phase.

As the field gets older and more oil and/or gas is extracted so the reservoir pressure declines and the risk of disasters such as blowouts also declines. Finally, as the wells age so some of the drilling department work falls into the category maintenance/repair. Normally referred to as 'workover', these activities are often, but not always, carried out by a different type of rig known as a 'workover rig'.

For the purpose of the model, all of the initial exploration and appraisal drilling activities have been completed and the rigs are working either in a development or 'workover' capacity. In a large production field, the drilling rigs operate far away from the central production area and are often hundreds of kilometres away from the senior management team.

Finally, there are many specialist companies that provide specialist services that neither the oil company nor the drilling contractor can provide. These sub-contractors are normally hired by the oil company and they integrate into the daily activities of the drilling contractor as required depending on the work being performed.

In regard to safety, the drilling department has full responsibility for all works carried out on the drilling rigs whether that work is being carried out by the drilling contractor or by one of the sub-contractors.

In Lancaster Oil Ltd., there are two different drilling contractors and a variety of specialist service sub-contractors. It is common practice to hire different companies at the same time to carry out essentially identical work as it maintains competition. All contractor companies are discussed in greater detail in section 5.3.7. The Lancaster Oil drilling department has a total of 9 staff and 230 contractor personnel.

5.3.2 Production department

Once the decision has been made to develop a field, a production facility is designed and constructed. Offshore, this is known as the 'production platform'; on land, it is commonly referred to as the 'production facility'. Unlike an offshore production platform where often the workforce live and work in close proximity to the production operations, on a land operation, the accommodation, support groups, field management, etc. are usually located up to several kilometres from the facility.

The purpose of the production facility is not to refine the oil or gas. In the case of an oil field, it exists to remove items such as gas/water/salt from the oil and ensure that it is pure enough to be exported by pipeline, to be sold into the marketplace for subsequent refining.

As would be common on any industrial site, the production facility is contained within a fenced area and the management of the production department has full responsibility for all operations within that fenced area. Normally, due to the nature of their operations, the production department does not use contractor personnel. The Lancaster Oil production department has a total of 44 staff and no contractor personnel.

5.3.3 Well operations department

Once the drilling department has completed a well, it hands over responsibility for that well to the well operations department. The well operations department looks after all of the wells within the LOL field. All subsurface and well head operations fall within its domain and it is responsible for all safety within the fences around each and every well site during well operations.

The well operations department uses a variety of specialised service companies to carry out operations on either the wells themselves or the oil/gas producing formations. As the ‘owner’ of all activities within the fence surrounding the well site, the well operations department has full responsibility for the safety of contractor operations. The Lancaster Oil well operations department has a total of 16 staff and 66 contractor personnel.

5.3.4 Infrastructure department

The Infrastructure department links the wells to the production facility. It is responsible for all gathering stations and pipelines (maintenance and construction) between the well pads and the facility. It is also responsible for construction and maintenance of the equipment on the well sites. Infrastructure uses a variety of specialist companies for tasks such as pipeline construction and other general labour providers. The Lancaster Oil infrastructure department has a total of 10 staff and 242 contractor personnel.

5.3.5 Maintenance department

The duties of the maintenance department are fairly self-explanatory. It mostly works within the production facility and other supporting locations nearby. It does not get involved in any well site work neither does it look after the maintenance of the vehicle fleet nor the accommodation camp. Maintenance use a small number of general labour contractors. The maintenance department has a total of 53 staff and 20 contractor personnel.

5.3.6 Support department

For the purpose of simplicity, a single department was created to handle all activities within Lancaster Oil not directly associated with drilling or production. Within Lancaster Oil, the Support department looks after all accommodation, catering, IT, telecoms and transportation (land and air). It has jurisdiction over waste management and all non-occupational health issues, e.g. drinking water, swimming pools, food, etc. The Lancaster Oil support department has a total of 27 staff and 241 contractor personnel.

The final structure of Lancaster Oil Ltd. is as shown in Figure 5.2 below.

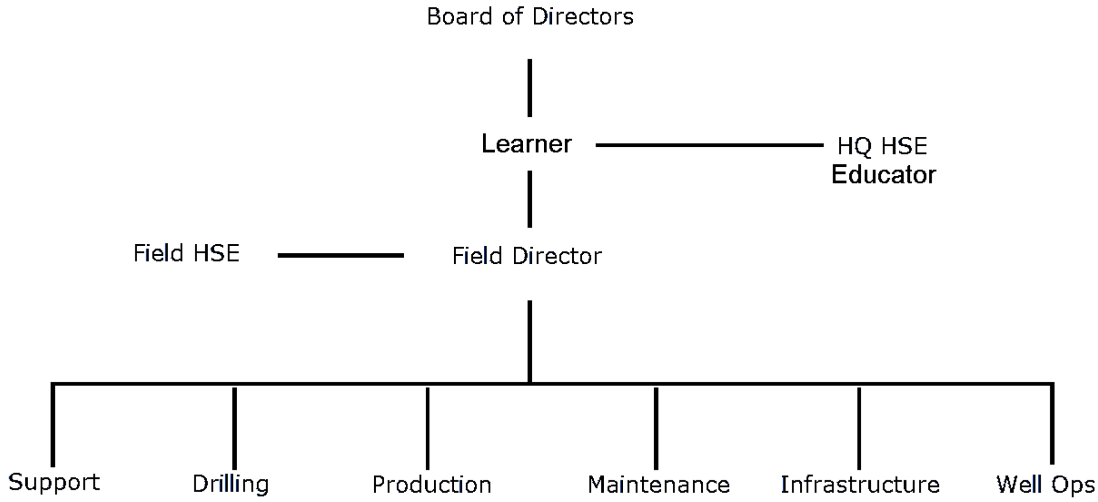


Figure 5.2 The structure of Lancaster Oil.

5.3.7 Contractor companies

In total, Lancaster Oil Ltd. has a total of 159 staff and 800 contractor personnel, bringing the total headcount being modelled in the learning environment to 959.

The decision to use multiple contractor companies rather than one simple amorphous organisation called ‘Contractors’ was based on two criteria. The first was credibility within the profession. No oil executive would accept that one single contractor group could possibly represent that vast variety of technical skills, work disciplines and occupational risks that an operating oil company faces. The second criterion was to offer the opportunity to participants to compare and contrast different contractors perhaps working in exactly the same discipline.

In total, 11 contractor companies were incorporated into the SCLE -

- Drilling companies 1 and 2
- General service companies 1, 2 and 3
- Catering companies 1 and 2
- Specialist service companies 1, 2 and 3
- Well operations company 1

5.3.7.1 Drilling companies 1 and 2

These two companies work exclusively for the drilling department and provide a degree of competition both from a financial and a performance perspective. Each has its own HSE systems and ways of doing things, although, fundamentally, they operate in exactly the same manner. Both companies have similar numbers of people.

5.3.7.2 General services companies 1, 2 and 3

These work for several different departments. They are not ‘high technology’ organisations although they are skilled in activities such as pipeline construction. Much of their work is of a ‘manual labour’ nature. Not all of them have their own HSE systems in place.

5.3.7.3 Catering companies 1 and 2

These provide all catering services both at the head office camp and at the field location. They also look after all accommodation and general duties of a ‘domestic’ nature.

5.3.7.4 Well services company

This is a company which handles all work on the wells In the LOL field after they have been ‘handed over’ by the drilling department. It is not a particularly ‘high technology’ or highly skilled labour force and it works exclusively under the direction of the well operations department

5.3.7.5 Specialist services companies 1, 2 and 3

These are ‘high technology’, highly skilled organisations that perform very specialised work on the wells. They are exclusively concerned with sub-surface operations and may work for either the drilling or wells departments.

5.4 Management representation

With the corporate structure and size established, each department was assigned a manager. Continuing in the vein of maximising ‘believability’, a variety of individuals (the department managers and board members with whom the participant would be interacting by e-mail during the course of the session) was created using facial modelling software. Each ‘individual’ was assigned a different ‘personality’ and ‘attitude’ towards safety. This was done because the participants were going to be engaged in communications with these individuals, albeit through the medium of e-mail, and it was deemed important that the people at the other end of the participant’s e-mail system have characters which were in line with the e-mails the character was supposed to be writing and sending. In addition, in the real world, whenever managers are analysing data or reviewing performance, they would be aware of the personalities of the managers/direct reports and would most likely take this into account when arriving at conclusions regarding their commitment to safety.

An interactive corporate organigram was created and available to the participants for reference during the duration of the session. The participant was ‘introduced’ to the management team and his own boss during the induction prior to start-up.

5.5 Classification

Few companies maintain education, learning or development departments while many support a training department. It is well beyond the scope of this project to delve in depth into the subtle differences between each category. It is, however, worth referring to the work of Masadeh (2012) who concluded that, although it may be difficult to distinguish between the various terms, it was nevertheless useful for organisations to develop different definitions in order that they might better understand the differences, and hence the challenges, faced in each of the disparate activities. They pointed out that use of the terms interchangeably, as happens today, can lead to confusion and that adopting clear definitions for each category can help to clarify issues and improve overall achievement of organisations’ stated objectives.

Mumford (1995) whose definition of learning reads - *“People can demonstrate that they know something that they did not know before (insights and realizations as well as facts) and/or when they do something they could not do before (skills).”* When the observations of Masadeh (2012) and Mumford (1995) are taken in conjunction with Mezirow’s concepts of Transformative Learning (1997), it becomes apparent that the most appropriate domain within which this type of teaching tool should reside is that of a learning environment rather than an active simulator or a passive emulator.

A question also surrounds whether the participants are being educated, trained or developed. The entire word count of this thesis could be used up in the debate as to the differences (and similarities) within these terms. Following are some definitions from the literature.

Training -

Manpower Services Commission (MSC) (1981, p. 62 cited in Masadeh 2012) -

> *'A planned process to modify attitude, knowledge or skill behaviour through a learning experience to achieve effective performance in any activity or range of activities. Its purpose, in the work situation, is to develop the abilities of the individual and to satisfy current and future manpower needs of the organisation'*

Truelove (2001, p. 291) –

> *"Training endeavours to impart knowledge, skills and attitudes necessary to perform job-related tasks. It aims to improve job performance in a direct way."*

On the differences between training and learning, Sloman (2005, p.2) observes –

> *"Training is characterised as an instructor-led, content-based intervention leading to desired changes in behaviour, and learning as a self-directed, work-based process leading to increased adaptive capacity."*

Education –

Manpower Services Commission (MSC) (1981, p. 62 cited in Masadeh 2012) -

"Activities which aim at developing the knowledge, skills, moral values and understanding required in all aspects of life rather than knowledge and skill relating to only a limited field of activity."

Truelove (2001, p. 291) –

"a process whose prime purposes are to impart knowledge and develop the way mental faculties are used. Education is not primarily concerned with job performance."

Development –

Gansberghe (2003 cited in Masadeh 2012)

"a long-term process designed to enhance potential and effectiveness. It is also defined as the growth or realisation of a person's ability, through learning, often from planned study and experience."

Truelove (2001, p. 291) –

"a process whereby individuals learn through experience to be more effective. It aims to help people utilize the skills and knowledge that education and training have given them."

There is considerable overlap in these definitions though the definition of training put forward by the Manpower Services Commission probably best describes the objective of the learning environment experience. So, despite the confusion from the succinct definition provided by Garavan (1997, cited in Guardian Initiative 2014) –

> *"Training for instance, can be associated with 'learning by doing' whereas education is more synonymous with 'learning by thinking'; development involves learning, thinking, doing and feeling"*

which suggests that the participants in the learning environment are being educated as most of the session is surely occupied by a surfeit of thinking, for the purpose of this document, the words 'trained' or 'training' will be adopted when referring to the experiences of the participants.

Notwithstanding, it is the author's personal belief that this teaching tool is biased much more towards education rather than training, however, the entire objective of this research project was to provide a pragmatic solution to a historical industrial problem. The pervasive use of the term 'training' within industry is the principal reason it has been adopted throughout this document. However, when referring to his own role in the learning process, the author has continued to use the term 'educator' rather than 'trainer'.

5.6 Educator interaction

A passive animation of a company in action would fail at every level to deliver the required outcomes and so, while recognising the dangers inherent in permitting user interaction with the raw data, some form of interaction was essential both to maintain interest and to facilitate evaluation of the participants' changing beliefs, attitudes and knowledge levels as the process continued.

In order to affect real perspective change, it would be necessary to create an environment where the learner, working alongside the educator and through the medium of the training tool could begin to challenge previously held ‘habits of mind’ and ‘points of view’ as defined by Mezirow (1997). Mezirow goes on to say that learners need to be aware of their own and others’ assumptions and that practice is required to re-define problems from a different perspective.

Essential to this process was the creation of an environment where the learner had access to all of the material required to formulate a new frame of reference and was able to test any new frame through discussion and interaction with the educator and to a lesser extent with his ‘management team’.

5.7 Role player involvement

The inclusion of role players has been shown to have a positive effect on changing learners’ opinions (Janis & King 1954) and serious consideration was given to their inclusion in the learning environment. Definite benefits did appear to be achievable including the opportunity for the participants to engage in actual discussion with their direct reports and manager on current issues. While some benefit may have derived from that opportunity, the arguments against using role players were much stronger.

Most significant of all of the reasons not to use role players were -

1. Available time and
2. Number of role players required

The computer model was intended to display data representing several years' worth of operational inputs for a typical company. Through practical necessity, prolonged discussion on particular issues, attitudes, styles and behaviours would likely lead to time being wasted on issues which, by the time they had been discussed at length, would most probably mean that the model had advanced by weeks or even months. By this time, the issues, in real life, may no longer be relevant.

The number of role players was also a factor. From personal experience of running emergency response and crisis management exercises for some of the world's largest oil companies, the use of a single individual to represent many entities can, and often does, lead to confusion. Exercise participants expect that when they make different calls to different entities that a different person will answer them. Having the same voice representing different departments or individuals was considered too high risk when subjected to a 'cost/benefit' analysis.

Role playing was therefore restricted to the educator alone providing optional e-mail replies at his discretion, written by him but appearing to come from the different managers to whom the original communication had been sent by the participant.

5.8 Optimum time-scale

This was a particularly awkward question to answer as it had a direct link with the question, 'How long should the learning process take to complete?'. A year is a short time in the statistical safety performance of an organisation. Similarly 10 years might possibly result in diminishing returns. Also, producing a 10 year time frame would in all probability result in an unacceptably long session time. After much consideration, it was decided that a 5 year time frame would provide the best compromise between length of time to run the SCLE and the validity of the data trends presented to the participants in the form of graphs and charts together with the associated trends and other interpretations which required a reasonable time-scale to develop. There is no reason why this time could not be extended or reduced in the future. Coincidentally, Nuclear Safety Sim discussed in Chapter 2 also uses a 5 year timespan in the model.

5.9 Training session length

On the matter of the length of time to participate in the learning process, there were two aspects to this research. On the one hand was the need to evaluate the success or otherwise of any tool which might be created in terms of its ability to deliver intense and complex training to management. This would involve securing sufficient volunteers to participate in the research. On the other hand, part of the research needed to consider the possibility of such a tool migrating to the industrial world. While research volunteers are very likely to be more receptive to the needs of the project, working executives are probably under much greater time constraints. For this reason, the SCLE needed to be designed with possible industrial application in mind. Senior managers are busy people and it was considered unlikely that any of them would be able, or prepared, to give up more than a single day to engage in safety culture training.

It was, therefore, essential that, within one day, the participants could receive their introduction to the learning environment, complete the 5 year time frame and participate in a round-up meeting at the end. Assuming 1-2 hours at the start to introduce the participant to the tool, the company, and the plan for the day ahead plus a wash-up session at the end of the day, it was decided that the learning environment should complete the 5 years in the space of 8 hours. While a 10 – 11 hour day may appear to be an excessively long time there are many sources indicating that the present day executive works at least 50-60 hours a week (CIO 2006, Vanderkam 2012). In much of the oil industry, workers are used to the 12 hours on, 12 hours off rotational aspect of work. For these reasons, a 10–11 hour session was adopted as the time frame with 8 hours specifically devoted to replicating the 5 years of the learning environment time frame.

5.10 Origin of data

It was essential for a variety of reasons such as confidentiality, data protection and not least any legal implications, that no actual data relating to any company or individual be used in the development of the system. In order to populate the databases, therefore, it would be critical to create information/records which bore no relation to any actual event, person, company or location.

To achieve this goal, the author applied his circa 40 years' experience in the international upstream oil and gas industry to produce databases which contained the embedded knowledge required without the need to use any actual information from any companies or other organisations.

Personal recollections of a wide variety of events were incorporated and sanitised where appropriate and references to previously published material now in the public domain was also used to populate the different databases and e-mail traffic.

5.11 Measuring participant performance

The purpose of the learning environment is to achieve a paradigm shift in the participant's beliefs on how to measure and evaluate safety culture. The most likely measure of their changing beliefs, therefore, would be demonstrated through them providing an analysis and explanation of the safety culture they perceived within Lancaster Oil based on the data with which they were being presented. The learning environment covered 5 years of a typical oil company's life. Given that it is normal in most companies to provide annual departmental reports, so the requirement for a report at the end of each SCLE 'year' on the safety culture of Lancaster Oil was included. This formed part of the assessment of participants' changing views and attitudes during the session.

In addition to the annual safety culture reports and for the research aspect only, analysis of the pre- and post-session interviews would also be a good source of information on how effective the lesson had been.

5.12 Ideal participant profile

This question had two answers. In the short term, i.e. this research thesis, the intended participants ideally needed to come from a variety of disciplines/managerial levels (section 4.3.3) in order to evaluate the effectiveness of any solution under a variety of different conditions.

Should the learning approach ever transfer to the industrial world then the participant profile would be significantly narrower. The SCLE is not specifically intended for safety professionals for one main reason, they do not have the line authority or position within the organisation to either change or directly influence the safety culture of the organisations in which they work. Safety professionals are paid to care about safety. They are not a line management function but are in the organisation primarily in an advisory capacity. Certainly, they might benefit from having access to the sorts of knowledge and experience that this type of learning environment can provide but it is possible that many safety professionals may feel threatened by this encroachment on what has hitherto been viewed as their professional domain. The ideal candidate for training is someone who manages a business operating in a high risk environment with sufficient personnel to generate enough data to make analysis reasonably valid.

5.13 One-to-one basis or multiple participants

As with the question on the ideal profile, this question too has different responses depending on the objective. For the research purpose, it should definitely be on a one-to-one basis. This part of the research is to evaluate how effective the tool is in educating individuals and while it is certainly true that groups may learn from each other as well as from the environment in which they find themselves, to conduct the research for both individuals and groups would have enlarged the scope of the analysis (and to a large extent the design of the data and presentations) to the point where the project would not have been achievable in any reasonable time and cost.

There is certainly mileage to be gained by reviewing the finished tool in the future to establish whether it can be modified, more in terms of style, presentation and interaction rather than content to cater for multiple candidates coming from perhaps middle management echelons as part of their developmental training for future senior management roles or even departmental managers as a way of improving their buy-in to safety management improvement. For this project though, it was expedient to restrict the participants to a single individual at a time.

5.14 Information presentation style

It was clear from the start that the project was going to involve communicating large quantities of data in both parallel and in series. Each particular data set represented 5 years of elapsed time and the data needed to be presented serially. The requirement to present 14 different data sets each with its own 5 year history meant that 14 different data streams would be required and that the data sets needed to be presented in parallel.

Many industries are familiar with such presentation demands including oil and gas, chemicals and refining industries with their control rooms, television companies with their multiple screen presentations and the financial industry with the various stock market screens, to name but a few.

Given the established and widespread use of such technology a similar approach was adopted and the decision made to present the data on a video wall comprising 14 different displays.

5.15 Construction viability

The entire project depended on a satisfactory answer to this question. Examination of the responses to the previous questions and the nature of the domain suggested that ultimately being able to deliver a project which would satisfactorily answer the research questions was definitely feasible providing sufficient resources were available. The problem, therefore, shifted to what exactly constituted sufficient resources.

In terms of data, that was a relatively straightforward problem. The author's experience in the oil business, including over 20 years in HSE, around the world brought with it more than enough knowledge to construct the appropriate knowledge/databases to provide the operational data foundations. A second bonus was the author's previous IT education and experience in Knowledge Based Systems which meant that the technical aspects of building a system from both a hardware and a software aspect would not be an insurmountable problem. The author's belief, after considering all of the major issues, was that such a model could be designed, built and evaluated within the required parameters of cost and time.

With all of the major questions answered, attention focused on maximising possible interaction with the participants. This was recognised as essential to avoid 'switching off' participants through simple boredom.

5.16 Session start-up and interaction

5.16.1 Start-up

At the pre-programmed time, all of the computers in the learning environment begin processing data and displaying the information on the screens. Beginning with no historical data gave the participants the opportunity to explore the various modules and data pages without feeling too overwhelmed by a large volume (at this stage) of seemingly incomprehensible information appearing in front of them. At the same time e-mails began flowing into their inbox. These will be discussed in greater detail in section 5.17.

5.16.2 Interaction

Merrill (2002, p. 45) describes a conceptual framework for the first principles of instruction –

1. Learning is promoted when learners are engaged in solving real-world problems.
2. Learning is promoted when existing knowledge is activated as a foundation for new knowledge.
3. Learning is promoted when new knowledge is demonstrated to the learner.
4. Learning is promoted when new knowledge is applied by the learner.
5. Learning is promoted when new knowledge is integrated into the learner's world.

Of these 5 principles, the first 3 were directly applicable to the inclusion of participant interaction within the learning environment. It was important that the participants not sit passively and watch as the data unfolded over the 5 year period of the learning environment. They needed to be given real problems to solve and real issues to address in order both to maintain their interest and enhance their learning opportunities. By having them produce annual reports and make presentations to the board (with subsequent interrogation by the educator in his role as chairman) they were able to experience directly how their abilities were improving. Finally, by including presentations to the participants that were designed to assist their understanding of safety culture and safety performance issues, they gained an increased awareness and appreciation of key aspects of safety management.

As far as the last two items of Merrill's principles are concerned, these fell outside the domain of the research project. It is only when the participants return to their organisations that they are in a position to apply the learning they have experienced and can incorporate their new knowledge into their daily professional activities.

5.17 Communications

Mezirow (1997) stresses the importance of discourse in facilitating transformative learning and the importance placed on how well the facilitator can produce an environment where those involved in the communication have the full information to hand and that they have opportunity to question/challenge/defend/explain their points of view and the evidence being presented to them. He further stresses the need for openness and a willingness to listen and search for common ground or, if that can not be reached, for the opportunity to synthesise a common understanding in order to facilitate progress.

The communications module of the learning environment is designed to reproduce, as far as is realistically possible, within the confines of a computerised learning medium, a situation where participants have the opportunity to interact with their own management teams and with their own manager.

In addition to the 14 computers delivering safety performance data to the video wall, an additional 2 computers function as the communications infrastructure of Lancaster Oil. During the course of the session, over 250 pre-programmed e-mails are delivered to the participant's computer terminal using the SCLE's e-mail server.

Of the different approaches to problem solving and learning identified by Habermas (1981), the communicative approach is the most appropriate to the issue of modifying the experienced and senior manager. As Mezirow (1997, p. 6) observes - *"Communicative learning involves at least two persons striving to reach an understanding of the meaning of an interpretation or the justification for a belief."* Actual direct 'live' contact with the individuals comprising the participant's senior management team was not possible as role players were not involved. Notwithstanding that, a limited degree of interaction was provided through the e-mail system. Every e-mail sent by the participant in response to issues which manifested themselves during the session was automatically routed to the educator's console. The educator could of course elect to respond and the e-mail system was designed such that all responses sent by the educator would appear at the participant's computer as if they had come from the manager of the department to whom the original communication had been sent. Extensive interaction was however discouraged as prolonged e-mail or verbal discussion carried the risk of wasting significant session time. With 4 days' 'SCLE' time passing every minute, a 'month' could easily pass while two parties explored a relatively insignificant issue.

Within the environment of the SCLE, the ability to interact verbally with the educator in his roles as both the participant's HSE manager and as the educator/advisor/facilitator gave the participant the best available environment in which to not only interpret the material with which he was being presented but also to answer the deliberately searching questions required to address to the satisfaction of the boss – the chairman of the board.

Combined, these communications serve a variety of purposes; most importantly they involved the participant in an active rather than a passive role. In addition, they added to the realism of the session by presenting the participant with real world issues to address, problems to solve and reports to make. As the session progresses, so the content of the e-mails becomes more demanding in terms of the need for the participant to be able to interpret the data in front of him in order to provide an appropriate response. While the majority of the e-mails are notifications of accidents and incidents as they occur during the five year time period of the session, over thirty are delivered from various managers, board of directors, members of staff and the educator in the guise of the participant's HSE manager.

It became apparent very early in the evaluation phase of the project that information overload was a distinct problem. Most of the participants experienced feelings of being overwhelmed with the volume of information with which they were required to deal. As a result of the very steep learning curve that they were required to follow, the quantity and complexity of the e-mail traffic was deliberately biased towards the second half of the session. This enabled the participants to take the time to review the data and digest the messages that the data were telling them before needing to respond to demanding requests from 'third parties'.

E-mail communications were classified into 3 categories -

- Informative
- Interventive
- Interrogative

5.17.1 Informative

The largest category of communications was the informative comprising mostly e-mails advising management of accidents and incidents as they occurred. Included in this category were e-mail communications which would normally, in most risk sensitive industries in the course of normal daily operations, be copied to senior management either as a matter of courtesy or in the hope or expectation of some form of management intervention. Aside from the obvious need to inform management of the occurrence of accidents and incidents, participants were advised to scan all accidents with a view to identifying any patterns or other concerns they may develop as the numbers of events grew during the session.

One of the most difficult decisions which had to be made around the informative communications was whether to include them at all in the session given the frequency with which they would be arriving in the participant’s inbox. The core of the database driving much of the culture awareness value of the tool is driven by the quantity, type and frequency of accident/incident occurrence. A total of 220 accident/incident events occur during the 5 years covered by the learning environment in the allotted 8 hour time frame.

Extending the 8 hours to 10 hours to provide the participants with more time did not bring any tangible benefit and, in fact, would probably have adversely affected the impact of the experience for the participants. Adding an additional 2 hours would only add 3.9 seconds to the length of time a single day took to pass in the SCLE. While an additional 3.9 seconds per day is not particularly significant on its own, the cumulative effect would be to lengthen the participant’s day to around 12 hours.

Given the need for pre- and post-session briefings, this meant extending the day to over 12 hours which was deemed unacceptable

Notwithstanding, delivering 220 accidents and incidents over 1,827 days meant that, on average, an accident would occur every 8 days or every 2 minutes 11 seconds for an entire 8 hour period. There was some concern at the start of the design phase of the project that an accident every 2 minutes coupled with additional communications might prove too demanding. This is discussed in greater detail in Chapter 7.

5.17.2 Interventive

Culture is not simply about learning to interpret a suite of numbers in a series of graphs and charts. There is a softer side to culture which addresses human factors such as attitudes, perceptions and beliefs. The Confederation of British Industry (CBI 1990, cited in Cooper 2002, p. 31) included the terms *"ideas and beliefs"* in its definition of safety culture. The ideas and beliefs of each of a manager's direct reports may not always be apparent simply by reviewing their performance numbers. Their attitudes, opinions and positions on safety related issues provide valuable insights into the underlying safety culture of the layer of management below the participant.

To highlight the importance and value of the knowledge which can be derived from careful consideration of the activities of this group, a suite of e-mail communications was produced which raised specific culture-related issues that the participant was required to address. These were pre-programmed to be delivered to the participant's e-mail inbox at specific times during the 5 years of the session. In some cases, the communications contained direct requests that the participant intervene in the debate/dispute/argument being played out in the e-mail record received. These were intended to give the participant a feeling for how safety was viewed by different departments and individuals within the organisation and to assist with developing the participant's new safety culture frame of reference. Other communications appeared to flow between different managers but were copied to the participant for his information. This is exactly what happens in any real organisation. The participant's responses to these communications was monitored by the educator and if the educator deemed it appropriate, the participant was encouraged to respond/intervene as, again, might be expected in a real company.

Additionally, some of these communications were designed to test the participant's sensitivity to safety issues, which, if they arrived in the public domain, might give rise to serious negative public relations or even legal consequences. Where the participant failed to spot the issues, the educator brought it to his attention with a brief discussion of the risks associated with accepting poor safety culture.

5.17.3 Interrogative

The third communications group was designed to test the participants' grasp of the knowledge they were expected to have acquired during the session in respect of evaluating the safety culture of his company. All of these emanated from the chairman of the board and all required that participants provide an answer. With the educator playing the role of chairman, this particular activity was not allowed to be overlooked. At the end of every year, the participants were required to submit to the board their annual report on their view of the overall safety culture of Lancaster Oil Ltd.

5.17.4 Presentations

In addition to e-mail communications, the participants were required to make two presentations to the board of directors. The first of these set the scene at the start of the session with a presentation on the safety performance for the year prior to the session start of 1st January 2020. The second presentation was made mid-way through the five year simulation. In both cases, the presentations were designed to sensitise participants to the need to understand the numbers they were either presenting themselves or that they were receiving from others in the organisation. In both cases, the participants were asked a single question relating to reporting culture – *"Do you believe, based on the information you have presented here, that you have a culture of full reporting within your organisation?"* Participants were made aware at the induction that they would never be asked questions which could not be answered by reference to the data that had been presented to them.

Regardless of whether the answer was 'yes' or 'no', they were required to explain their position. Following both presentations, the educator provided the correct interpretation of the data which they had been required to present and the correct answer to the question.

5.18 Maximising experiential learning

In the 1960s, Edgar Dale (1969) developed the 'cone of experience' model where he proposes that learners retain varying percentages of the information delivered to them depending on the delivery mechanism. According to Dale, the retention of information is lowest when the information is simply read and highest when the learner is involved in actual 'doing' rather than 'reading', 'hearing' or 'observing'. This form of learning has come to be known as ‘experiential learning’. The various percentages of information that participants generally retain after a period of two weeks are summarised in Table 5.2.

Activity	Percentage retention after two weeks
Reading	10%
Hearing words	20%
Seeing	30%
Seeing and hearing combined	50%
Participating in a discussion Giving a presentation	70%
Doing a presentation Simulating the real experience Doing the real thing	90%

Table 5.2 Dale’s experience retention percentages.

The design of the learning environment needed to address all of Dale’s cone levels. This was achieved through a combination of the interactions described in this chapter and which are summarised in Figure 5.3.

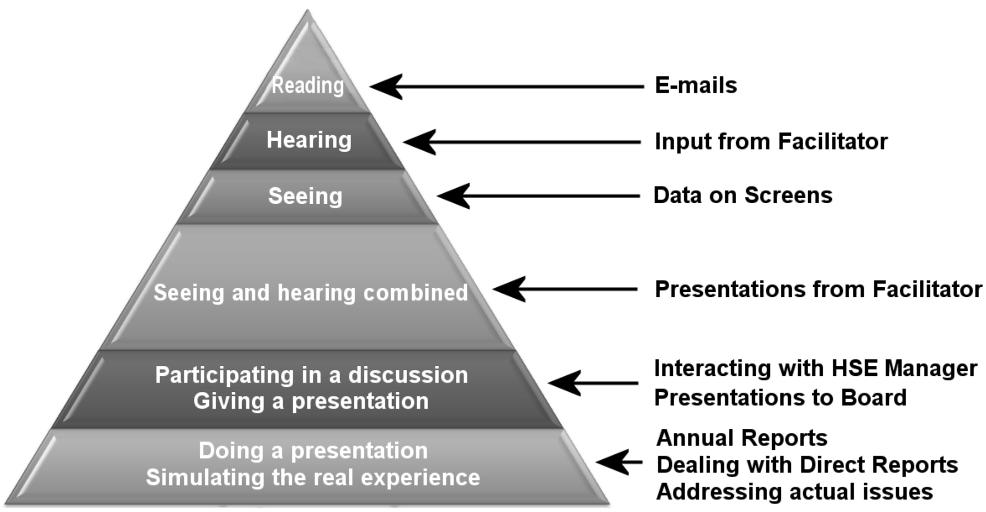


Figure 5.3 Relationship of SCLE inputs to Dale’s cone of experience.

The need to address every aspect of the participant's absorption, and retention of knowledge was reinforced by the fact that the learning environment was not a simulator in the sense that participants would be able to make inputs to the system in order to affect changes in the data outputs. It was therefore essential they participate in as many activities as possible which would not only challenge them and hence maintain their interest levels but also maximise the retention of the knowledge gained through the experience.

5.19 Summary

In this chapter, the most important questions which needed to be considered before constructing the learning environment were addressed; how interactive or otherwise the tool should be, what form the organisation needed to take, the interaction with the educator, the time needed to effectively present 5 years of a company's history without boring or overwhelming a participant, how to generate the data needed to populate the various databases, and how to best present the data to the participants were all key questions. Without adequate answers to these and others, the probability of creating an effective teaching tool would have been much reduced.

With answers to all of the questions established, however, it was possible to move to the next stage of the project which was the physical development of the learning environment. This is discussed in the following chapter.

Chapter 6 Learning environment construction and operation

Following completion of the theoretical model and identification of the data sets to be used, the next stage was to construct the learning environment. The project to date had turned out to be much larger than originally anticipated; thus a critical factor in the design of the system was that it should not rely on complex algorithms that would themselves use up valuable time while they were tested.

Off-the-shelf, commercial software was used at every stage of the project. This approach served a dual benefit. Firstly, it significantly reduced the time taken to construct the learning environment and secondly, it went a long way to ensuring that the final tool would be sufficiently robust. Commercial applications from blue-chip software providers are extensively tested prior to delivery and the use of these applications contributed to the development of a system which was extremely reliable and which did not exhibit any bugs at any point during the research period. It was decided from experience that the optimum approach to the construction of the learning environment was to adopt a rapid prototyping, proof of concept approach (Horton & Radcliffe 1995).

Design of the learning environment was broken down into 7 components -

- Data requirements
- Hardware and software requirements
- Timing
- Presentation format
- Individual data pages
- Online assistance
- Session design and timetable

Each of these is discussed in greater detail in the following sections.

6.1 Data requirements

Designing the databases for teaching purposes was a relatively straightforward task. Knowledge of the approximate distribution of accident and incident data as well as previous work on such topics as accident frequency (Cram 2007), safety performance (Cram 2010) and unsafe act and unsafe condition reporting (Cram & Sime 2011) greatly facilitated the decision making process on data to be included.

As previously discussed, the accident database influenced most of the modules in the learning environment. Just as in real-world operations, this influence does not derive so much from the intimate detail of each and every event but more from the patterns which exist and emerge from systematic analysis of the data. The accident database was created with the minimum of detail. This was not a detrimental factor in terms of the type of learning environment being created as the participants were not expected to get involved in the causes of individual accidents or subsequent actions to prevent recurrence. Indeed, they were actively discouraged from doing so by the educator as this training was about teaching them how to use existing data to get a better grasp of the underlying safety culture of their organisations and not how to perform ‘root cause analysis’ in order to prevent recurrence.

For each accident, it was only necessary to provide a brief description, date and time, department in charge and contractor company (if applicable). As a precaution, whether the possibility existed or not that this information might be mistaken for a real event, a data anonymisation process was applied (Edgar 2003) to ensure that there could be no risk of any information in the learning environment being mistaken for real events, people, companies or locations.

Only when the data were completely anonymised was an analysis of each accident carried out in terms of management systems failures, safety climate deficiencies and recommendations to prevent recurrence. Great care was taken to ensure that root causes and management system were not lost in the anonymisation process. This information was stored in separate databases and was used to drive other modules such as the safety climate module, both management system modules (organigram and radar) and the action tracking module.

From personal knowledge of issues surrounding training and training uptake, a database of several thousand records was constructed. Names in the database were generated using an internet based random name generator such as www.fakenamegenerator.com. The number of names generated was equal to the total staff number of Lancaster Oil less the management team and the names were then attached to the various departments in accordance with the staff numbers already assigned in the original company design. In terms of training uptake, the data were spread across the departments based on previous experience of a similar environment.

The data for the action tracking database were assigned from knowledge of existing action tracking databases and the distribution of action sources within them. From the perspective of confidentiality, no actual data pertaining to specific actions were used in the learning environment. Like the accident data, there is no need for participants to be aware of the individual items populating the databases. Their focus needs to be maintained on the meta-level knowledge that they can elicit by considering all of the different components in the database as pieces in a larger jigsaw.

6.2 Hardware and software requirements

This thesis is not concerned with the technical solutions to these questions; therefore there is no intent to treat any of the technical challenges in anything more than a superficial manner.

Before a single line of code was produced, a functional specification and detailed design were produced. It is beyond not only the scope but also the word limit of this project to include either document. A very high degree of rapid prototyping was, however, incorporated as time was not a commodity in abundance. In order to keep costs to a minimum while still achieving the objective of communicating as much data as possible, it was decided to develop each of the data sets as a stand-alone module. This called for 14 computers, one for each monitor. Rather than clutter up the working environment with a stack of computers, 14 external monitors were acquired along with the hardware necessary to construct a video wall capable of supporting all 14 monitors. Each computer was connected to one of the monitors in the wall as shown in Figure 6.1.

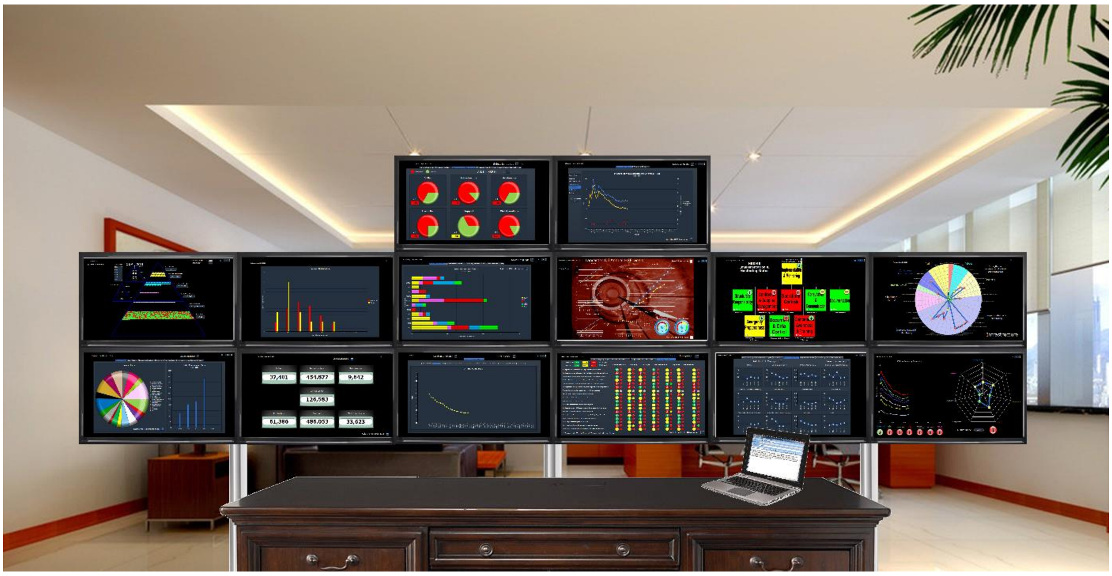


Figure 6.1 Learning environment video wall.

In addition to the display computers, an additional 2 machines were required; one for the participant to use as his communications machine; the second for the educator. The educator’s computer not only functioned as the e-mail server enabling the participants to actually send e-mail communications to the various members of the management team but also as a machine on which to deliver the various presentations which were required during the day; Induction safety presentation (January 2020), Board presentation (July 2022), and finally, the Poisson distribution presentation (June 2024).

One possible problem which was foreseen and catered for but which did not actually arise in the sessions was readability of the data being presented on the video wall. In the event that this had materialised as an issue the video output from each of the 14 display machines was split into two feeds. One feed went to a screen on the video wall, the other to one of the inputs on a 16 port video switch. The video switch enabled any output to be projected using a remote control onto a large screen to facilitate reading the material. As it turned out this option was not required during the sessions.

Finally, two additional machines were available in the event of a catastrophic failure during an evaluation session. These machines were configured as e-mail server and client lest there be a failure in one of the two communications machines but this did not preclude them from fulfilling the role of data machine if the need arose.

In order to enable participants to browse the data each computer was supplied with its own mouse and this immediately raised a possible problem; a plague of mice. For the first evaluation session, the participant was given a mouse for his own communications machine and 14 more mice arranged on his desk in the same layout pattern as the video wall. Each was identified by a label corresponding to the appropriate display monitor which was also labelled. This proved to be a less than optimum solution as it rapidly became obvious that expecting the participants to remember which mouse to use to access particular data, when already under considerable stress, was clearly asking too much of them.

The answer to the problem was identified in a commercially available product which enabled multiple computers to be controlled from a single mouse and this was installed and functioned flawlessly during every subsequent evaluation. As part of the induction, subsequent participants were given a brief introduction into how to use the single mouse and, without exception, this proved a thoroughly satisfactory solution to the problem for the rest of the participants.

With the hardware challenges solved, the next major hurdle was how to develop the software. Selection of the appropriate development tools was influenced by the need for –

- Simplicity
- Transportability
- Maintainability
- Robustness
- Cost.

The selection of these particular attributes was based on the author's past experience as an IT system developer.

6.2.1 Simplicity

At its most basic, this project was about presenting participants with a large quantity of data in the form of graphs and charts. In addition, the system needed to be able to send e-mails at a pre-programmed time to a pre-defined e-mail address.

The technical demands of the system which was to be designed to deliver these data were significant. It needed to be capable of synchronising the display of circa 250,000 data items on 54 pages of data displayed on 14 computers while simultaneously co-ordinating circa 250 e-mails at the appropriate time during the session. It also had to run 100% reliably without the requirement for maintenance from the first session onwards. All this meant that it was imperative that the system was simple.

The initial idea that commercially available software tools might have a role as development environments was very quickly dismissed. There was neither the time nor the resources available to hand-code any of the material especially in light of the amount of debugging that might have to be done. Every person who uses a computer system uses it differently and the author's experience as an IT developer envisaged enormous issues as individuals used the system in a different manner from that which it had been designed to accommodate, thereby causing possible problems during evaluation sessions.

6.2.2 Transportability

Technically, this should not have been a concern as, given the nature of the research, there was no intention to move the learning environment to a different technical platform after development. It did, however, seem reasonable to consider the transportability issue as part of the concept of delivering a useful working tool at the end of the project rather than a theoretical implement which might not be convertible to industrial environments. Migration to smaller tablet computers seemed to be the answer to this issue and since the project ended, the SCLE has been successfully migrated to a tablet environment.

6.2.3 Maintainability

There was neither the opportunity nor the desire to spend large amounts of time keeping the learning environment running. While recognising the need for updates to incorporate new ideas and enhancements, these were intended to be the exception rather than the rule as far as the research was concerned and all would be confined to the post-evaluation period. Evaluating the effectiveness of the tool as an education/training entity would be hampered if every participant was exposed to a different tool. Certainly, there is scope in the future to adopt an action research approach (Kemmis & McTaggart 2005) towards improving the environment.

6.2.4 Robustness

The system needed to be robust. It was deemed unacceptable if the learning environment did not run 100% correctly during each and every session. Wasting time conducting bug fixes unearthed during evaluations had enormous potential to detract from the quality of the presentation, and hence, the data being collected. This was especially true should the learning environment 'crash' at any point. A 100% reliable and functioning system was essential from the start of the project. This was achieved very simply by using commercial applications which had been thoroughly tested over many years and which had been developed by reputable software companies.

6.2.5 Cost

This project was not being funded by industry or grant. As such, all costs needed to be kept to a minimum. While the author's time is technically free, any delays or problems developing and implementing the tool had the potential to significantly increase the duration of the project and hence the overall cost.

6.3 Timing

The completed learning environment presented corporate data representing a 5 year period in the space of 8 hours. The initial calendar date was selected as 1st January 2020 and the SCLE ran until 31st December 2024. The reason for choosing dates in the future was an additional contribution to ensuring that there were no discernible links between the learning environment data and any real-world data. The total number of days was therefore 2 * 366 + 3 * 365 = 1827 days. In an 8 hour period, that meant that a day in the life of the learning environment was equal to 15.76 seconds. With such a short time between different days, there was every possibility that the different processing demands of the various modules could fall out of time with each other unless the modules were linked to the same baseline.

In order to maintain maximum credibility, there could be no possibility that the 14 computers dates fell out of synchronisation. With different computers processing different data, it was essential that the internal clocks on all of the computers were synchronised prior to the start of every session, as even a few seconds delay would result in different dates being displayed. Each of the 14 modules was, therefore, linked to the computer clock so that all the machines counted up a new date at exactly the same time.

Finally, in recognition of the possibility of delays due to unforeseen circumstances such as power cuts (a common problem in Spain), failed computers, sleepy participants, etc., a facility was incorporated to set the start time of each data module in increments of 1 hour. This meant that if there was an issue which either delayed the start or caused a major interruption during the session, all modules could be simultaneously re-launched at a different time as required.

6.4 Presentation format

This is not a research project into the optimum way to design and present data for use in this type of teaching tool although intuitively it feels that there is scope for future research into this. A suggestion to this end is included in Chapter 8. Notwithstanding, some attention was devoted to the use of colour and graphics in the presentation style.

6.4.1 Colour

"To paint well is simply this: put the right color in the right place." - Paul Klee

The second research question addressed by this project was to educate management in how to measure and evaluate the safety culture of their organisations. To achieve this, a picture of organisational safety culture would be painted using the graphs and charts on the various data pages that senior managers would learn to measure and evaluate. As part of that process, they were going to be presented with an enormous quantity of data which they would be required to assimilate rapidly and accurately. Putting the right colour in the right place was essential. As noted by Tufte (1998, p. 81) – *"...avoiding catastrophe becomes the first principle in bringing color to information: Above all, do no harm."*

The majority of people are familiar with the significance of the colours red, yellow and green which have been in use for over 100 years and are effectively a standard colour scheme for road traffic around the globe. For this reason, these three colours were selected for all graphs and charts where an indication of bad, average/warning or good was required. There is, however, a risk with this approach which, while not an issue in the research learning environment, is an issue which would need to be considered for such a training tool in an actual live environment; that is the possibility of colour-blind participants.

Two options were possible, either a version of the learning environment could be constructed specifically for colour-blind audiences or a toggle switch could be included to switch colour schemes as required. Both approaches have their pros and cons. It is beyond the scope of this project to explore the best approach other than to say that creating a duplicate system to accommodate colour blindness is much easier to achieve, as existing colours are simply exchanged for other more appropriate colours. The drawback to this approach is that two systems need to be maintained. The alternative option is to include a toggle switch to enable changing between the two different colour versions. This would require a modification to those algorithms controlling modules dependent on calculations to decide which colour to display, thereby increasing the complexity of the underlying data engine. The upside, however, is that only a single system would need to be developed and maintained thus simplifying version control. The latter would be the preferred approach in the author's opinion.

It should be noted at this point that colour blindness manifests itself in different forms and that red/green is not the only type of colour blindness which exists, e.g. blue/green is another variant. Any colour selection would need to accommodate the range of colour blindness that exists within the population. An in-depth study of the appropriate colours to accommodate colour-blind participants is beyond the scope of this project. There is, however, a wealth of information on the internet (e.g. Hesperian Solutions 2001). Further observations on the use of colour are given in the section on future research topics stemming from this project.

To test the feasibility of the second option, the action tracking module was constructed with a colour toggle option. This worked perfectly well from a technical perspective. It has not been possible, thus far, to present the module to a colour-blind person to gauge their reaction.

6.4.2 Graphics style and layout

With over a quarter of a million data items being presented in a continuous 8 hour period, the last thing participants need is to be put off by the presentation style. While there is always a tendency to try to make graphs and charts look as pretty as possible, this may have the undesired effect of making the information less easy to understand. Few's 9th rule of data presentation (Few 2008, p. 12) "*Avoid using visual effects in graphs*" is particularly applicable in this case. Fifty-four different pages of data each using a variety of visual effects might well have confused participants. For that reason a simple and consistent presentation format was retained wherever possible.

Data displays were primarily limited to line graphs, horizontal or vertical bar charts and pie charts. The most notable exceptions to this were the accident triangle, which required its own unique presentation style, the man hours screen, which only displayed numbers, and the management system radar plot which was also used in the Loughborough safety climate screen. The most complex display was in the leading indicators screen with 252 trend and status icons (Figure 6.45).

6.5 Individual data pages

With the data sets identified and the safety culture model defined, the final step prior to beginning construction of the learning environment was to establish exactly what data would be provided to participants on each of the screens in the video wall. As mentioned earlier, most companies retain databases as required by law. In the UK, these requirements are specified in the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (2013). In the USA, OHSA requires companies to maintain records and report illnesses under the OSHA (2001) Injury and Illness Record Keeping and Reporting Requirements (29 CFR 1904). In Australia, the obligation is imposed under the Work Health and Safety Act (2011).

A major aim of the SCLE is to persuade participants of the need actually to understand what the data they are seeing is saying. To accomplish this objective, each data set was examined in detail to establish what information could be extracted and how that data should be presented to the participants to maximise their comprehension while striving to minimise their cognitive load.

A close examination of each of the data sets identified in Chapter 3 resulted in the identification of 54 discrete data components that would be used as the foundation of the learning environment. Each of these components is described in detail in this chapter with examples of how they appeared on the video wall display. The relationships between the data sets and the final data components used in the learning environment are shown in Figure 6.2.

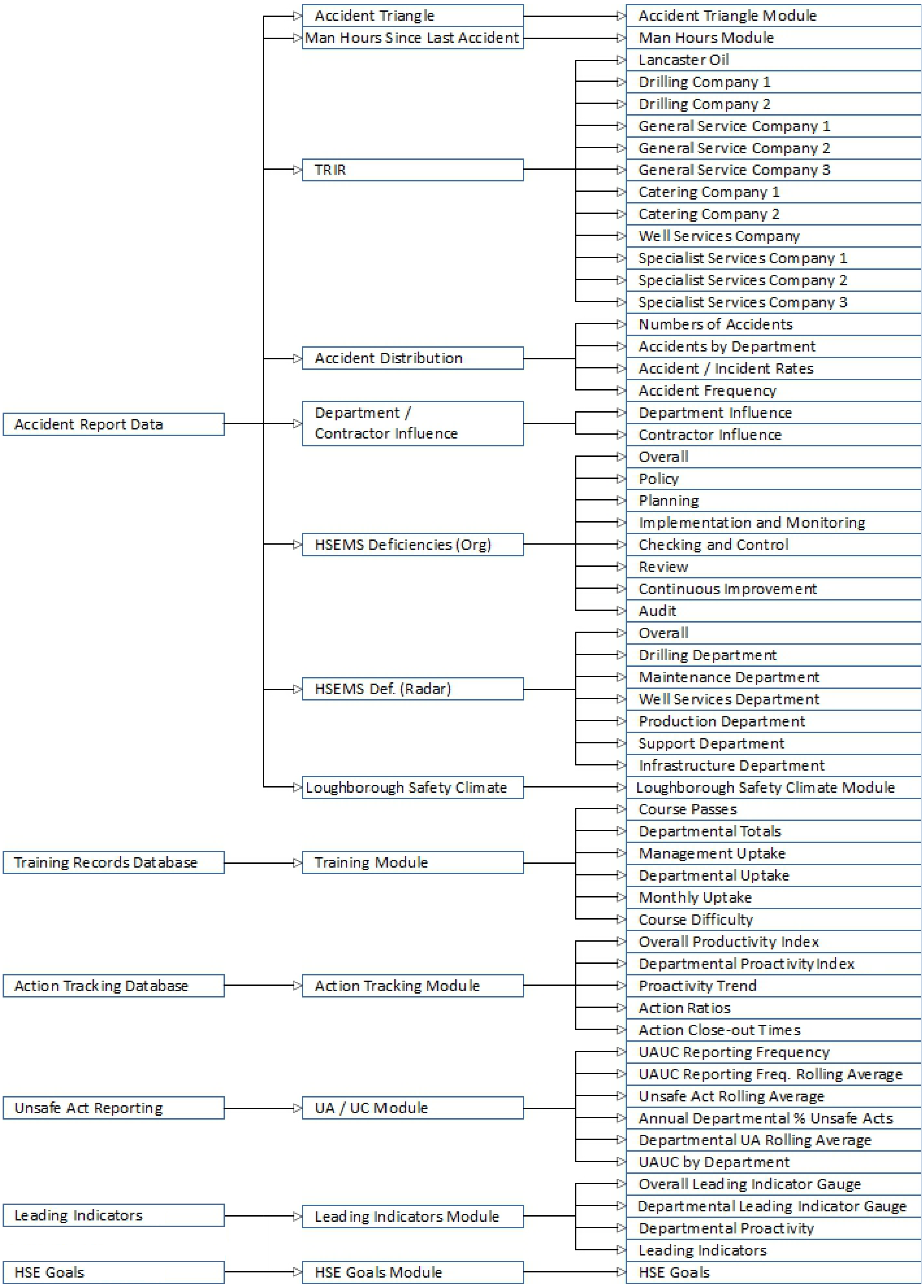


Figure 6.2 Final data components for learning environment.

6.5.1 Accident triangle

It is the author's opinion that a large number of classifications of accident severity is unnecessary and potentially misleading. Given the diversity in accident severity classifications, which the author believes to be an exercise in futility, it was essential to select an accident severity classification that would provide the participants with the information they required without over-complicating the issue for them.

Many organisations classify and report accidents according to a range of severities. This has the potential effect of concealing the truth from the casual observer. Some organisations do not regard an accident as ‘lost time’ if the victim is able to take up some task other than his usual work until he is able to return to normal duties. These are referred to as ‘restricted workday cases’ (OSHA 2001). Re-classifying a lost time accident as a restricted workday accident does not alter the fact that an accident took place, it simply makes the organisation’s Lost Time Injury Frequency Rate (LTIFR) look better.

A simple version of the accident triangle was adopted for the learning environment. This comprised 6 layers beginning with fatalities at the apex followed by; lost time accidents, recordable accidents, first aid accidents, incidents (events with no injuries), and at the bottom, unsafe acts and unsafe conditions.

Incorporated into the accident database, which powers much of the learning environment, there are over 200 accidents/incidents of varying degrees of severity. These occur on a pre-programmed time-line and, as each event occurs, a dot is placed in the appropriate layer of the accident triangle corresponding to the severity of the event which has taken place (Figure 6.3). Over the five years of the simulated history of the organisation, this builds into a comprehensive overview of the underlying reporting culture. A key message to which participants are introduced to during the session is that the distribution of the data should be triangular. If it is not triangular then there is an issue in the organisational reporting culture.

By becoming sensitised to, and aware of, discrepancies in the distribution of accidents and incidents resulting from ongoing operations, participants begin to achieve a greater insight into the reporting culture of the organisation represented by the data being presented to them.

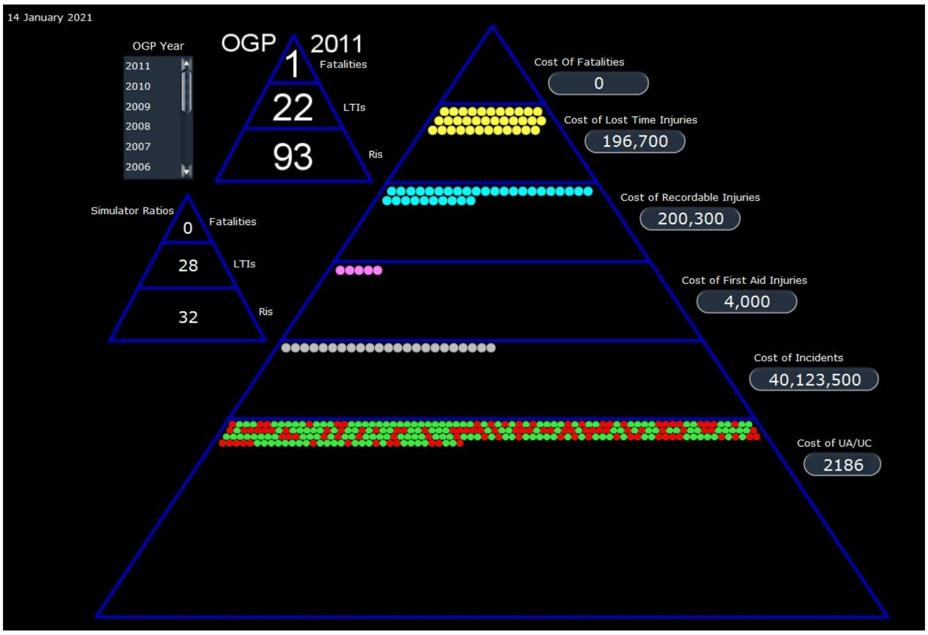


Figure 6.3 Screen shot of SCLE Accident Triangle Screen.

In addition to the real-time data being produced, two additional triangles are presented. All of the accident triangles produced by the OGP since 1999 (Figure 3.5) were included in the page as well as a pro-rated version of Lancaster Oil's equivalent triangle for comparison purposes. Finally, alongside each severity layer, the cumulative theoretical cost of all of the events within the layer was presented. The output from the triangle component of the simulation was displayed on one of the elements of the video wall (Figure 6.4).

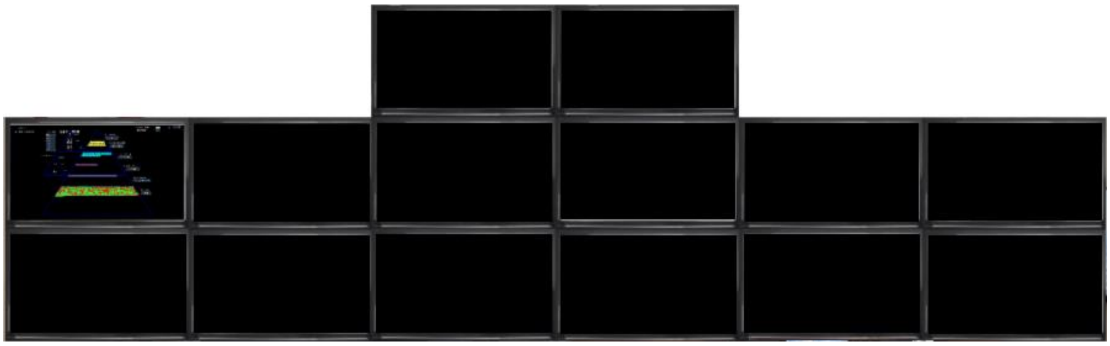


Figure 6.4 Location of accident triangle screen in video wall.

6.5.2 Man hours since last lost time accident

From the date and time of a lost time accident in the accident database, it is a straightforward exercise to calculate the man hours worked for the organisation as a whole (total staff (including contractors) x hours worked per day x number of days since last lost time accident) and the man hours for the department experiencing the accident (total departmental staff (including departmental contractors) x hours worked per day x days since last departmental accident).

A single page in the video wall (Figure 6.5) displays the man hours worked for each of the six departments of Lancaster Oil and for Lancaster Oil overall. At appropriate junctures during the session, participants are asked what the numbers are telling them in respect of understanding the safety culture of his organisation. From their own responses, they begin to learn that this metric is of no use to them at all.

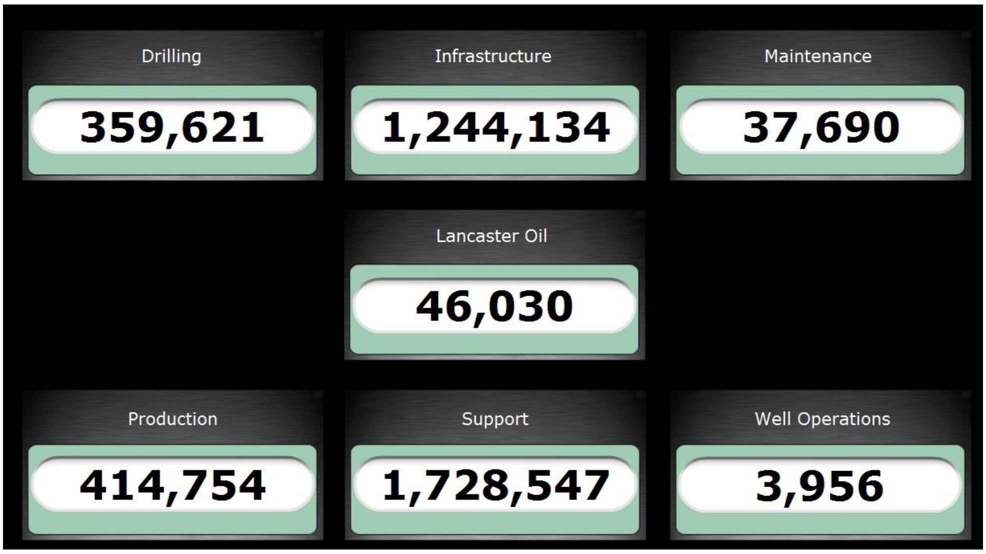


Figure 6.5 Man hours since last injury data screen.

Figure 6.6 highlights the location of the man hours since last accident screen.

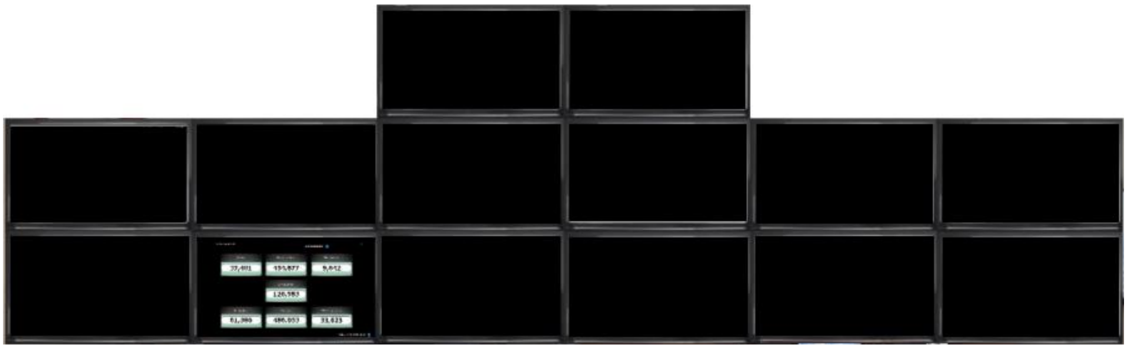


Figure 6.6 Location of man hours screen in video wall.

6.5.3 Total recordable injury rate

The first page in the Total Recordable Injury Rate (TRIR) data set is devoted to Lancaster Oil Ltd. and provides three plots to the participant: the overall TRIR for Lancaster Oil Ltd. including both staff and contractors; the TRIR for Lancaster Oil Ltd. staff and the combined TRIR for all of the contractors. In order to smooth the data, a six month rolling average is used to eliminate the peaks and troughs associated with random accident occurrence.

The other 11 pages in this data set provide the participant with the TRIR performance of each of the individual contractor companies employed by Lancaster Oil Ltd. Information is, however, only displayed for a particular company when it has had a sufficient number of accidents to enable a realistic plot of its safety performance to be produced. All of the information required to populate this data set is found in the accident database. Figure 6.7 illustrates a single page from the TRIR data screen showing the 3 different plots of TRIR for Lancaster Oil, contractors and Lancaster Oil plus contractors combined. The location of this screen in the video wall is illustrated in Figure 6.8.

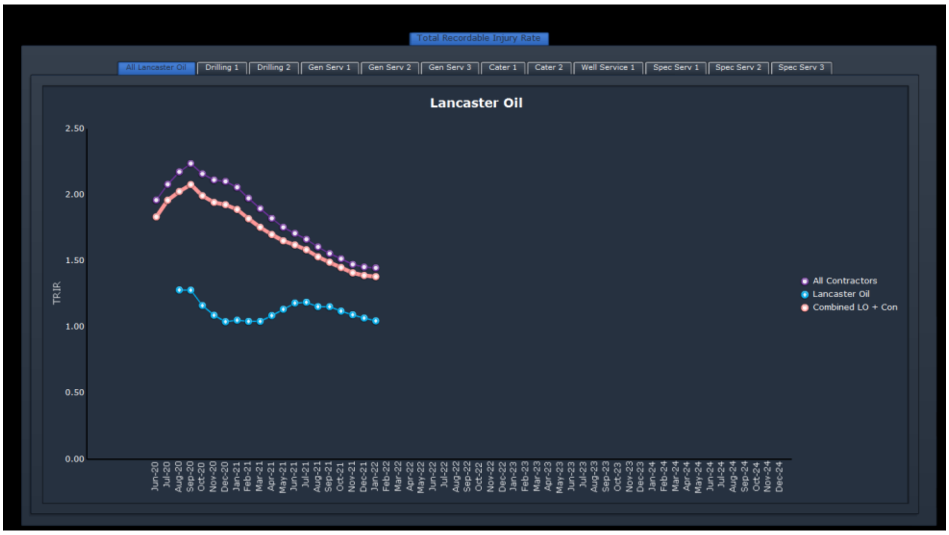


Figure 6.7 Total recordable injury rate plot.

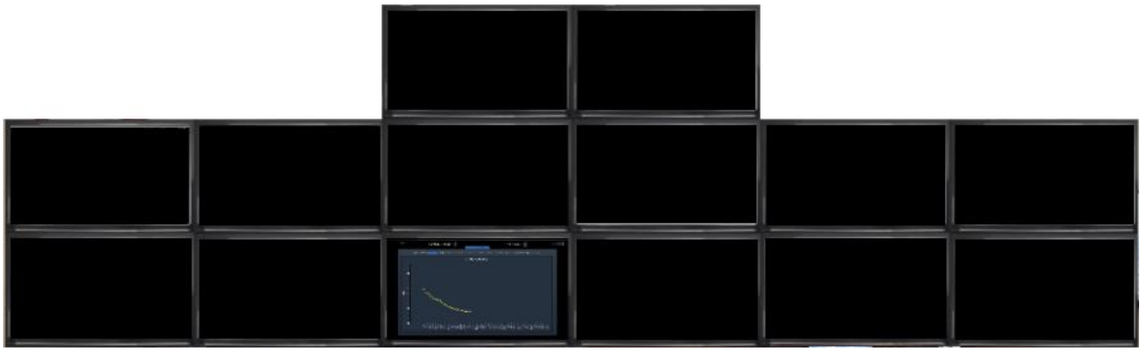


Figure 6.8 Location of TRIR screen in video wall.

6.5.4 Accident distribution

By drawing once more on the data from the accident database, 4 individual pages can be identified from the available information.

6.5.4.1 Accidents by contractor per year

Knowing who has had accidents by itself is not an actual measure of safety culture. It is, however, an insight into what may be an issue within the overall safety culture picture of the organisation; for example, what is it about the organisation's safety culture that it uses or continues to use a contractor company (Figure 6.9) with a particularly high accident rate? Is there a cultural issue at the forefront of the decision making process that allows such poorly performing companies to continue to win business?

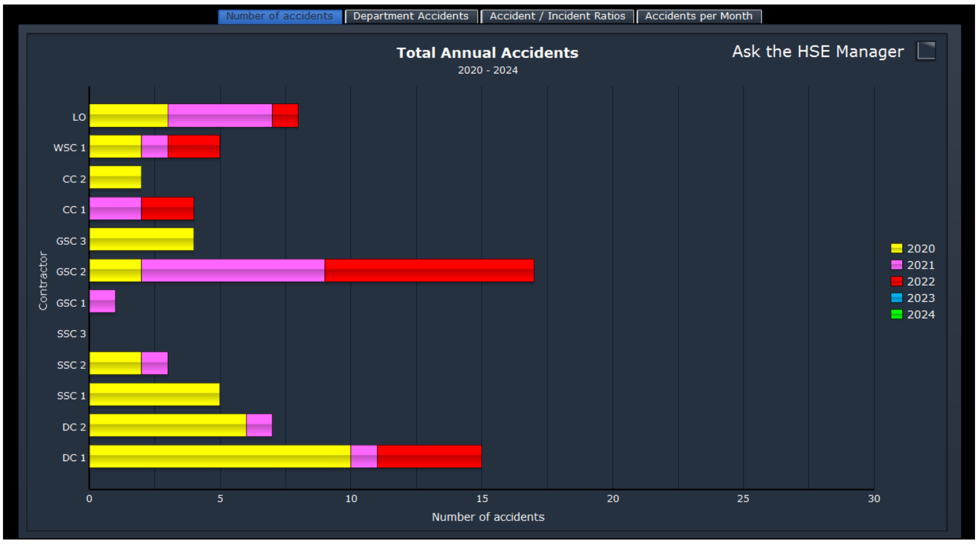


Figure 6.9 Accidents by contractor.

6.5.4.2 Accidents by department

Addressing the same accident data, but considering it from the perspective of the department (whose departmental managers are directly responsible for the safety performance of the contractors under their control) engaging the contractors, presents a different picture of contractor safety management (Figure 6.10). Are there issues within departments that enable contractors with poor safety records and/or performance to continue to be selected to provide services to particular departments?

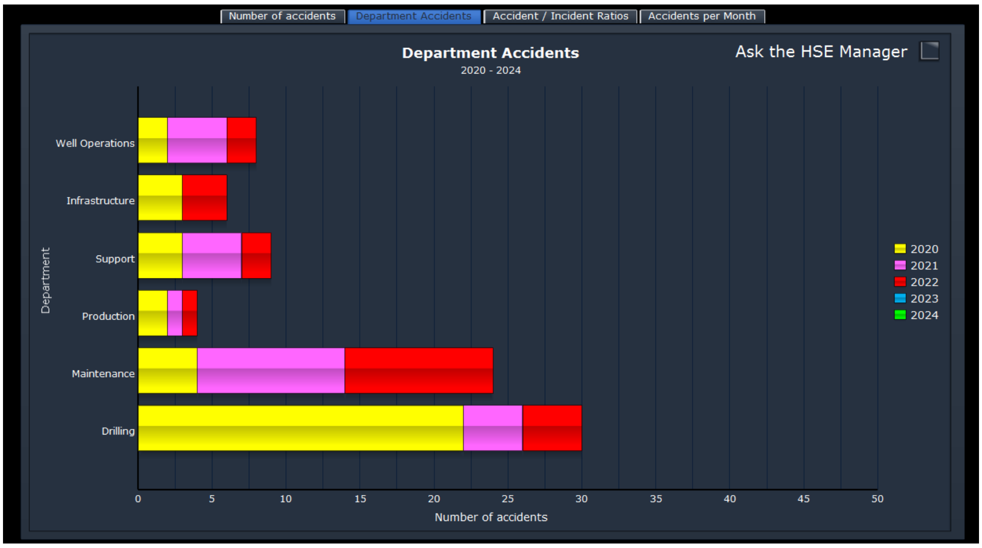


Figure 6.10 Accidents by department.

6.5.4.3 Ratio of accidents to incidents

The third component which can be constructed from the original raw data comprises various charts (Figure 6.11). By looking at the ratio of accidents to incidents on an annual basis, it is possible to glean important information on the reporting culture of the organisation. If the data are viewed in the form of pie charts and each pie has two items, the number of recordable accidents that the organisation has had and the number of incidents it has experienced over the same time period then a clear picture of one aspect of corporate reporting culture emerges.

From the definition used throughout this tool that an accident is an event with an injury and an incident is an event with no injury then, theoretically, the number of non-injury events should significantly outnumber the injury events given the triangular nature of accident/incident occurrence. Any deviation from this pattern is yet another clue for the participant pointing to potential deficiencies in regard to the company's safety culture. If the number of recordable accidents is much higher that the number of incidents, there is clearly an issue. When viewed in conjunction with the accident triangle in component 1, the participant is able to identify where questions need to be asked, and answers found, in order to understand their corporate safety culture.

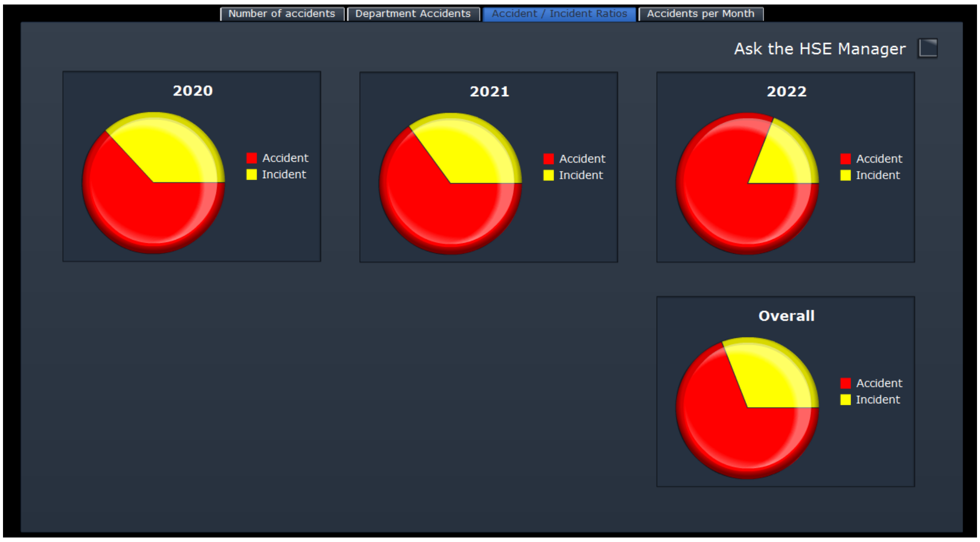


Figure 6.11 Accident versus incident ratios.

6.5.4.4 Accidents per month

The plot of accidents per month shown in Figure 6.12 says nothing directly about the culture of the organisation. It is included to enable the interactive component of the tool (the e-mail system) to question the participant regarding data which are presented on the plot and to elicit a response from the participant on his proposed course of action. This component is included specifically to enable a particular learning issue to be presented and addressed with the participant. As such, it is an invaluable component of the accident occurrence data. The location of the accident distribution data in the video wall is shown in Figure 6.13.

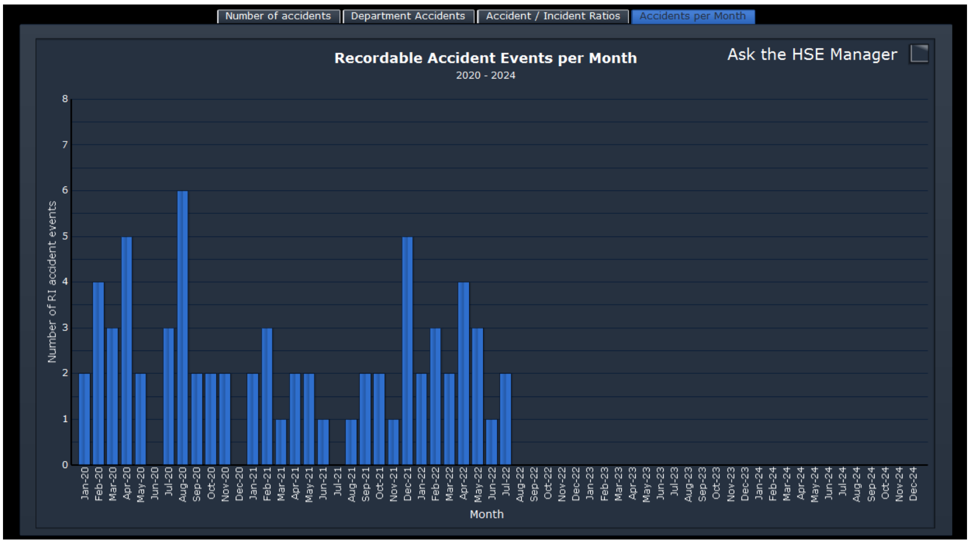


Figure 6.12 Accident distribution by month.

Figure 6.13 Location of accident distribution screen in video wall.

6.5.5 Department and contractor influence

'Ipsa Scientia Potestas Est'. When dealing with subordinate management or suppliers 'knowledge itself is power'. From the information in the accident database, it is a simple matter to attribute accidents to the department or contractor (or both) experiencing the event. Basic arithmetic then enables two graphs to be produced; the first shows the overall corporate TRIR and the second, the overall TRIR if the department or contractor had not had the accident(s) which they have actually experienced.

The department and contractor contributions component provides that information to the participant from two pages; one page for the individual departments in Lancaster Oil; and the other page for the contractor companies working for Lancaster Oil. When the participant selects a department or a contractor from the on-screen menu, the safety record for the selected item is extracted from the TRIR calculations and a second plot is displayed showing what the TRIR for Lancaster Oil would have been if that department or contractor had not had any accidents.

6.5.5.1 Departmental influence on safety performance

This page provides the participant with the opportunity to extract the safety record from the overall performance of the company. In this way, department managers can be presented, in a single graph, with the full impact of their own department's safety record on the organisation's safety performance.

6.5.5.2 Contractor influence on safety performance

The contractor page (Figure 6.14), located in the video wall as shown in Figure 6.15, provides the same information as the department page except that here, the safety history of each individual contractor can be extracted from the overall organisational results. This helps the participant evaluate which of the contractor companies is having the most negative impact on organisational safety performance and whether that influence is worsening or improving on a continual basis.

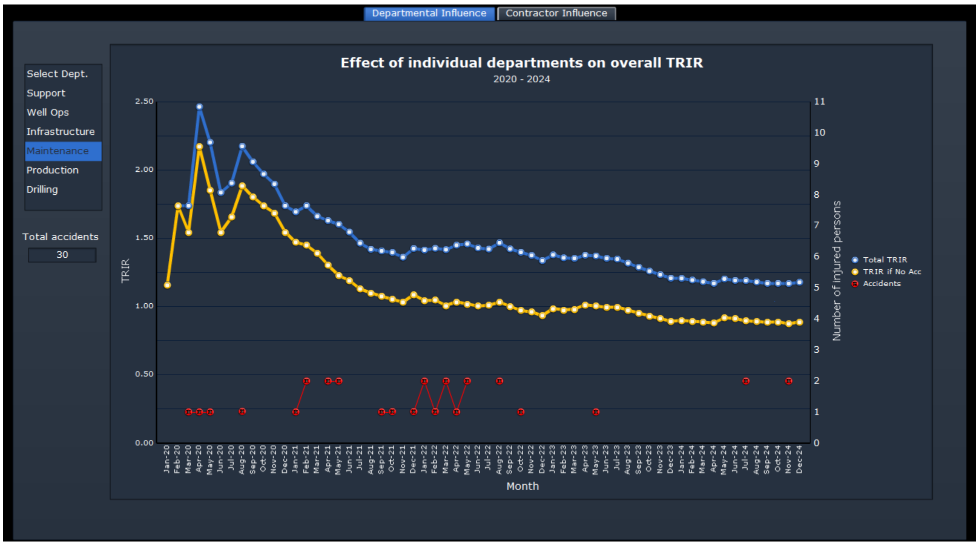


Figure 6.14 Department and contractor influence on overall safety performance.

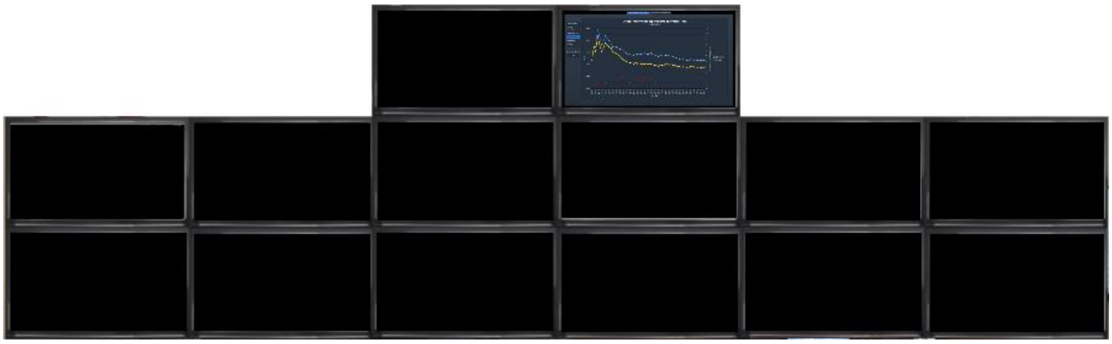


Figure 6.15 Location of department/contractor screen in video wall.

6.5.6 HSE management system deficiencies (organigram)

For all of the two hundred and twenty accidents/incidents in the database, a ‘Management System Deficiency Analysis’ was carried out during the initial database creation. This involved, for each of the accidents, identifying which of the 28 elements of the Lancaster Oil HSE MS were poorly implemented in order for that accident/incident to have occurred. At the end of the analysis, each of the contributing elements of the management system found to be deficient was given a score (no weighting was given to suggest importance though this might be a topic for future research) to indicate that it had played a role in contributing to the accident/incident.

In the course of normal corporate operations, and in view of the effectiveness of various safety initiatives in the fictitious company, it was to be expected that the implementation levels of the various elements of the management system would change over time. To reflect this, a rolling average score for every element of the management system was determined. There were two possibilities when it came to determining the period for the rolling average; it could be calculated over a fixed time period or it could be calculated over a given number of accidents.

A rolling average over the previous 12 accidents rather than over a period of time was adopted on the basis that time has no tangible connection to the effectiveness of management system implementation. Whether accidents occur two days apart or two weeks apart does not change which elements of the management system were deficient, thereby contributing to their occurrence.

Eight pages comprise this module; one for each of the components mentioned above; and one for the overall HSE MS and all content was derived from analysis of the information in the accident database.

Figure 6.16 shows the top level page displaying each of the seven sections of the Lancaster Oil HSE MS (which the participant receives at the start of the session in the form of an organigram). Each of the underlying elements is displayed as a green, yellow or red icon representing ‘no impact’, ‘minor impact’ or ‘major impact’ respectively. Combined with each icon is a trend icon indicating whether the last change, due to the most recent accident/incident, resulted in an improvement, a worsening or no change in the component contribution.

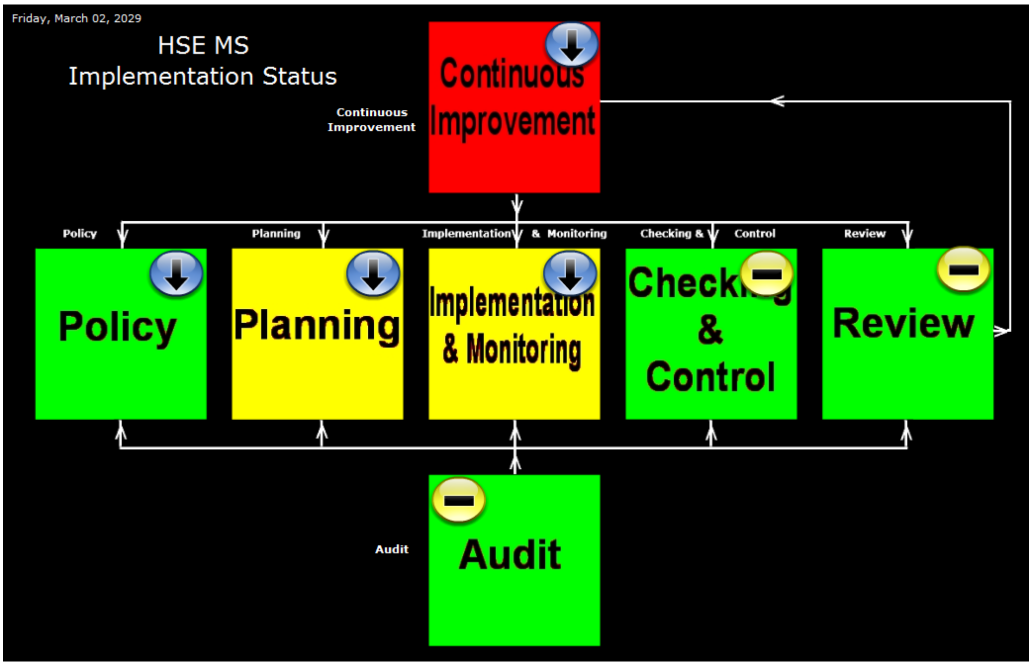


Figure 6.16 Overall HSE MS influence.

Participants have the option to drill down into the data should they wish to evaluate which aspects of the individual components have the effect of moving them to either yellow or red.

The seven individual elements comprising the HSE MS and their sub-elements are presented on their individual pages

- **Policy (1)**
  - Policy
  - Strategy
- **Planning (2)**
  - Risk and hazard assessment
  - Prevention and mitigation
  - Legal and other requirements
  - Objectives
- **Implementation and monitoring (3)**
  - Structure and responsibility
    - *Line management*
    - *Individuals*

        - *HSE function*
    - Competence, awareness and training
        - *Competence*
        - *Awareness*
        - *Training*
    - Consultation and communication
    - Documentation
    - Document and data control
    - Operational control
    - Emergency preparedness and response
    - Contractor and supplier management
        - *Evaluation, qualification and selection*
        - *Management*
        - *Performance*
- **Checking and control (4)**
    - Performance measurement and monitoring
    - Accidents, incidents, non-conformances and corrective and preventive action
    - Records and record management
- **HSE MS review (5)**
- **Continuous improvement (6)**
    - Self-assessment
    - Lessons learned
- **Audit (7)**
    - Audits
    - Results
    - Actions

Each of the seven elements of the HSE MS is presented on its own page of the HSE MS organigram element. By way of example, the implementation and monitoring page is shown in Figure 6.17.

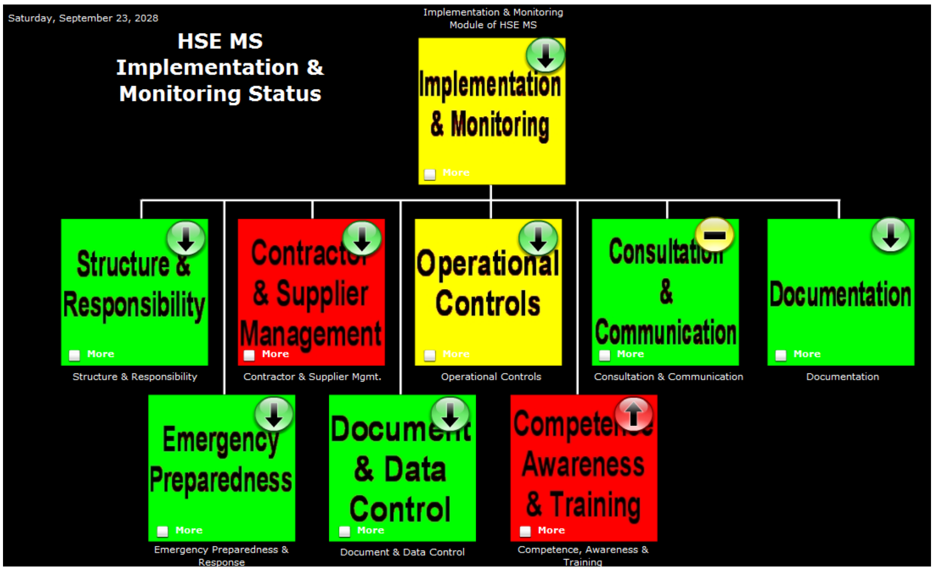


Figure 6.17 Implementation & monitoring section of the HSE MS.

In addition to the green, yellow and red icons, each of the individual element pages 2 – 7 permit the participant to view the historical data concerning the increase or decrease in significance of the topic under consideration (Figure 6.18). To maintain maximum clarity, as the graph changes, so does the colour of the points being plotted, thus avoiding the participant having to return to the previous screen to confirm which bands that particular data set had occupied and for how long. The HSE MS Organigram screen is located in the video wall at the position shown in Figure 6.19.

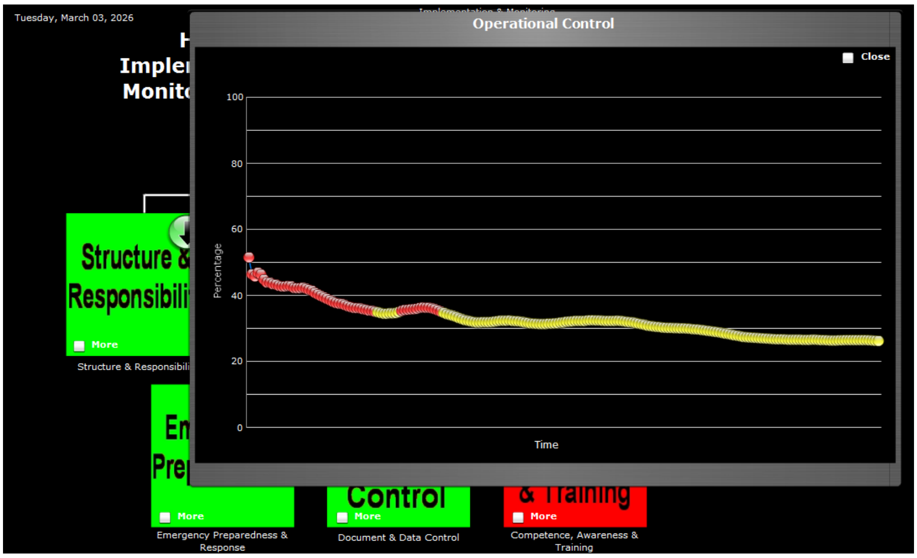


Figure 6.18 Historical plot of sub-element progress.

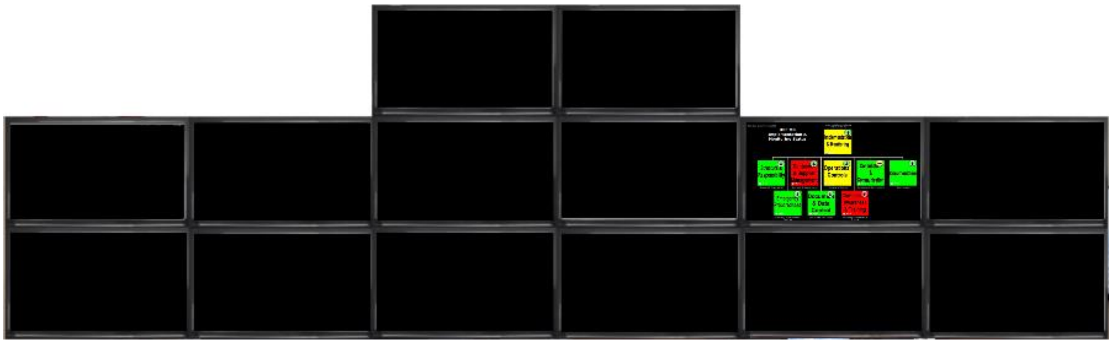


Figure 6.19 Location of HSE MS (Organigram) screen in video wall.

6.5.7 Training uptake

Training is not only a useful exercise in terms of increasing workforce awareness of safety and safety issues, an analysis of safety data also provides important insight into the safety culture of the organisation. The uncommitted boss pays little or no attention to safety training. The committed boss instructs people to go on the training. Leaders have taken every training course possible and ensure that every person working under their authority is aware of their personal belief and commitment.

Included in the training database are approximately 6,000 simulated training records representing the total HSE training for Lancaster Oil over the five years of the session. The training element provides the participants with 6 pages of data which build as the years pass.

6.5.7.1 Total training achieved

The first page, shown in Figure 6.20, provides information in two forms; a pie chart indicates the training courses passed by subject material and an adjacent bar chart displays the total courses passed per year, from the beginning of the simulated time period of January 1st 2020, until the end of the session which occurs five years later on December 31st 2024.

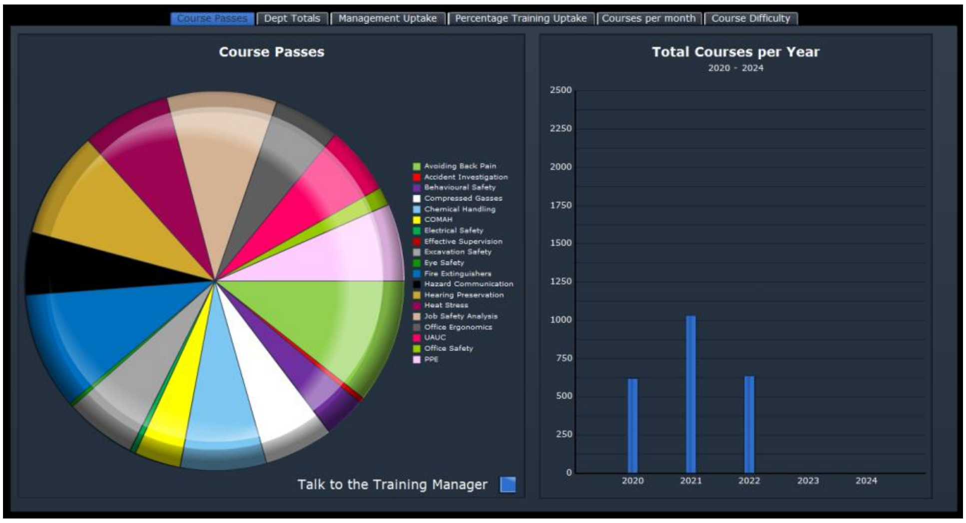


Figure 6.20 Total training uptake.

6.5.7.2 Department totals

By analysing the training consumption by department and contractor (Figure 6.21) a picture emerges as to which managers support and encourage training participation. On this page, the participants can examine which of the departments under their control are actively involved in training their staff. The annual figures are displayed both as actual annual numbers in a bar chart, and as annual proportions of total training achieved in the form of a pie chart.

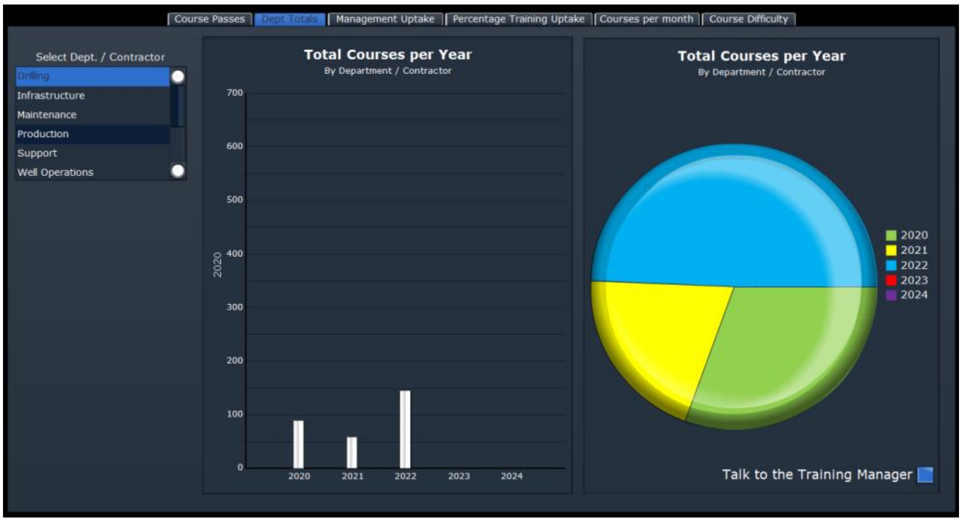


Figure 6.21 Departmental training totals.

6.5.7.3 Management uptake

Effective management and leadership include the need for setting an example. Page three (Figure 6.22) presents two insightful graphs. The first shows the percentage of available training that each individual departmental manager has actually completed. Presenting the data in this way highlights which individuals are committed to setting the right example. The second graph presents the cumulative percentage of training which each manager has taken during the five years of the model.

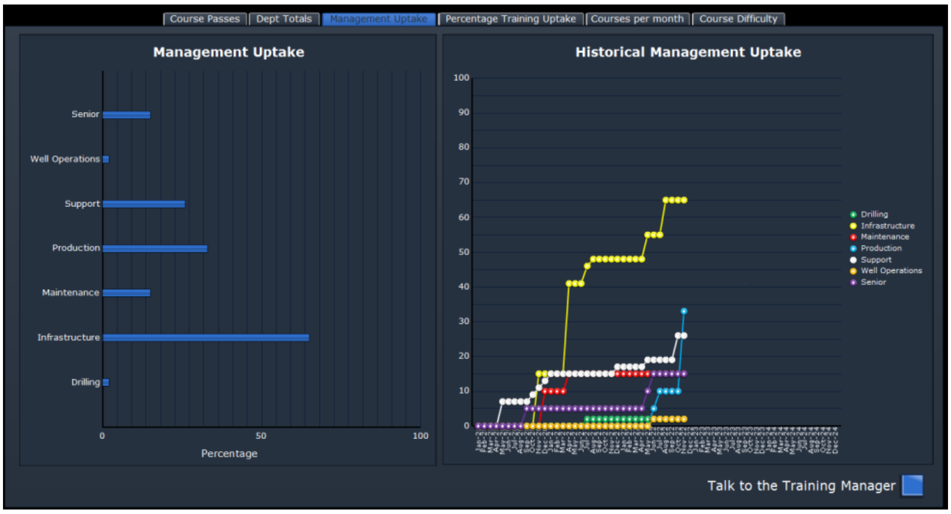


Figure 6.22 Departmental management training uptake.

6.5.7.4 Workforce uptake

Different departments in any company have different staffing levels. Lancaster Oil is the same. Comparing the number of training modules completed by department X as opposed to department Y is meaningless if department X has four hundred staff and department Y has only five. When the data are viewed as a percentage of possible training available then a clear picture of commitment manifests itself (Figure 6.23). This picture becomes more interesting when the piece of the cultural jigsaw called 'management uptake' is added.

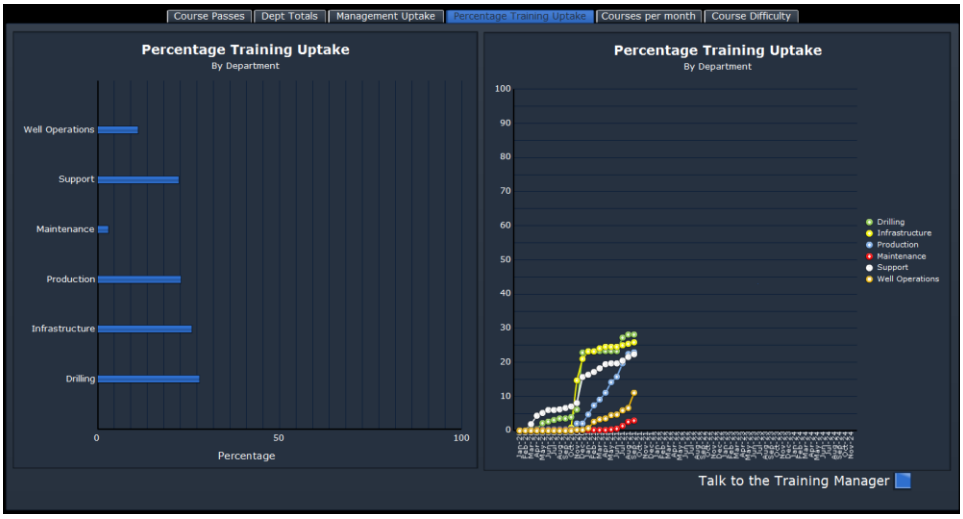


Figure 6.23 Workforce training uptake.

6.5.7.5 Courses per month

This page is a simple bar graph of the number of courses completed each month in the entire Lancaster Oil organisation (Figure 6.24). In isolation, it shows trends in training uptake on a month-by-month basis, which are useful. It is only when the information from this piece of the puzzle is combined with other information in other modules of the SCLE that vital insights into the management and attitudes of staff become clearer over time.

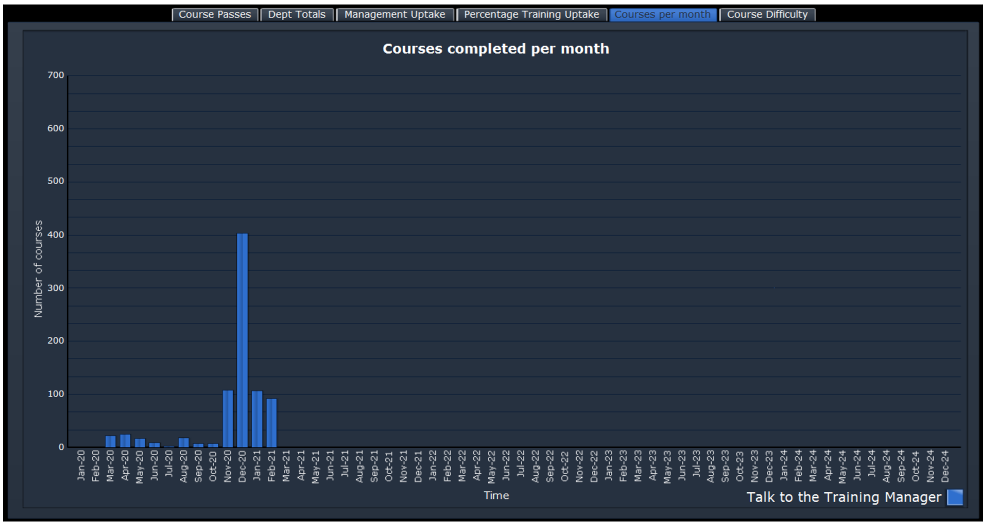


Figure 6.24 Total courses per month.

6.5.7.6 Average course scores

Page 6 (Figure 6.25), located in the video wall as shown in Figure 6.26, presents the average scores for all of the employees of Lancaster Oil for the circa 6,000 completed modules. An interesting picture emerges as participants examine some of the reasons for the different distribution of test scores.

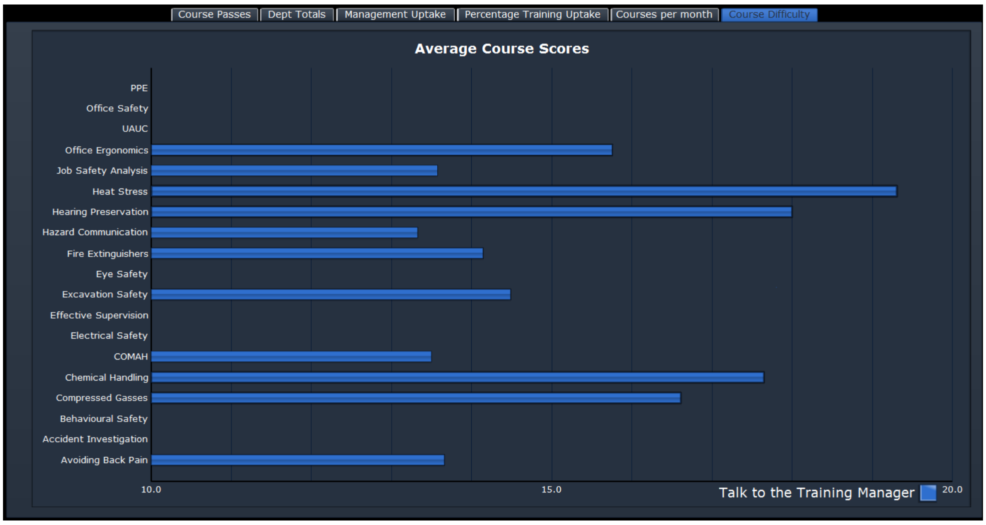


Figure 6.25 Course difficulty.

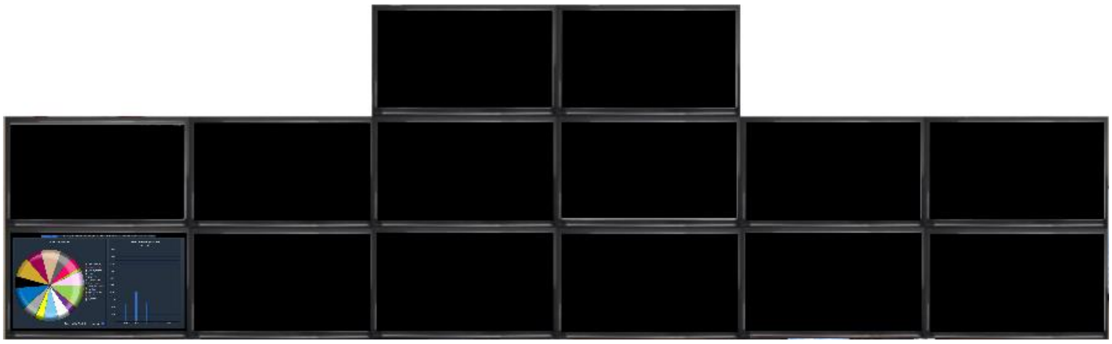


Figure 6.26 Location of training screen in video wall.

While training records have the potential to reveal much useful knowledge regarding underlying safety culture, communications between various entities also supply more pieces to fit into the overall corporate safety culture jigsaw picture. The e-mail component of the SCLE provides additional training-related input to the participants during the course of the session.

6.5.8 Action tracking

From the action tracking database containing several hundred actions generated from various sources in the organisation, 5 different data pages are produced. As the session progresses, actions are closed out and new actions generated as would happen in any operating entity. Based on the source of the actions, they are classified as ‘proactive’ or ‘reactive’ meaning that they have been generated either as the reactive result of an accident/incident or as the result of a proactive initiative on behalf of the organisation such as an inspection, risk assessment, etc. The ratio of proactive actions to reactive actions is termed the Pro-activity Index A ‘PI(A)’ (where A denotes ‘actions’ to separate this pro-activity index from others in different elements of the tool).

6.5.8.1 Overall pro-activity index

The first page (Figure 6.27) highlights the pro-activity index of Lancaster Oil as a whole. If the organisation is predominantly reactive then the red component of the pie chart is correspondingly larger than the green (proactive) component. Included is a numerical value for the overall pro-activity index which is the ratio of the reactive actions to proactive actions. The larger the index, the more proactive is the company in generating actions to improve safety before an accident or incident occurs.

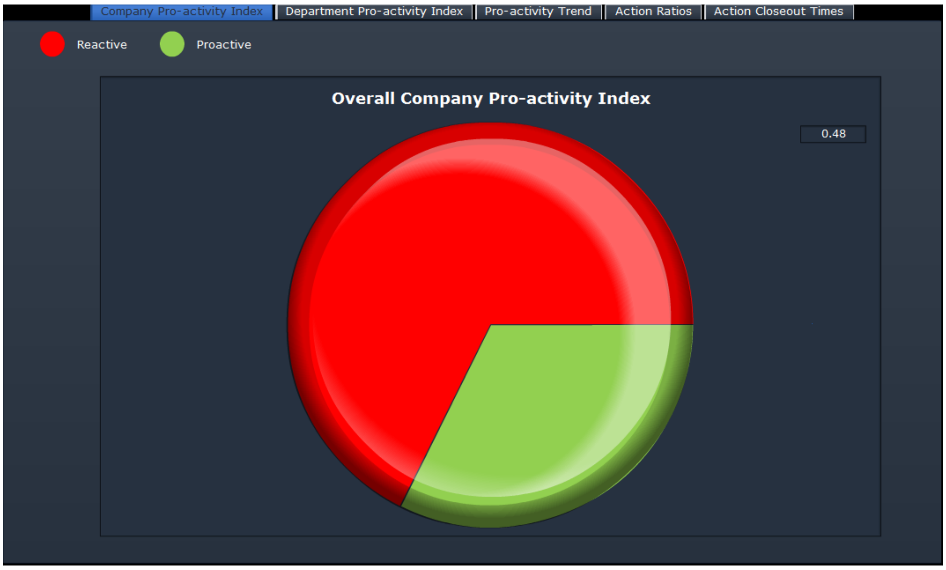


Figure 6.27 Overall pro-activity index (actions).

6.5.8.2 Departmental pro-activity index

This information on this page is identical to the information on Page 1 of the module, except that, on this page, it is broken down into individual departments (Figure 6.28). The ability to be able to identify safety culture at deeper levels in the organisation is in line with the Health and Safety Executive’s observation regarding the need to include smaller organisational divisions in understanding safety culture (thesis section 2.4, HSE 2006).

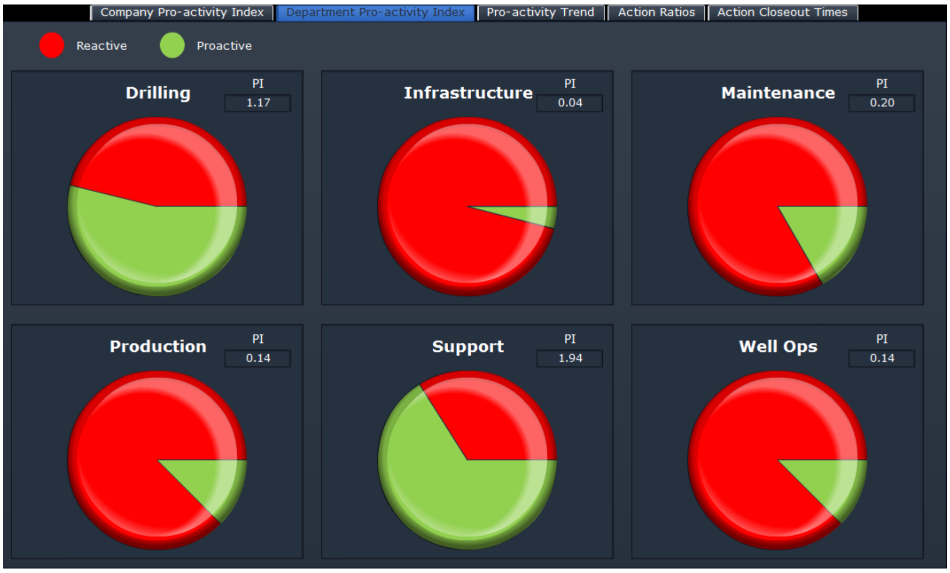


Figure 6.28 Departmental pro-activity index (actions).

This enables management to see at a glance which departments are waiting for accidents to happen versus those who are taking steps to prevent accidents before they happen.

6.5.8.3 Historical productivity index

While the instantaneous PI(A) is useful, to see whether the organisation as a whole or a specific department are proactive or reactive at any point in the session, it is also invaluable to understand whether individual departments are improving their pro-activity or otherwise. Page 3 (Figure 6.29) displays the historical plot of PI(A) for the five year duration.

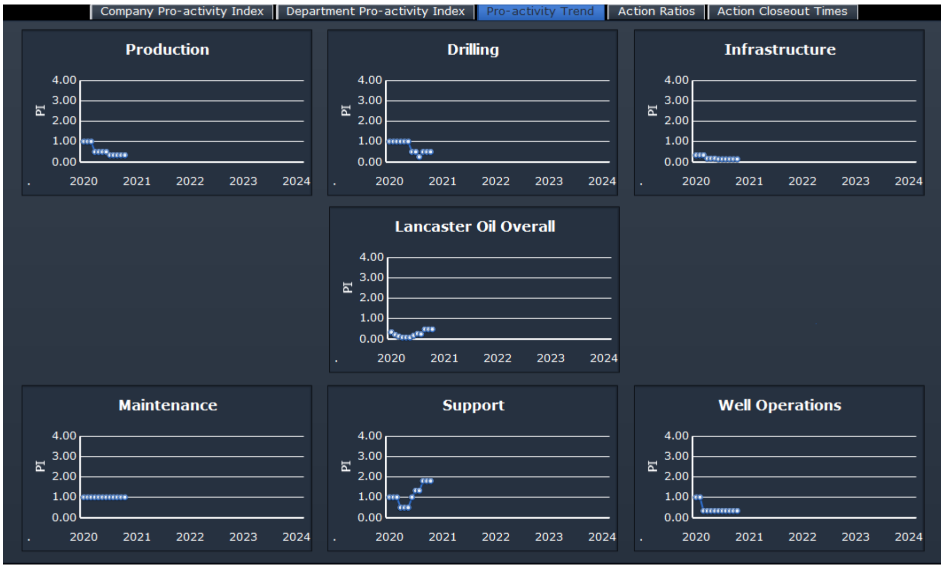


Figure 6.29 Historical pro-activity index.

6.5.8.4 Action ratios

In any action tracking system it is normal to categorise actions according to their priority in relation to improving safety. In the Lancaster Oil learning environment, actions are categorised as priority 1, 2 or 3 with priority1 being the most urgent. The fourth page (Figure 6.30) provides a breakdown of how many open priority 1, priority 2 and priority 3 actions by department are currently in the system.

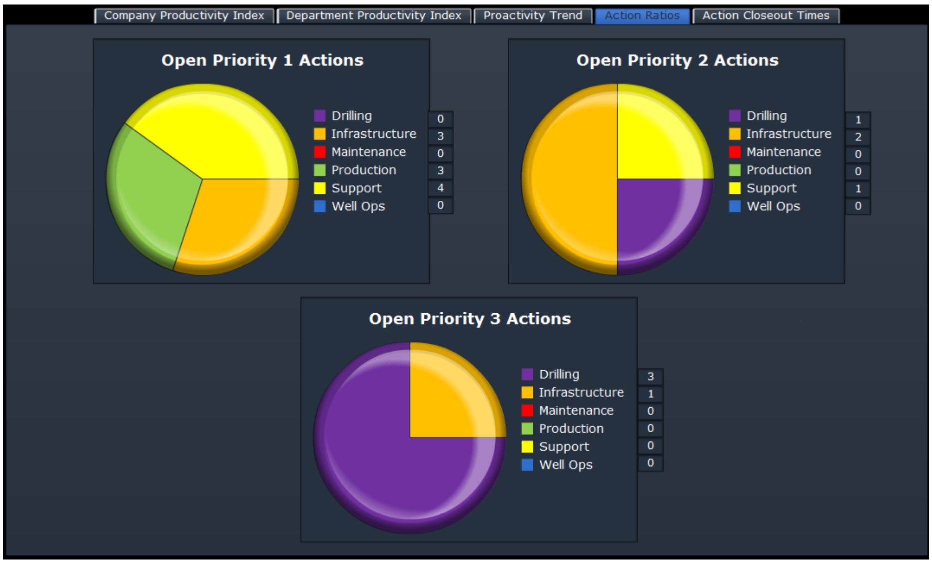


Figure 6.30 Action priority ratios.

6.5.8.5 Action close-out times

While not always true, the more proactive and committed an entity is to improving safety, the more likely it is that it will endeavour to complete actions to improve safety more quickly than others whose management may be less committed and whose safety culture may be poorer than others’. The final page in the action tracking system (Figure 6.31), located in the video wall as shown in Figure 6.32, plots how long each department takes to close out their priority 1, priority 2 and priority 3 actions.

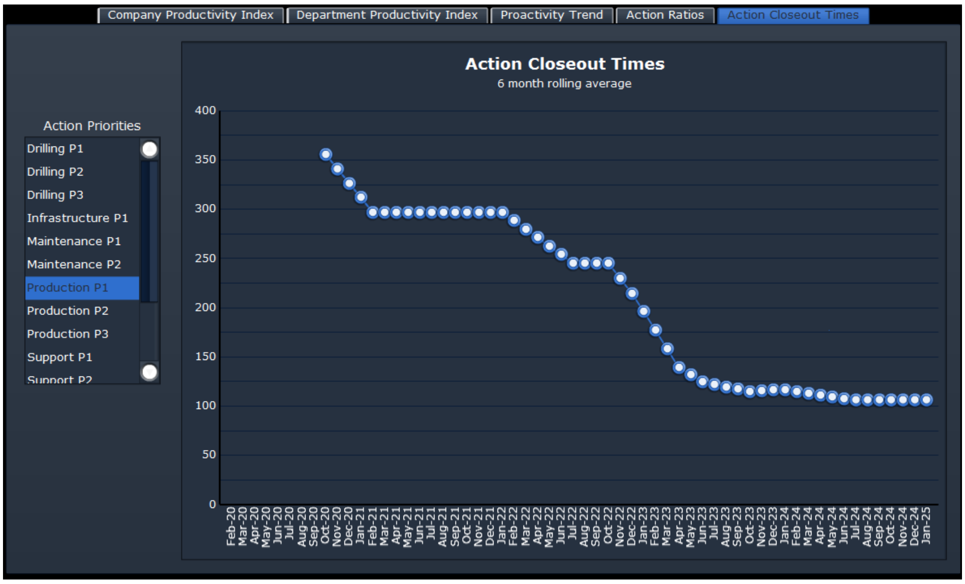


Figure 6.31 Action close-out times.

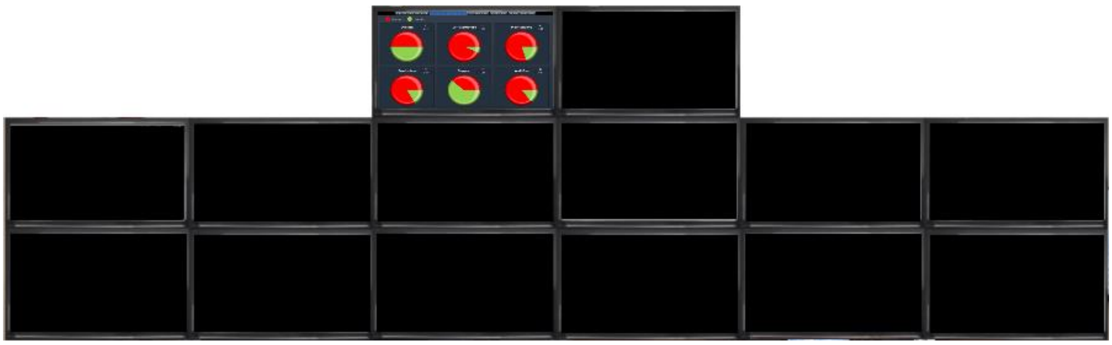


Figure 6.32 Location of action tracking screen in video wall.

6.5.9 HSE goals

At the beginning of the second year of the session time frame, a note is sent to all managers in Lancaster Oil summarising the 'presumed' agreement to implement a goal setting programme at the start of year 2. The participants are encouraged by the author in his 'educator' and 'HSE manager' roles to demonstrate management support for this sort of initiative.

Throughout the remaining 4 years of the session, the goals are updated monthly to illustrate progress and, at the start of each of years 3, 4 and 5, new goals are set where appropriate. Progress toward goal achievement (Figure 6.33) is displayed on the video wall (Figure 6.34) in order to provide participants with a quick analysis of how effective their people are in achieving organisational targets.

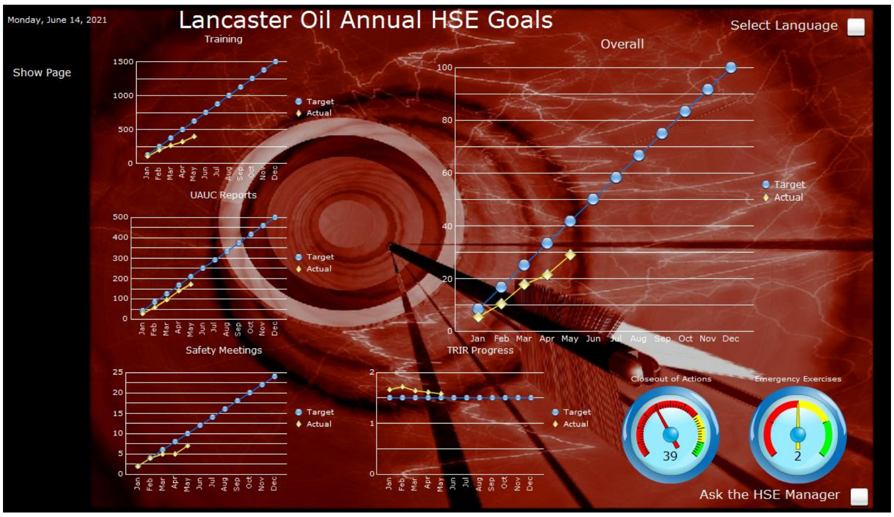


Figure 6.33 Goal achievement progress.

Figure 6.34 Location of HSE goals screen in video wall.

6.5.10 Unsafe act and unsafe condition reports

This module activates automatically at the end of the third month of the session, driven by an ongoing initiative to improve safety performance and reporting within Lancaster Oil.

6.5.10.1 Total reports received per month

The first page (Figure 6.35) presents a simple bar graph of the total number of reports received. On its own, this page provides the participant with an overview of whether the UA/UC reporting initiative appears to be working or not. In a no-blame culture, where the workforce believes in management’s commitment to improving safety and when the members are confident that reporting unsafe acts and conditions will not be punished, the organisation should expect to see a rise in reporting levels.

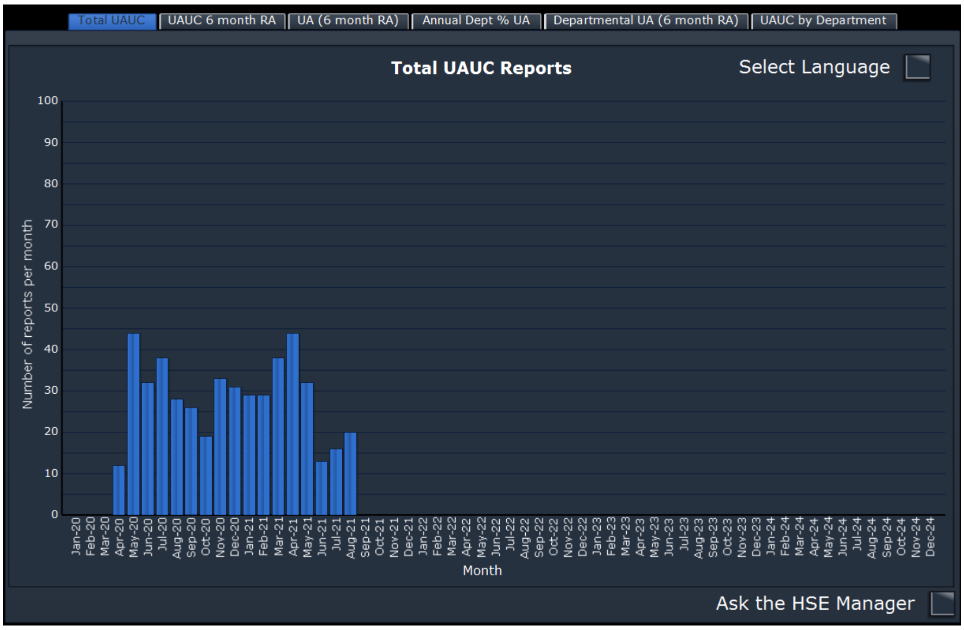


Figure 6.35 Total UA/UC reports per month.

6.5.10.2 Six month rolling average

In order to smooth out the often considerable monthly fluctuations in reports received, a six month rolling average is presented (Figure 6.36) which enables participants to obtain a better indication as to whether the reporting initiative is working or not.

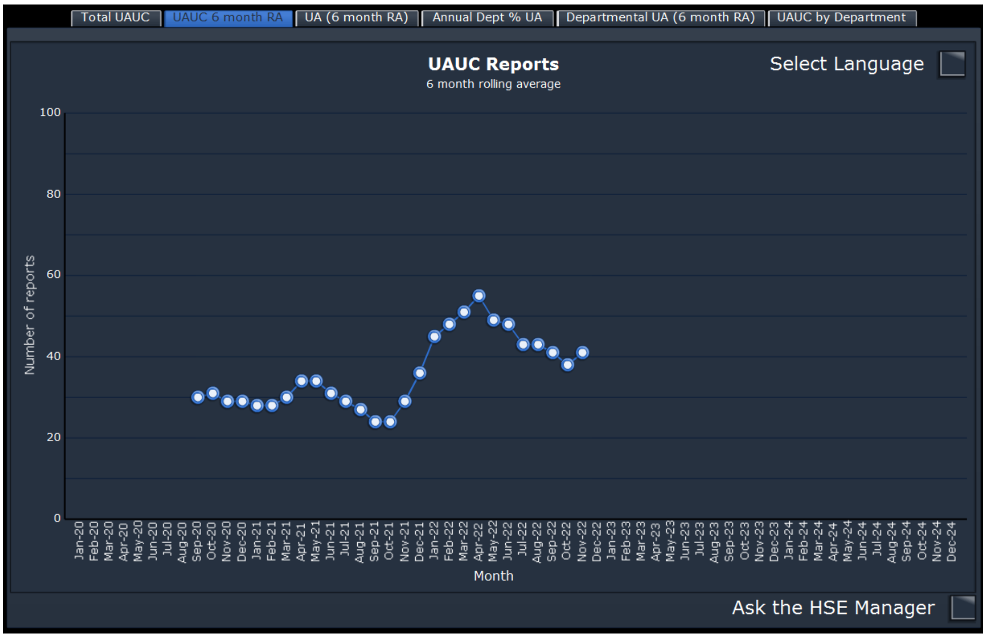


Figure 6.36 6 month rolling average of total UA/UC reports per month.

6.5.10.3 Unsafe act six month rolling average

As in the six month rolling average of total reports, smoothing the unsafe act report numbers (Figure 6.37) makes it easier for the participant to identify trends.

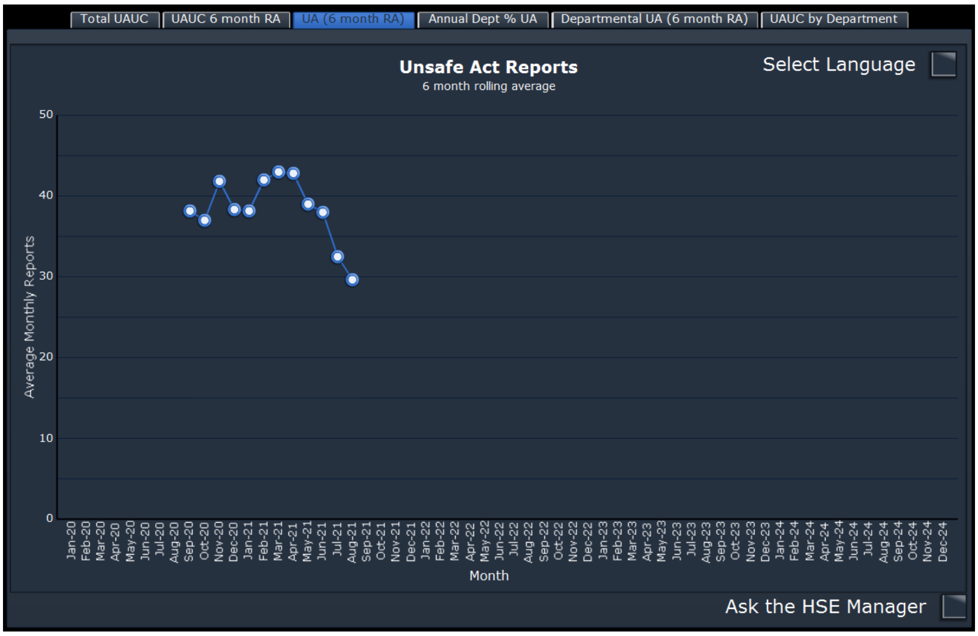


Figure 6.37 6 month rolling average of total unsafe act reports per month.

6.5.10.4 Annual department and contractor unsafe act totals

A single page summary of the annual number of unsafe acts submitted by selected individual contractors and Lancaster Oil departments (Figure 6.38) reveals individual trends over an extended time frame.

Figure 6.38 Annual unsafe act by department and (selected) contractors.

6.5.10.5 Individual departmental reports

Two graphs are presented here. The first (Figure 6.39) shows the total number of unsafe acts and unsafe conditions recorded by each department and contractor. The second displays the percentage of the total reports received which were unsafe acts. Participants are encouraged to evaluate what the combination of plots tells them about this piece of the safety culture picture.

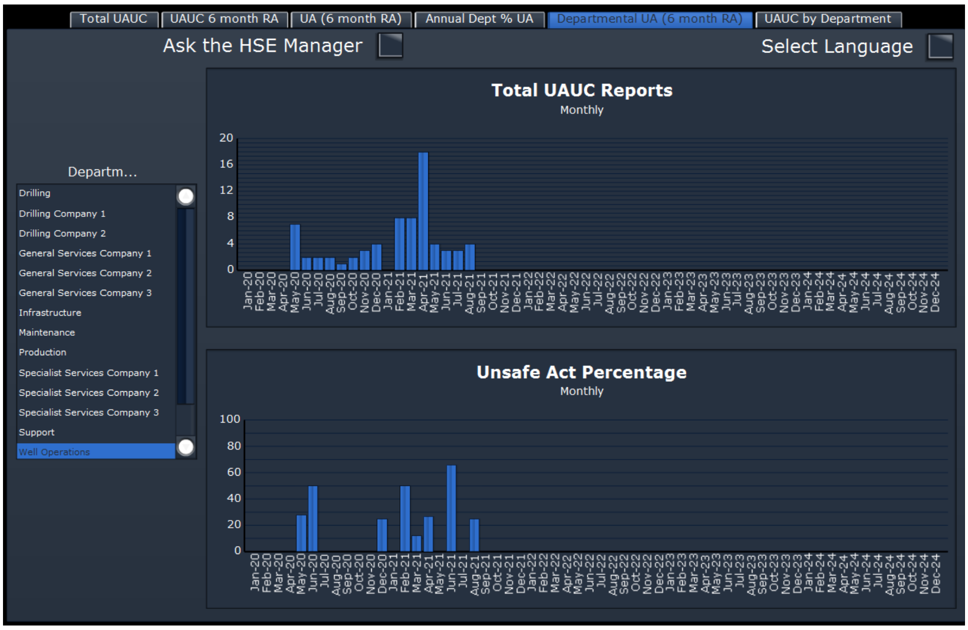


Figure 6.39 Monthly total and unsafe act reports by department and contractor.

6.5.10.6 Reports submitted by department and contractor

Finally, the sixth page (Figure 6.40) provides a simple plot of percentage of total reports submitted by each department and contractor in the form of a pie chart. The UA/UC screen is located in the video wall as shown in Figure 6.41.

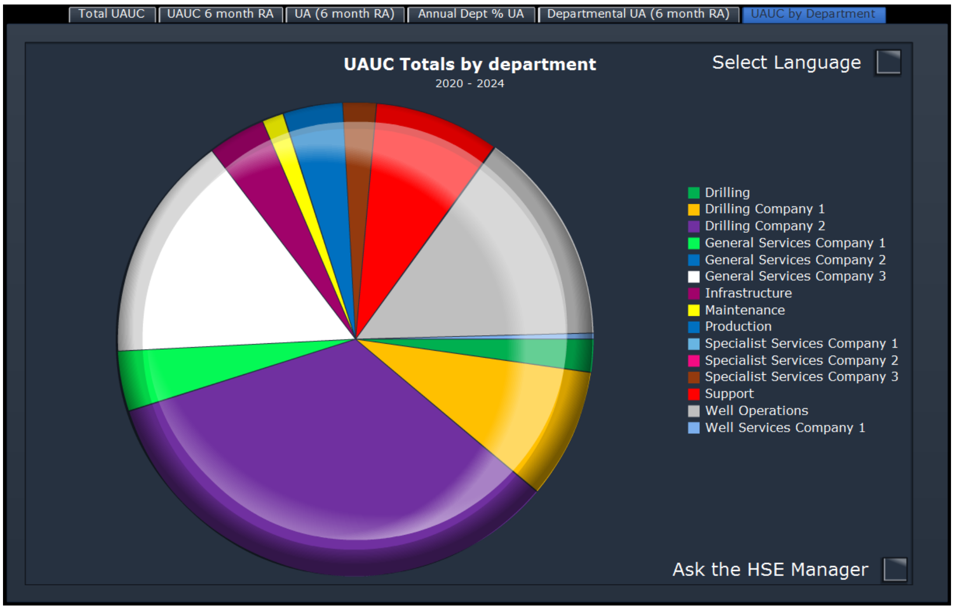


Figure 6.40 Total unsafe act reports by department and contractor.

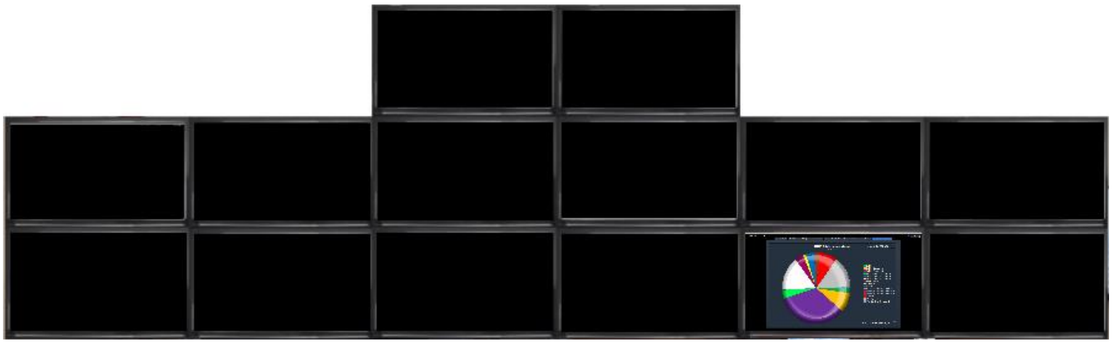


Figure 6.41 Location of UA/UC screen in video wall.

All of the information presented in the 6 pages mentioned in this section can be obtained from even the most rudimentary database of UA/UC reports. Reviewing this information can provide interesting and potentially useful pointers to possible issues within the organisation. By way of example, anecdotally, it was the author’s experience when reviewing UA/UC reports, which included the time of day, that over 90% of the unsafe acts/unsafe conditions observed occurred before midday. While this may not at first glance appear significant, when several hundred are reviewed and 90% of them concerned events/situations observed before midday, a valid question in respect of organisational safety culture might be along the lines of – ‘Why do safety observations appear to be limited only to the morning?’

A variety of authors have reported on how many accidents are caused by human error.

- *“96% of injuries and illnesses are caused by unsafe acts.”* DuPont (in USIU 2005, p. 4)
- *“88% [causes of industrial accidents] are unsafe acts of persons.”* Heinrich 1941 (in Carlton 1996, p. 18 and Manuele 2014, p. 37)
- *“Of accidents, 84% - 94% were due mainly to human error.”* (Salminen & Tallberg 1996, p. 1)

- *"80% - 96% of road accidents are said to be the result of driver error."* (Carlton 1996, p. 21)
- *"50% - 80+% of accidents according to statistics are due to human failings."* Kletz 1990, p. 1 (in HSE [2] 2012)

While the vast number of unsafe acts do not result in an accident or even an incident in most cases, the learning opportunities to the organisation are the same though without the cost in both human suffering and financial loss to the company. Various sources report the ratio of fatalities to unsafe acts ranging from NASA 1:2,000,000 (Lineberry 2012) to 1:30,000 (William Haley Engineering 2013). Regardless of the actual ratios, (which will most likely never be known with any degree of accuracy), the empirical evidence which pervades all industries operating in high risk environments is conclusive; there are many more unsafe acts than actual accidents.

Clearly, the learning available from an investigation of a 'near miss' event, which could easily have resulted in a fatality under slightly different circumstances, will reveal the same lessons for improvement as an investigation of a fatal accident, under almost identical circumstances. This highlights the importance that unsafe act/unsafe condition reporting plays in a good corporate safety culture.

6.5.11 The gauge

According to Step Change in Safety (2000, p. 2), leading indicators *"measure the inputs to the process that will affect future outcomes."* The leading indicators component is intended to present participants with a novel approach to evaluating the proactive nature of the organisation regarding safety improvement. The four pages of this element provide the participants with a top-down view of which departments in the organisation are actively delivering progress towards achieving the leading indicators that the management of Lancaster Oil has agreed.

6.5.11.1 Organisational performance

The first page presents 'the gauge' (Figure 6.42). It is the author's belief that all managing directors of organisations operating in high risk environments should have this screen available to them on a continuous basis, displayed in their offices, and duplicated around the organisation in public locations. The gauge provides the participants with a top level view of how the whole of Lancaster Oil Ltd. is delivering against its objective of 100% achievement of leading indicator targets. Compiled from the equivalent pro-activity measures for each of the individual departments, the 'Pro-activity Index (Leading)' (PIL) for the organisation as a whole provides an illustration of how well or otherwise the organisation is performing in achieving all of its leading indicators.

There are 4 key items of information provided on the page –

- Percentage progress towards 100% achievement of leading indicators (large gauge)
- Pro-activity index (PIL)
- Historical progress towards 100% target
- Improvement/worsening icon

Every month, the progress each department has made towards achieving its leading indicator targets is evaluated, consolidated and presented on the large gauge. At a single glance, the participant can see whether his company is doing well or not.

Some months, there will be more or less progress by individual departments than others and for a variety of reasons. The PIL is a summation of individual department's activity over the previous month. While snapshots are useful, a chart of historical progress allows the participant to see whether progress is continuing, reducing or remaining the same. The green (improvement) or red (worsening) icon is a simple visual indicator for the senior manager to know at a glance whether the previous month saw improvement in his organisation or not. This is a useful piece of knowledge when dealing with direct reports especially at such events as weekly meetings, etc.

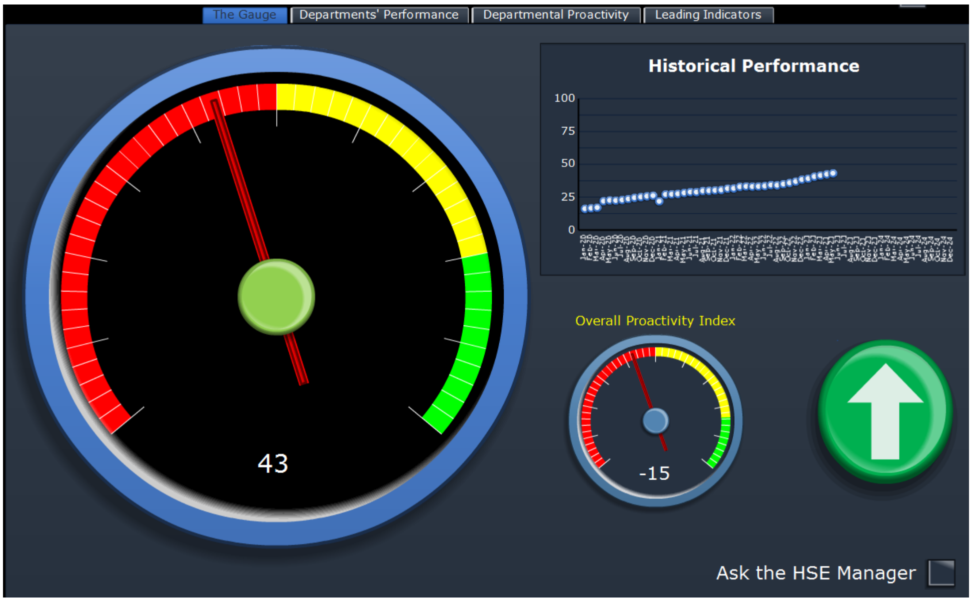


Figure 6.42 Top level gauge.

6.5.11.2 Individual departmental performance

Recalling the reference to the UK HSE in section 2.4 on departmental safety culture (HSE 2006) if participants want to determine why their organisation is not functioning at maximum commitment, they have the option to drill down to departmental level.

The second page of this data set (Figure 6.43) provides participants with the ability to look at each department and see who is performing better in terms progress towards achieving the organisation's leading indicator targets. The information presented on this screen is the same as that presented at the topmost organisational level with the exclusion of the pro-activity index which is presented on the following page for clarity of screen layout. Knowing which departments failed to improve during the previous month is a powerful tool (weapon?) at regular management meetings.

Figure 6.43 Departmental level leading indicator performance.

6.5.11.3 Individual department pro-activity

Being able to identify which department is the most proactive in terms of delivering results against corporate targets is essential. On the departmental pro-activity screen (Figure 6.44), the progress data from the individual columns are collated and presented to the participant as a set of six dials; one for each department. These dials indicate how proactive each department has been in the previous month towards delivering full leading indicator implementation.

The coverage of the red, yellow and green sectors of the 6 gauges was selected entirely randomly and does not follow any convention. For the purpose of the session, all that is important is that the participants appreciate the differences in departmental pro-activity and, in conjunction with other data screens, they begin to experience how to evaluate the individual departmental cultures as influenced by their line managers.

Figure 6.44 Departmental level pro-activity index.

6.5.11.4 Individual leading indicator targets

At the deepest level, it is important for managing directors to be aware of how well their organisations are delivering against individual targets. The final page of data in the element displays organisational progress towards delivery of each of the leading indicator targets selected and agreed by the corporate management team.

This is the most complex page in the entire learning environment; however, it reveals much about how the organisation as a whole and, more importantly, the departments in particular are working towards delivering success against every individual leading indicator selected by the organisation.

Figure 6.45 Leading indicator progress matrix.

The underlying premise of this screen is that, in an organisation which is proactive about improving safety performance, managers will have selected areas of safety that they wish to improve. It also assumes that quantifiable metrics can be assigned to these targets, otherwise, there would be no means to evaluate whether the targets have been reached and hence, no justifiable reason for having selected them in the first place.

At the beginning of the session the participant is made aware, by pre-programmed e-mail, that the senior management team has agreed eighteen leading indicators which all of the participant's departmental managers are encouraged to work towards implementing. The leading indicators page presents these eighteen indicators in the form of a 'progress matrix' (Figure 6.45). For each leading indicator, seven pairs of icons are presented. Each pair represents one of the six Lancaster Oil departments with the seventh pair being the overall status for Lancaster Oil. Each pair of icons represents –

- Progress for the previous month
- Current implementation status of each leading indicator

If progress was made by a department in the previous month then a green up arrow is displayed in the corresponding icon pair. By itself, this has the potential to be misleading, as progress can only be made against a target which has not been achieved. To address this potential confusion, a status icon forms the second icon in the pairing. In this manner, the participant can see at a glance the status of progress toward achieving all leading indicator targets by the organisation as a whole and also by individual departments. Table 6.1 shows the various icon combinations with explanation.

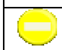
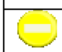
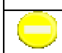
Progress Icon	Status Icon	Explanation
		The level of delivery against this item was already bad and the situation got worse over the last month
		The level of delivery against this item was already bad and the situation did not change over the last month
		The level of delivery against this item was already bad but there was some progress over the last month
		The level of delivery against this item was not that good and it got worse over the last month
		The level of delivery against this item was not that good and the situation did not change over the last month
		The level of delivery against this item was not that good but there was some progress over the last month
		The level of delivery against this item was good but it got a bit worse last month. Status is still good though.
		The level of delivery against this item was good. There was no progress over the last month. Not necessarily a bad sign.
		The level of delivery against this item was good and even more progress was achieved.

Table 6.1 Explanation of icon/status pairs.

To obtain a better visual impression of progress or status, icon toggle switches are provided for participants to hide either icons or status indicators as shown in Figure 6.46.

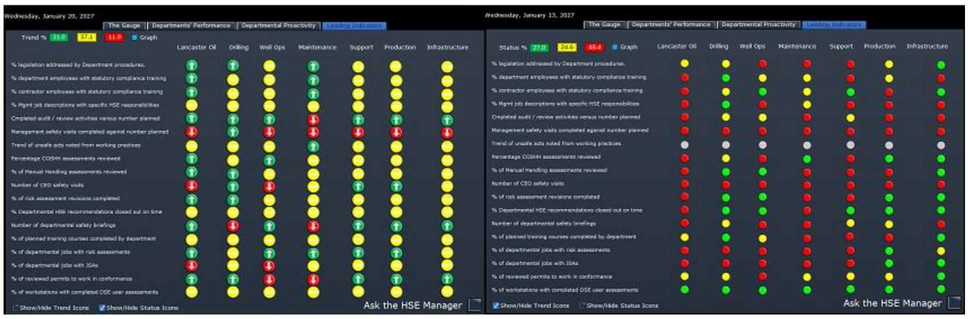


Figure 6.46 Option to display or hide icons and/or status indicators.

At the top left of the screen are 6 coloured boxes. These boxes display the percentage of each coloured icon or status indicator on the screen. In a perfect world, all of the status icons would be green and all of the trend icons would either be green or yellow. In keeping with the entire philosophy of this research project that culture is a continually evolving process, a picture of progress is also available.

Two graph toggle switches are available, one for icons and the other for the status indicators. Selecting either will produce a plot of the percentages of each icon or status indicator from the start of the session (1st January 2020 to the current date) as shown in Figure 6.47.

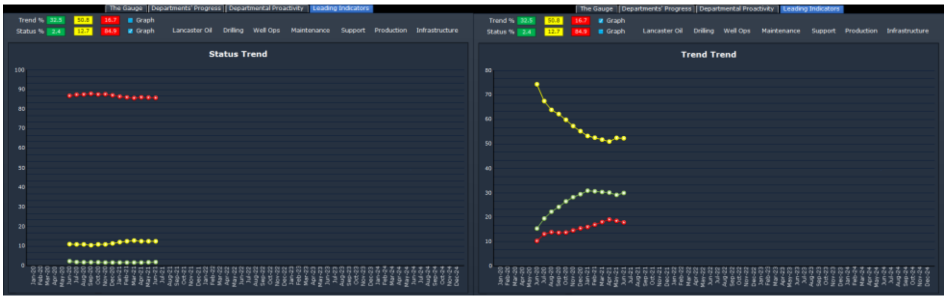


Figure 6.47 Graph of icons and status indicator percentages over time.

While an instantaneous view of the organisation is useful, looking at the changes in trends and status over time provides a valuable view of organisational commitment. If every department is progressing every month then all of the trend icons on the screen will be green. Conversely, if all of the trend icons are red, this indicates that the organisation is failing to meet its implementation objectives. By plotting the percentage of different trend and status icons of each colour, it is a simple matter to view how the organisation as a whole is progressing and where issues may lie.

From these four pages located in the video wall as shown in Figure 6.48, the participant is able to form a true picture of which departments are proactively working to improve safety from the perspective of their commitment to leading indicator activities.

Figure 6.48 Location of gauge screen in video wall.

6.5.12 HSE MS radar plot

Using the same base data as that powering the HSE MS organigram screen (section 6.5.6), this page presents the participant with HSE MS related information in the form of a radar plot (Figure 6.49). Arranged around the plot are the twenty-eight sub-elements of the Lancaster Oil HSE MS grouped into the seven top-level elements;

policy, planning, implementation and monitoring, checking and control, review, continuous improvement and audit. For clarity, each section of the radar plot is coloured differently.

As with the organigram approach, all of the calculations used in this plot are based on a rolling average of the last twelve accidents/incidents and therefore, the plot does not activate until after twelve events have occurred. On activation, a record of the initial state is shown as a thin black line which remains constant throughout the session enabling participants to see at a glance, by comparing it with the blue line showing current status, whether the contribution of a particular sub-element to accident occurrence is increasing or decreasing as they progress through the 5 years of the learning environment.

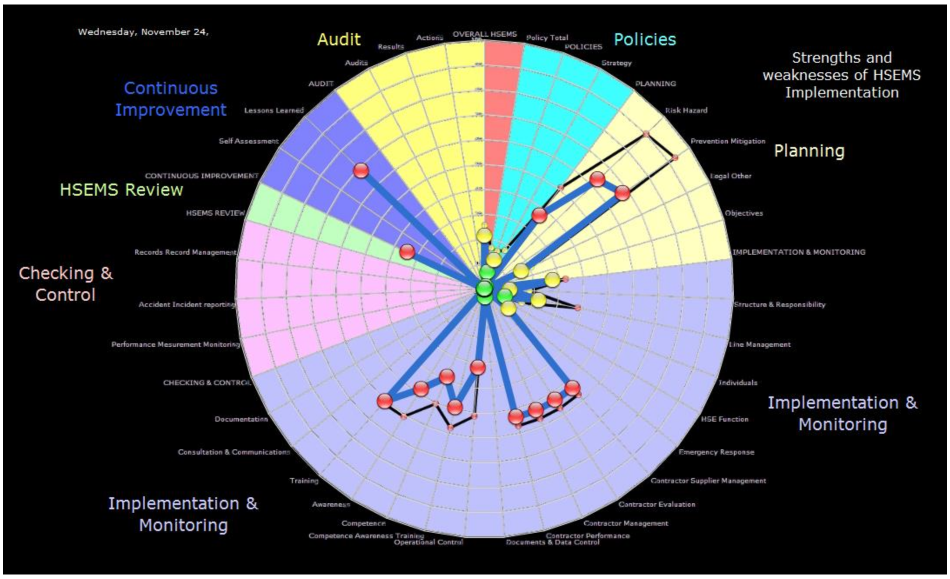


Figure 6.49 Radar plot of HSE management system deficiencies.

The HSE MS radar plot is placed alongside the HSE MS organigram screen (Figure 6.50).

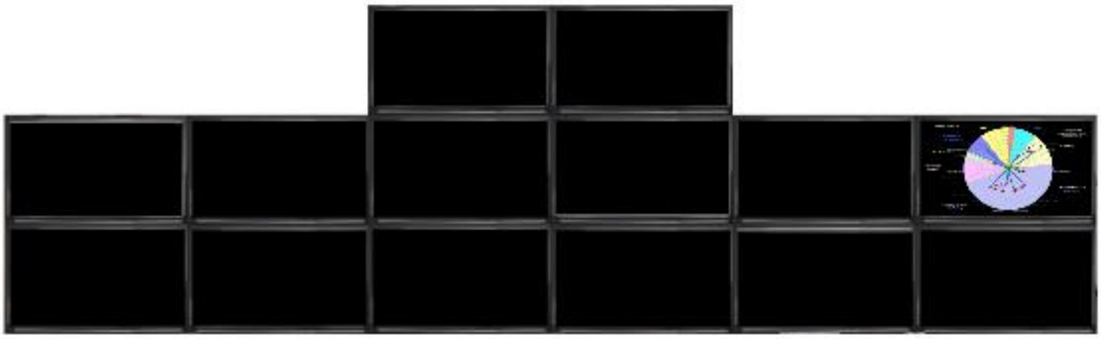


Figure 6.50 Location of HSE MS radar screen in video wall.

6.5.13 Poisson distribution

The Poisson distribution screen (Figure 6.51) is included to teach participants that the obvious answer is not necessarily the correct one and that they need to look beyond hasty conclusions based on ill-founded interpretation of the data if they are to understand what is really happening in their organisation (Cram 2007).

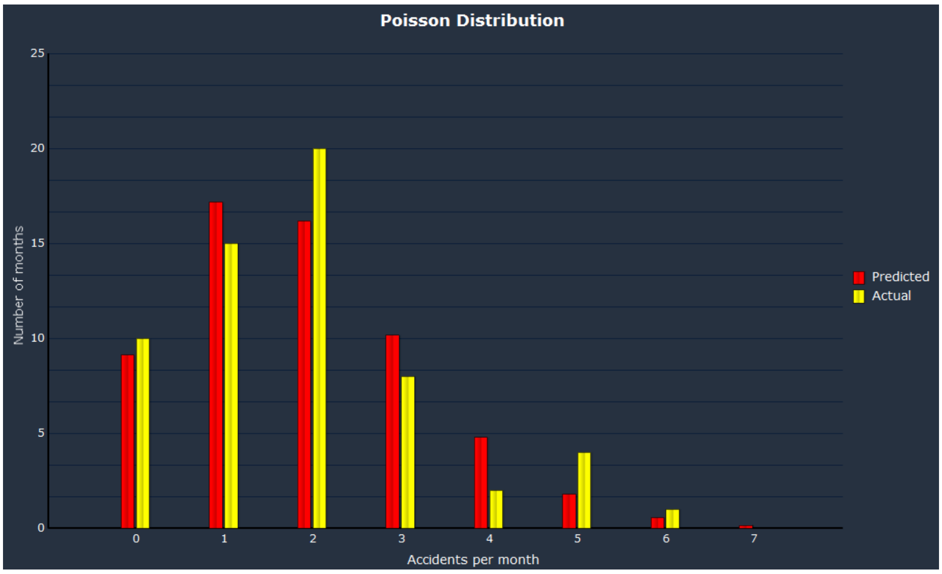


Figure 6.51 Poisson distribution of accident occurrence.

In the learning environment, the accident distribution has a period of several months when the organisation has experienced zero accidents. This is followed a short time later by a spike in accidents for a particular month. Immediately after this spike, the participant receives an e-mail from the chairman of the board asking why the company has gone from a period of five months without an accident to having the second highest monthly accident total since operations began. The participant is asked to highlight to the board how he intends to remedy the situation and return the organisation to its previous good safety performance. He is given time to consider his response which is discussed briefly and he receives a presentation regarding the Poisson distribution to illustrate the futility of attempting to address an issue which can not be solved by spontaneous and/or ill-informed actions.

Participants learn from the presentation that their data too follows a Poisson distribution and as such, they are better situated to both understand the organisation and formulate a credible response to the board.

For most of the session, the Poisson distribution screen is turned off. The program continues to run and, at the appropriate time, which is indicated by the arrival of the e-mail from the chairman requesting information, participants receive their presentation on the importance of understanding what the figures really mean. Synchronised with the presentation, when the screen is turned on (Figure 6.52), the page display is the same as that in the presentation slide.

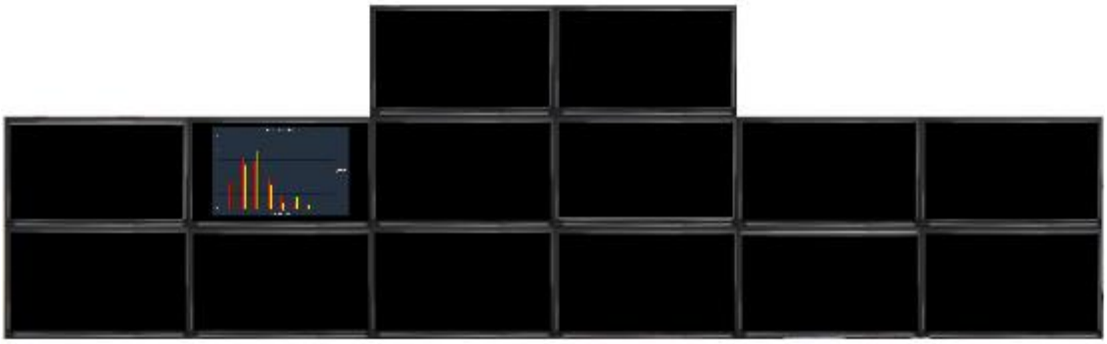


Figure 6.52 Location of the Poisson distribution screen in video wall.

6.5.14 Loughborough safety climate model

The typical approach to evaluating safety climate is to use survey questionnaires which are sent to a sample group within the organisation (Williamson et al. 1997, Havold et al. 2001, Fernandez-Muniz et al. 2009). As discussed in detail in Chapter 2, there is a great deal of research which suggests that this approach is flawed.

If the observations by Quast (2004) and Reason (2000) (discussed in section 2.2) regarding the importance of safety culture in providing a safe workplace and protecting against accidents are correct, then it should follow that an organisation with a perfect safety culture might expect to have achieved the goal of a zero accident operation. Conversely, organisations with a poor safety culture should anticipate accident incidence on a frequency which might be expected to have some relationship to the quality of organisational safety culture.

It is important to clarify that the achievement of a ‘perfect safety culture’ resulting in a zero accident work environment is more of an aspiration that a realistically achievable goal. There will most likely always be mistakes, errors and lapses which will result in undesirable events. Reason (2009 p. 71) refers to human error as *"the failure of planned actions to achieve the desired goals – without the intervention of some unforeseeable event"*. Notwithstanding, it is the author's opinion that it is important not to specify any goal other than that of a zero accident environment. To do otherwise may be construed as support for the view that 'accidents happen' and may provide line management with the opportunity to argue that their organisations have achieved as safe a working environment as they are able. Only a zero accident target should be the acceptable ultimate goal with regard to industrial safety performance. Such a goal could therefore be argued to go hand-in-hand with the need for the 'perfect' safety culture. In support of this position, a conclusion which can be drawn, is that, underlying accident root causes, is a deeper level requiring investigation, that of deficiencies in one or more aspects of an organisation's safety culture. Furthermore, if safety climate is a "*temporal state measure of safety culture"* as suggested by Wiegmann et al. (2002, p. 10) then the word 'climate' can be substituted for 'culture' in the above conclusion for any particular point in time. It is further proposed that an optimum point in time at which to evaluate deficiencies in the instantaneous state of organisational safety climate is at the time of an accident.

In most companies committed to improving safety performance, a process of accident investigation will be in place. Typically, this involves some form of root cause analysis (RCA) where investigators seek to move beyond the immediate causes and uncover the underlying or root causes which have contributed to the event. The next investigation level down looks at which elements of the HSE MS failed in order for the accident to have taken place. Proceeding even deeper into organisational influence (Figure 6.53), a Climate Deficiency Analysis (CDA) can be used to identify where deficiencies exist in organisational safety climate which permit HSE MS failures to occur.

Figure 6.53 Post event levels of investigation.

Many different questionnaire-based safety climate surveys exist (Bureau of State Risk Management 2013, CAMTS 2012, Elgood et al. 2004, Government of New South Wales 2012, Loughborough University 2000, University of Texas at Austin 2003). For the purpose of developing the safety climate module of the learning environment, questions selected were adopted from the work done by Loughborough University (2000) and the UK Health and Safety Executive. These were subsequently divided into similar categories to those identified by Cox and Cheyne (2000) although the number of categories was reduced to the following list to simplify the module for the participants -

- Management commitment
- Priority of safety
- Communication
- Safety rules
- Supportive environment
- Involvement
- Personal priorities and need for safety

The typical OHSAS 18001 based safety management system (Appendix 1) was used as the basis for the climate deficiency analysis.

The first step in developing the safety climate model was to created a matrix. On one side of this matrix were the individual elements of the Lancaster Oil safety management system and on the other, the questions from the Loughborough safety climate measurement toolkit. Each question from the toolkit was considered in turn, and wherever there was a relationship to an element in the safety management system, a non-weighted score of one point was assigned. This was a many-to-many mapping as many elements of the Lancaster safety management system mapped onto many different Loughborough safety climate questions.

A management system failure analysis had already been carried out in order to develop the HSE MS modules of the SCLE and these analyses were used to produce the CDA. Whenever a management system failure element was identified, all questions from the Loughborough safety climate toolkit which had been mapped to that particular element were assigned a score of 1. At the conclusion of the analyses, each relevant question had a cumulative score relating to the frequency with which they were implicated in the appropriate management system failures.

By combining the scores generated by each accident for each of the Loughborough safety climate categories over a rolling 90 day average, it was possible to present the participants with ‘real-time’ plots of the criteria most influencing current safety climate. Two plots were produced. The first presented the results (Figure 6.54) in the same radar plot presentation style used by Cox and Cheyne (2000).

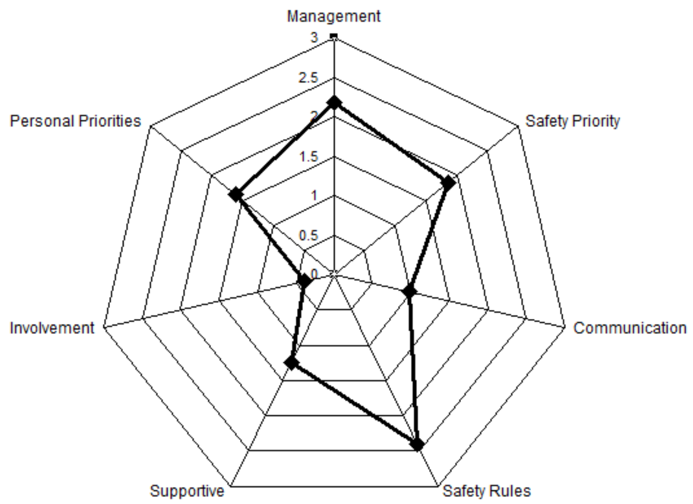


Figure 6.54 Radar plot of instantaneous safety climate elements.

An important point to note here is that, unlike the management system failure analysis described in section 6.5.6 which averaged values over the previous 12 accidents, the safety climate calculation averaged values over a period of 90 days. The rationale behind this decision is that time is a component in the consideration of safety culture/climate and so needs to be included in any calculation relating to this metric. In other words, the longer the time between accidents, the better the safety culture.

A metric referred to as the 'safety climate index' was produced by calculating the area of the radar plot bounded by the seven elements of the climate deficiency analysis. This provided participants with a simple numerical indicator to identify whether safety climate had improved or worsened over the preceding time period. The lower this number, the more improved the overall safety climate of the organisation.

The second plot (Figure 6.55 – left side) presents the same individual safety climate elements in the form of a line chart illustrating safety climate changes over time. This enables participants to see real changes over time in the various aspects of their organisation's safety climate, and for them to link this information with the other 13 modules in the SCLE in order to derive a clearer picture of the prevalent overall safety culture with their operations.

Finally, for each topic of the safety climate an icon indicating whether there had been an improvement or worsening since the last update was included. As with the indicators in other modules, the inclusion of such indicators offers an opportunity for the manager seeking to continually improve safety performance to focus on the areas which are not getting better rather than adopting a broad strategy in the hope that issues will be caught up in broad-reaching action.

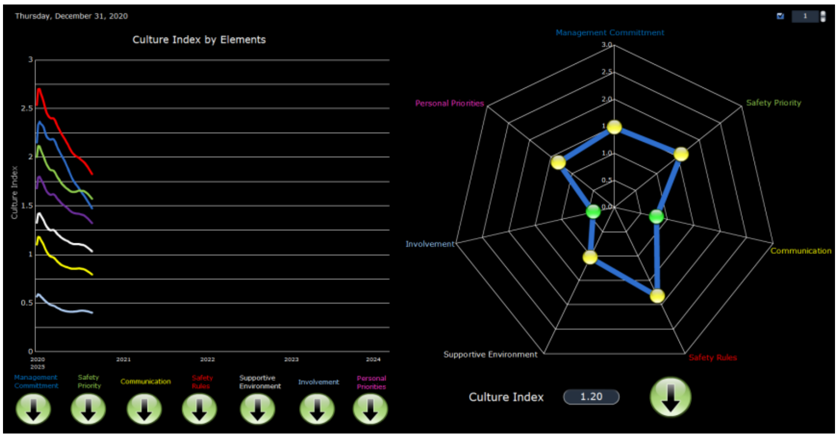


Figure 6.55 Safety climate screen.

The safety climate screen is located in the video wall as shown in Figure 6.56.

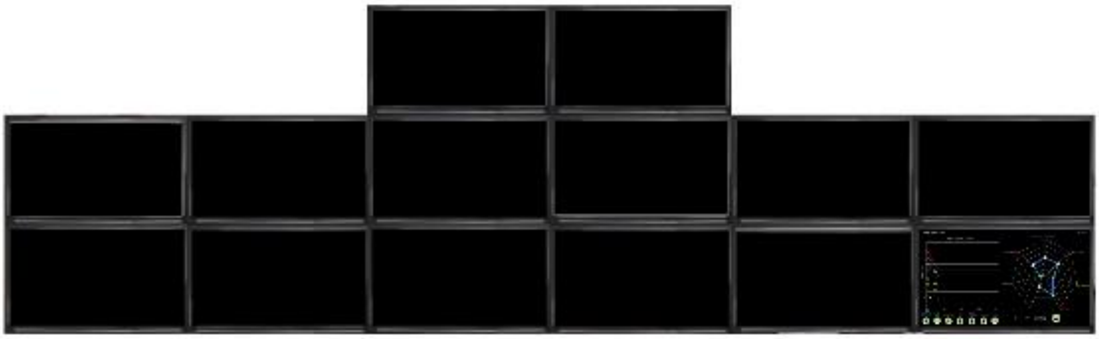


Figure 6.56 Location of the safety climate screen in video wall.

6.6 Online assistance

In addition to his function as educator, the author role played two positions within Lancaster Oil Ltd. namely those of chairman of the board and the participant's HSE manager. It was this latter position that resulted in the idea of incorporating context sensitive avatars to provide help and information to the participants on every one of the 54 pages of the learning environment.

Help information was written on what each page of data was designed to show and about the particular safety topic being reviewed. This information was then programmed into an animated audio-visual avatar which could be activated at any time by the participant by clicking on a toggle switch on the data screen. If selected, an animated avatar appeared and spoke to the participant using commercially available, highly realistic text to speech technology to provide context sensitive help and information. Where required, an optional menu of pre-programmed questions that participants could ask was included. Two examples of different avatars are shown in Figures 6.57 and 6.58.

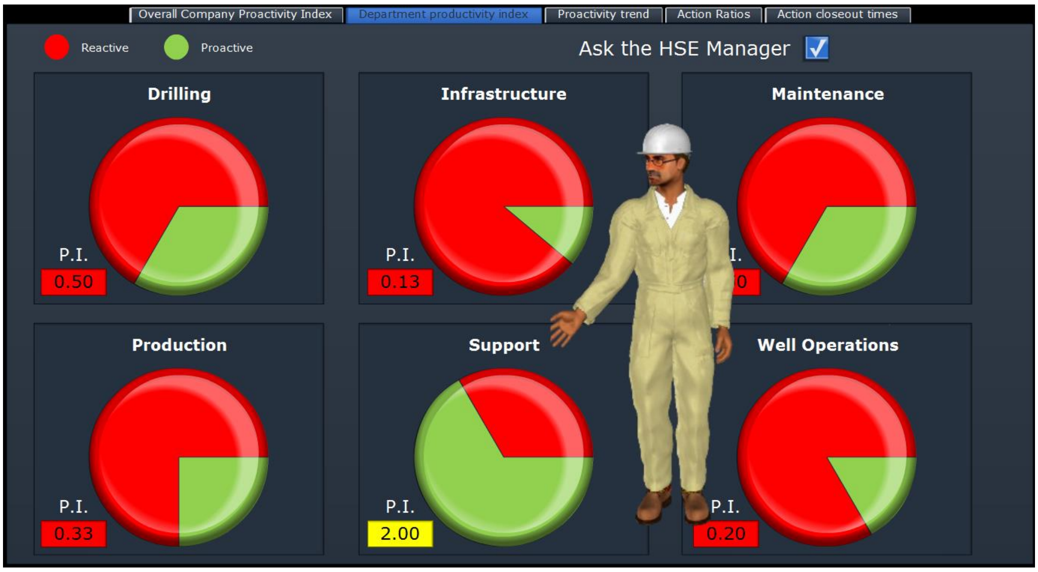


Figure 6.57 Example of online HSE avatar.

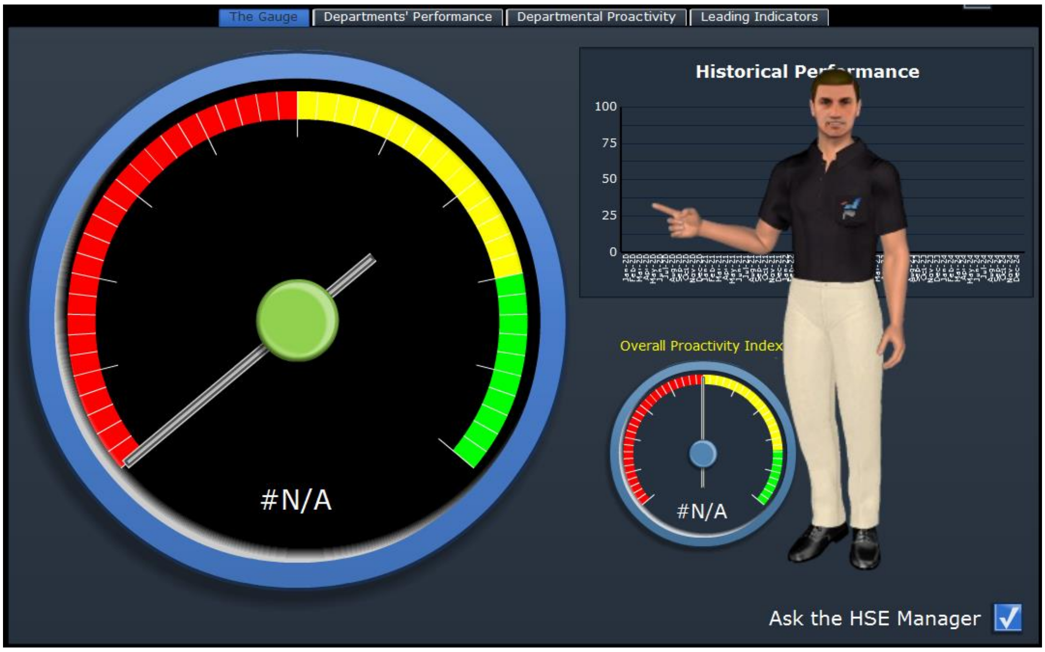


Figure 6.58 Second example of online HSE avatar.

Interestingly, not a single user ever accessed the online HSE manager facility. It is unclear whether this was due to a lack of interest in avatar technology, the fact that the educator was there as a living HSE manager or whether they were so busy absorbing information that they forgot it was available despite a screen prompt telling them how to access the avatar. During the debrief interviews, the general response was along the lines of ‘I never thought about it’. As this facility was incorporated more for its curiosity value rather than as a key aspect of the research project, no further investigation was carried out.

As mentioned in section 5.17, effective communications and discourse are essential components of a transformative learning environment. While not germane to this specific project, as all participants were native English speakers, the opportunity to explore whether it was feasible to produce an effective multi-language version, as a vehicle to explain complex concepts to non-English speaking participants, was not squandered. The facility to change (during a live session) the language of the learning environment using an on-screen menu was developed and implemented. The avatars were also programmed to deliver their verbal information in any of 6 test languages. Given that the participants were all native English speakers, this facility was not brought to their attention but a successful ‘proof of concept’ test was carried out.

6.7 Summary

A rapid prototyping approach was adopted as the most appropriate mechanism to construct the learning environment given the size of the project and the available time-scales. Commercially available tools were used at every stage of the project to avoid the need for software testing which, from the author’s experience as an IT consultant, can often be an exceptionally time-consuming process. This proved to be the correct choice as it enabled the learning environment to be built and tested in less than a year. Given the immense amount of data that was incorporated into the system (over a quarter of a million items) and the testing and validation of the graphs and charts that was required, any other approach might not have been able to deliver this research project in the available time.

While the actual data used in the project itself did not represent any particular form of expertise, the knowledge contained within the data, in the form of patterns of occurrence and relationships with other data sets, did require training in order to be able to interpret the overall safety culture picture.

The use of a video wall to convey the information rather than a single computer running 14 different applications was deemed essential to enable the participants to review different pages from different modules simultaneously in order to get a better interpretation of the overall picture of safety culture. Using a single screen (or at best 2) from one computer, while reducing the cost and the footprint of the project would have significantly reduced the effectiveness of the training experience.

Much thought went into the actual time required to run the learning environment. The speed at which the learning environment could be set to run was technically easy. The key question was how long the participants would be able to maintain their level of interest and concentration. The selection of 8 hours was eventually selected as the most appropriate, not least because it was considered unlikely that the intended audience for such a teaching tool, being senior management, would give up more than one day. A shorter session would not have provided enough time to make presentations, write reports, receive presentations or hold discussions with the trainer.

The actual number of pages and data screens fell naturally out of an analysis of the available data. Certainly, it would have been possible to add more data, for example, leak reports which do give good indications of operational integrity issues. The 14 modules, however, with their 54 pages of graphs and charts were considered a good balance between data provision and the risk of cognitive overload (Kirsh 2000).

The incorporation of online help facilities illustrated that the participants preferred to talk to the facilitator rather than interact with the data screens. Given the natural desire of humans to talk to each other, this is not really a surprising result. The inclusion of the avatars was solely for its curiosity value and did not form part of the research project. It is mentioned here for exactly the same reason.

Finally, the design of the session needed to address the possibility of the entire session becoming a passive experience for the participants where they simply studied data on the screens and commented on it in reports. The inclusion of e-mail communications, the need for reports and for giving and receiving presentations all increased participant involvement in the learning experience in addition to facilitating the absorption of knowledge throughout the session.

Chapter 7 Data analysis

Yin (1994, p. 20) observes – *"...you should bring your own prior, expert knowledge to your case study. …… If you know your subject matter as a result of previous investigations and publications, so much the better."* Such is the case here. The author has spent much of the last 25 years analysing and evaluating safety data, most of the time from perspectives not previously considered. In addition, his HSE experience coupled with a background in both the upstream oil and gas industry as a petroleum engineer and as an IT/knowledge based systems engineer have provided a skill set which contributed much to the evaluation of the participants during their learning experiences and subsequent evaluation of their performance.

A case study was determined as the most appropriate methodology to establish how effective the learning environment is in improving participants' abilities to assess the underlying safety culture of an organisation. An evaluation approach was incorporated into the case study where appropriate, i.e. in instances where a quantitative measurement was possible and where such an approach would assist in identifying whether actual improvement in participants' knowledge had been achieved.

There are instances in such evaluative elements where comparisons are made between 'highest'/'lowest' or 'top'/'bottom'. There are no industry benchmarks against which the scores by groups in different elements can be compared. The SCLE is a novel concept and thus no prior equivalent data exist to enable a direct comparison with industry 'norms'. As such, any reference to terms such as 'top' or 'bottom', etc. should be treated solely as comparisons within the groups who participated. Similarly, there is no particular significance in terms of the magnitude of the difference between expressions such as ‘highest’ or ‘lowest’. These terms are used to identify the ranking rather than address any particular significance to the differences themselves.

In total, 17 participants took part in the research. The distribution and experience level of each participant is presented in Table 7.1.

Participant	Discipline			Sector		Seniority		
	HSE	Finance	General	Oil	Non-Oil	Senior	Middle	Junior
1	X			X		X		
2			X		X	X		
3			X		X	X		
4			X		X			X
5		X			X			X
6		X			X	X		
7	X			X			X	
8	X			X		X		
9			X		X		X	
10	X			X			X	
11	X			X				X
12			X		X			X
13			X	X			X	
14		X			X		X	
15	X			X			X	
16			X		X			X
17			X	X			X	

Table 7.1 Distribution of participants by discipline, sector and seniority.

For each of the participants, the following information was recorded -

- Individual audio-visual material
- Screen importance perceptions
- All inter-departmental e-mail traffic
- All annual reports
- Pre- and post-session interview records
- HSE manager job profile modifications
- Participant score of SCLE usefulness as a teaching tool

From these records, the total quantity of material available which was extracted and available for analysis was –

- 136+ hours of audio-visual records
- 17 screen importance perceptions
- 314 e-mails (excluding annual reports)
- 85 annual reports
- 34 interviews (2 each)
- 17 HSE manager job profiles

The evaluation phase was broken down into several discrete approaches -

- Analysis of video information pertaining to data component access
- Analysis of video information in respect of duration of display
- Analysis of individual e-mails with regard to safety culture recognition
- Analysis of annual safety culture reports to determine a participant's improved interpretation skills
- Analysis of job profile to establish change in beliefs regarding appropriate job skills for HSE managers
- Comparison between perceived screen importance versus actual usage
- Evaluation of participant usefulness scores

In accordance with Figure 4.6, each of the data sets acquired from the sessions was classified according to the 4 data components identified –

Field observation
- Audio-visual records

Documents
- E-mail traffic
- Annual reports
- Job profiles

Interviews
- Pre- and post-session interviews

Statistical data
- Screen importance perceptions
- Participant feedback
- Perceived usefulness

As discussed in section 4.3.2, the ‘unit of observation’ for the project is each of the participants. While there is little to be gained by evaluating their performance individually, as illustrated by the graph in Appendix 7, when the individuals are organised according to their professional discipline, background and seniority, the analysis of these groups (unit of analysis) does provide the optimum basis for evaluation of the effectiveness of the SCLE as a teaching tool.

Eight groups in 3 different categories were identified and each participant was included in each of the three categories: discipline, background and seniority (Table 7.2). It should be noted that the categories were not part of the analysis/evaluation, they merely served to organise the 8 groups.

Category 1 - Discipline	HSE	Finance	General Industry
Number of Participants	6	3	8
Category 2 – Background	Oil Industry	Non-Oil Industry	
Number of Participants	8	9	
Category 3 - Seniority	Senior Management	Middle Management	Junior Management
Number of Participants	5	7	5

Table 7.2 Participant numbers by group.

7.1 Data component access

Using a commercially available video editing toolkit each session video was reviewed to the nearest second. To facilitate analysis, the actual learning environment time of 5 years (8 hours) was broken into 1 year intervals. A year of learning environment time therefore equated to 1 hour 36 minutes of session time.

A screen copy of a typical analysis exercise is shown in Figure 7.1. There are 54 individual pages of data in the learning environment. At any time, any of these 54 pages might be displayed on one of the 14 monitors. When a page was displayed, a marker was placed on the time-line at the moment the page display began. When that particular page was replaced by a different page on the same monitor, another marker was placed to indicate that the original screen was no longer visible and the process was repeated for the new page. The sum of all the display periods could then be added to provide a total display time for each of the 54 pages of data.

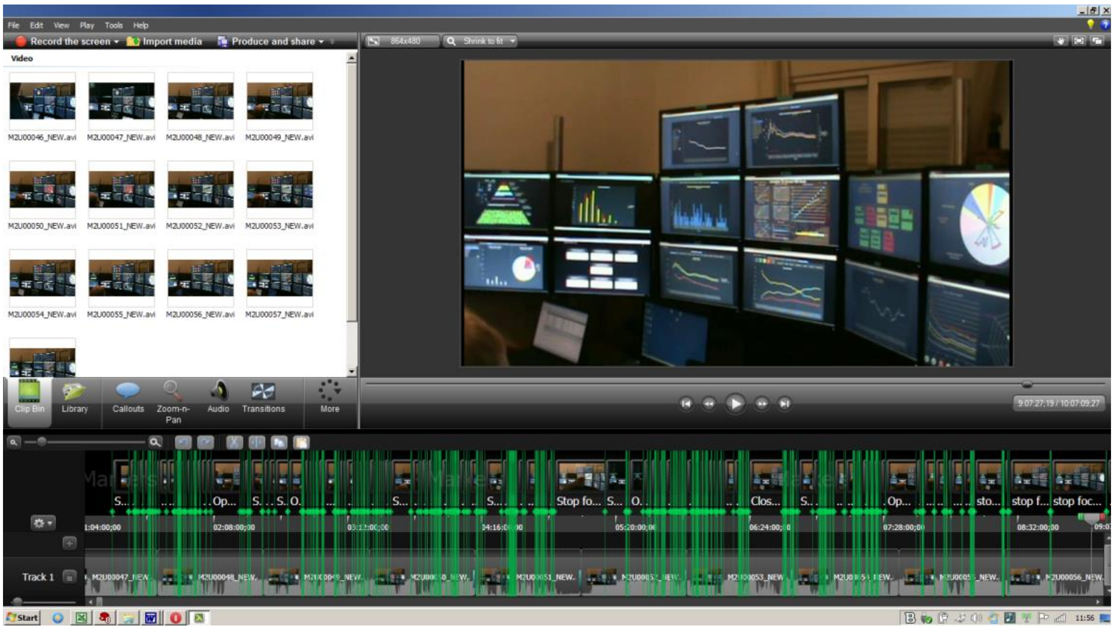


Figure 7.1 Example from video analysis exercise.

It was normal for pages to be displayed even though the participant was examining other pages and so a second set of markers was used to indicate when a particular page became the focus of the participant's attention and when focus shifted to another page. At the end of the 136 hours of audio-visual records, 4 items of information were identified for each participant and thus, when consolidated, for each group. The information obtained was –

- Number of times a particular page was displayed
- Total time a particular page was displayed
- Number of times a particular page was the focus of the participant's attention
- Total time a particular page was the focus of the participant's attention

An example of the information collected is given in Appendix 6. Analysing these data provided an excellent source of distraction. In total, over 8,000 observations were made of the frequency and distribution of the different screens for each of the 8 groups. Graphs were made of such topics as –

- Length of time a page was on display
- Length of time a page was the focus of attention
- Total number of times a page was on display
- Total number of times a page was the focus of attention
- Number of times per year each of the pages was on display
- Number of times per year each of the pages was the focus of attention
- Average length of time a page was on display over the 5 years
- Average length of time a page was on display each year
- Average length of time a page was the focus of attention over the 5 years
- Average length of time a page was the focus of attention each year

What was apparent at the end of this extensive analysis was that there was nothing useful to be learned other than the lesson that this had been an exercise in futility in this particular instance.

Every participant used the tool in a different manner. In addition, during the frequent discussions with the educator during the session, the video wall was often used to facilitate the ongoing conversation. Even when the discussion was over, many of the participants reviewed the data to which they had been referring after the conversation was over. This meant that, indirectly, the educator was actually influencing the usage of the data screens. Given that there was an extensive ongoing dialogue between the participant and the educator in his varied roles as educator, HSE manager and chairman of the board, and not always on the same topics, attempting to extract the participant's personal use of the video wall was deemed to be a pointless exercise.

The conclusion concerning this data set is that, while it may appear important at the outset of the investigation, the reality appears to be that there is little or any useful information that can be derived from it to indicate whether an individual has learned more about how to evaluate the safety culture of their organisation or not.

This does not mean that investigating how people use tools such as video walls to learn is not a worthwhile pursuit in itself. The knowledge gleaned by studying this data may well have an application in understanding how best to construct such facilities and how different personalities, backgrounds and experience levels access and use the information during their education process. A suggestion for future research is provided in Section 8.2. For the purpose of this research project, however, no useful insights were obtained by conducting this analysis. Indeed, there was a risk that further exploration of such an apparent treasure trove of quantitative data might detract from the true objective of the research which was to determine if the SCLE was an effective answer to research question 1 and not how participants used a particular technological presentation.

7.2 Screen importance perceptions

At the end of each session, participants were asked to complete a grid mimicking the video wall to state which screen they thought had been most important to them. The first participants scored the grid by entering a 1 for the screen they felt had been the most useful down to a 14 for that which was the least useful in their opinion. It would have been much more intuitive had they given a score of 14 to the screen they found the most useful and a corresponding 1 to the least useful as this would have resulted in the case of - the bigger the consolidated score, the more important/useful the data.

However, since the first sets of scores were all ranked with ‘1’ for the most useful screen, subsequent participants were asked to score the screens using the same ranking. Given that the actual numerical scores do not in themselves carry any weight other than by way of classification, this was deemed a reasonable approach and a simple colour coding approach was adopted to highlight the results. Had there been 15 screens in the video wall, it would have been a simple matter to rank the screens in three groups – most important, medium importance, least important. With 14 screens, a bias was inevitable. Two options appeared the most ‘sensible’ – a 5:4:5 ranking (most important : mid-importance : least important) versus 4:6:4. The first option produced the most even distribution and so was adopted for all of the groups’ perceptions. The screens with the 5 lowest (indicating most useful) scores were coloured green, the highest (indicating least useful) 5 scores were coloured red and the 4 middle scored screens were coloured yellow.

The results for the groups are presented in Figures 7.2 – 7.4. A reference diagram identifying each screen in the video wall is included to facilitate data set identification.

7.2.1 Screen importance grouping by professional discipline

For each of the screen perception figures (7.2-7.5 and 7.7-7.8) a layout screen is included for clarity. The 14 screens in the SCLE are, from left to right and top to bottom -

Action Tracking - (Actions)
Department or Contractor Influence – (Dept. Cont.)
Accident Triangle – (Triangle)
Poisson Distribution - (Poisson)
Accident Occurrence – (Accidents)
Annual Goals - (Goals)

Safety Management System (organigram) – (SMS Org.)

Safety Management System (radar plot) – (SMS Radar)

Training Records – (Training)

Man hours - (Man hours)

Total Recordable Injury Rate – (TRIR)

Leading Indicators – (Lead. Ind.)

Unsafe Acts/Unsafe Conditions – (UA/UC)

Loughborough Safety Climate (Climate)

The first analysis of the screen importance perception was conducted with the participants grouped by their professional discipline. This broke down into health, safety and environment (HSE), finance and general industry professionals. The numbers in each set were HSE - 6, finance - 3, general industry – 8. The perception rankings of each group are shown in Figure 7.2.

		Actions	Dept. Cont,		
Triangle	Poisson	Accidents	Goals	SMS Org.	SMS Radar
Training	Man hours	TRIR	Lead. Ind.	UA/UC	Climate

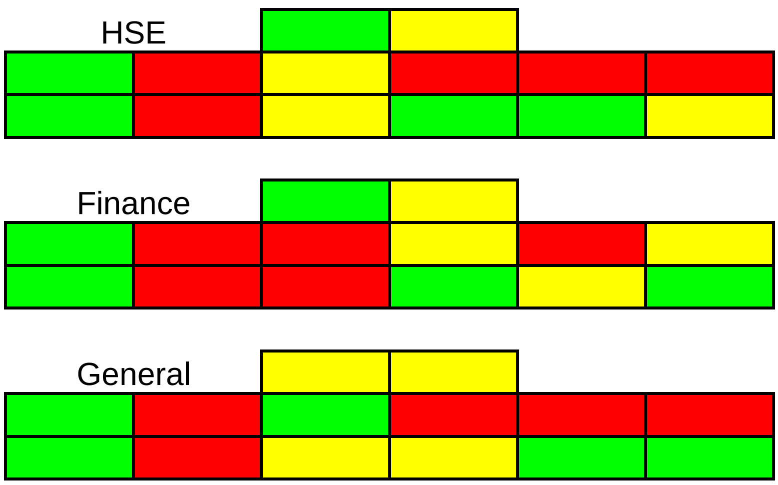


Figure 7.2 Screen importance by discipline groups.

Several interesting facts emerge from this grouping. Most notable, is the agreement across the groups that the Poisson distribution and man hours since last lost time accident are two of the least useful screens. In the case of the Poisson distribution this is not a surprise as it was only presented to the participants in order to teach them the importance of understanding the true picture in terms of accident frequency distribution within their organisation before rushing into potentially harmful action. Given that the man hours since last lost time accident is so frequently displayed at worksite entrances and in reports, it was notable that participants universally ranked this screen the least important of all in the learning environment. It would appear that that particular message had been successfully communicated.

All three groups agreed that they found the training and accident triangle information of most use in evaluating safety culture. The action tracking, leading indicators, UA/UC and continuous safety climate data sets featured as most important by 2 of the 3 groups. Interestingly, none of the groups agreed about the importance of the accident distribution information. A major surprise was the broad dismissal of the information being provided on the 2 management system screens. Rated lowest, on average, by both the HSE specialist group and the general management group, the HSE MS radar plot was only rated as of medium importance by finance group participants, again, on average.

7.2.2 Screen importance grouping by industry sector experience

The second group comparison was organised according to whether the participants came from an oil industry or non-oil industry background (Figure 7.3). The learning environment was designed around an operating oil company and it was important to establish whether this appeared to have influenced participants who had no experience in this type of environment. Grouping the participants in this manner resulted in 8 participants from an oil industry background and 9 from other industry sectors.

		Actions	Dept. Cont,		
Triangle	Poisson	Accidents	Goals	SMS Org.	SMS Radar
Training	Man hours	TRIR	Lead. Ind.	UA/UC	Climate

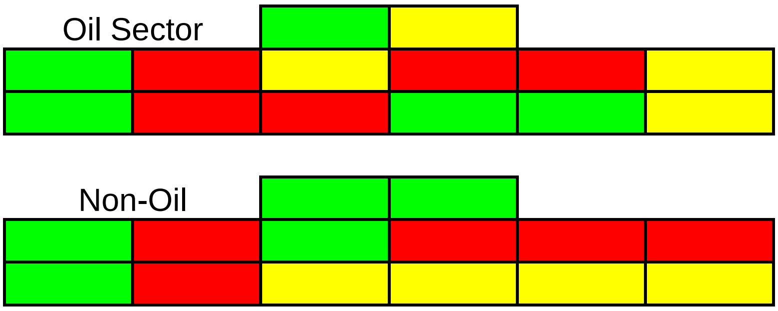


Figure 7.3 Groups by industry experience.

As with the discipline groups, the participants grouped by industry experience also regard the Poisson distribution and man hours worked as unimportant in terms of providing input to the evaluation of organisational safety culture. Both groups also view triangle and training data as the most important which is consistent with the discipline groupings. Once again, there is almost complete rejection of the usefulness of the HSE management system data sets as sources of safety culture related information. The oil industry group sees value in the UA/UC reporting data and also the leading indicators data while the non-oil group prefer HSE goals and the contribution made to overall safety performance by individual departments/contractor companies. This difference may have been driven by the oil industry participants having greater exposure to working in high risk environments. It may be that, had other participants possessed such experience outside the oil industry, they may have produced a similar response.

7.2.3 Screen importance grouping by corporate seniority

The third grouping classified the participants by their managerial experience in their industry. Three classifications were used, senior, middle and junior. The results of this grouping are presented in Figure 7.4. This breakdown produced a spread of senior – 5, middle – 7 and junior – 5 participants across the three managerial levels.

		Actions	Dept. Cont,		
Triangle	Poisson	Accidents	Goals	SMS Org.	SMS Radar
Training	Man hours	TRIR	Lead. Ind.	UA/UC	Climate

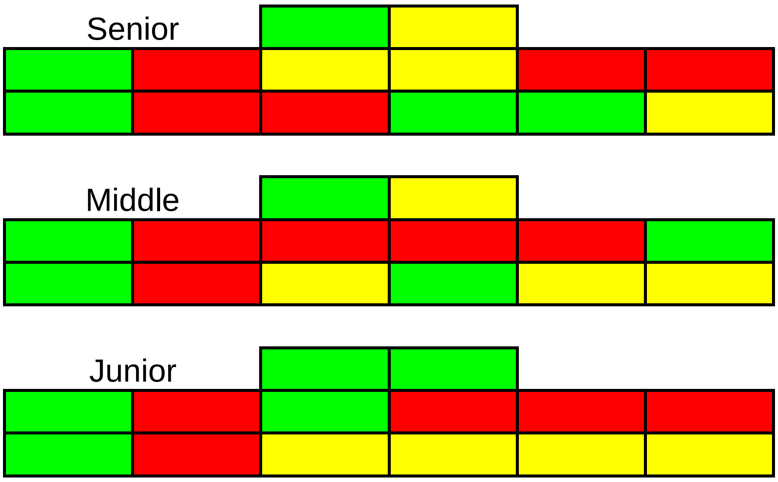


Figure 7.4 Grouping 3. Screen importance by corporate seniority.

Once again, this final arrangement of 3 groups reveals similar opinions on which screens are of importance in helping them to understand the safety culture of the company (accident triangle, training, action tracking) while once again rejecting the contribution from the management system data as did the groups in sections 7.2.2 and 7.2.3.

7.2.4 Comparison with the author

The final analysis using screen rankings was to compare the different groups with the judgement of the author as the educator and the designer of the learning environment. The author also ranked the display screens in what he considered to be their order of importance in contributing to identification of organisational safety culture. This was done without bias and without reference to any of the other participants' data or groups. The author's ranking is presented in Figure 7.5.

		Actions	Dept. Cont,		
Triangle	Poisson	Accidents	Goals	SMS Org.	SMS Radar
Training	Man hours	TRIR	Lead. Ind.	UA/UC	Climate

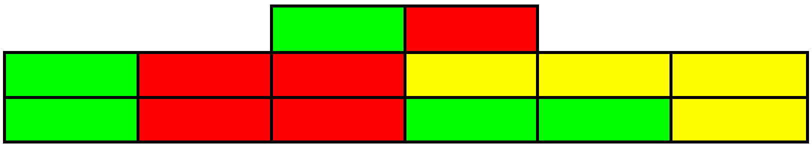


Figure 7.5 Author's ranking of data screen importance.

To compare with the other groups, the modulus of the difference between each pair of rankings for each screen was calculated. These were then totalled to provide an overall score for the entire video wall. Had there been perfect agreement then the modulus for each screen would have been 0 as both rankings would have been the same. Conversely, the worst case would have been when the author and the participant disagreed entirely on the importance and so ranked screens with completely opposite scores, i.e. 14:1, 13:2, 12:3, etc. The maximum possible score in this case would have been 98. This provided the boundaries for a comparison between a score of 0 for complete agreement to 98 representing complete disagreement.

Each group was then compared with the author's judgement. The level of agreement between each of the 8 groups compared to the author's view is presented in Table 7.3 and as a graph in Figure 7.6. Closest agreement was with HSE, oil and senior management. While this should possibly have been anticipated, it prompted the question 'Did the participants arrive at the conclusions they had because of the knowledge they had gained from their experience with the learning environment or did they arrive at their conclusions because that is what the educator told them to think?'

Nine of the participants from different seniority and experience levels and backgrounds were subsequently contacted and asked the question – *"When ranking the data screens in order of their importance in helping you reach your conclusions regarding the safety culture of Lancaster Oil Ltd, do you believe that you arrived at these conclusions independently, through the data and knowledge you had received, or do you feel that you were directly influenced by the educator in your final decision?"*

Eighty-eight percent responded that they had reached their own conclusions with regard to the importance of the various data screens and did not believe that they had been led to, or encouraged to have, the opinions they expressed, by the educator.

Group differences from Educator's ranking of screen importance	
HSE	24.8
Finance	28.0
General	32.8
Oil	22.4
Non-Oil	31.6
Senior	23.2
Middle	29.0
Junior	35.6

Table 7.3 Differences between author's and groups' importance rankings.

The data from Table 7.3 are presented in graphical format in Figure 7.6. The smaller the number, the closer the agreement with the author's assessment.

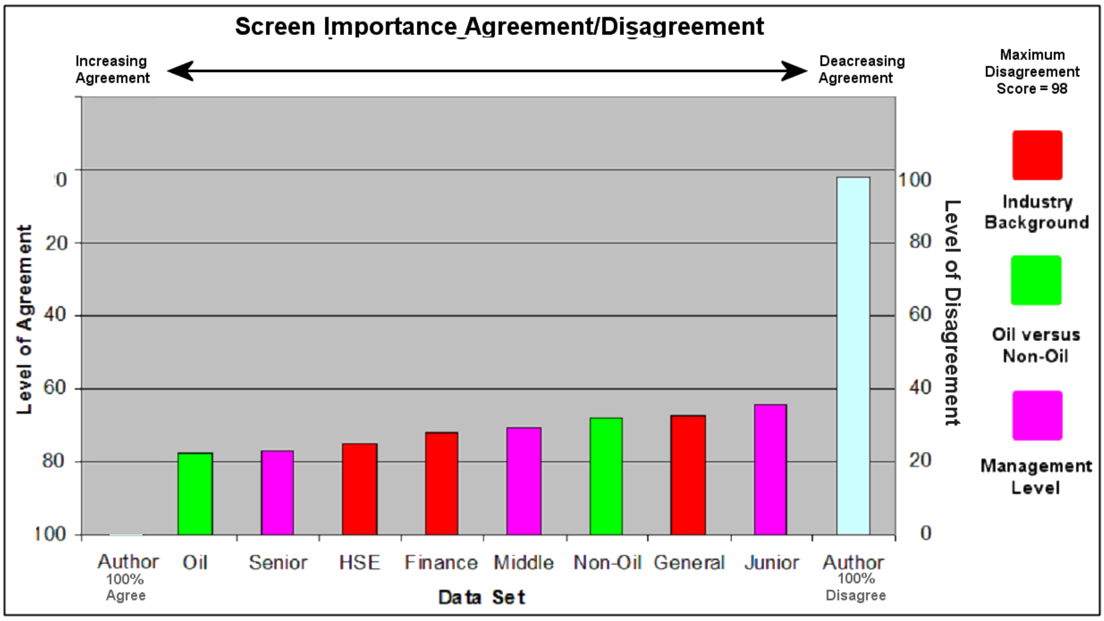


Figure 7.6 Screen importance agreement/disagreement.

A final comparison was between that of the author and all of the participants as a single group. This produced a particularly interesting result. The screen importance perceptions for the 17 participants combined is shown in Figure 7.7. What is immediately clear is that there is 100% agreement between both on which screens they judge as providing the most useful information in regard to safety culture. What is also evident is the disagreement on the screens which provide the least agreement. The overall participant view of the value of the management system screens is consistent with the views of the 8 groups used in the study: that the management system screens were included in the least useful set.

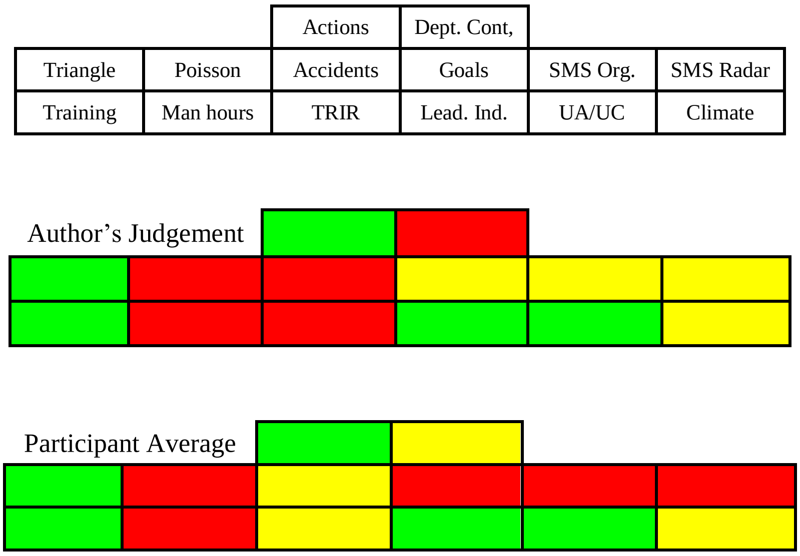


Figure 7.7 Author judgement of screen importance versus all participants combined.

When the level of agreement is calculated for the entire group, it produces a score of 22 which is the closest agreement with the author’s personal judgement. This provides additional evidence that the SCLE is achieving its purpose as a safety culture teaching tool. Furthermore, given that only 6 of the 17 participants are from an HSE background (Table 7.1), the fact that 65% of the participants had never had any dealings with safety management or safety culture yet still agree 100% with the author which are the most important screens suggests that the tool is achieving its objective.

To the charge that the non-HSE participants are merely repeating what the educator has been telling them during the session as they have no professional experience on which to base a different opinion, this can be refuted by comparing the judgement of the participants from an HSE background with all of the other participants grouped together. This is shown in Figure 7.8.

		Actions	Dept. Cont,		
Triangle	Poisson	Accidents	Goals	SMS Org.	SMS Radar
Training	Man hours	TRIR	Lead. Ind.	UA/UC	Climate

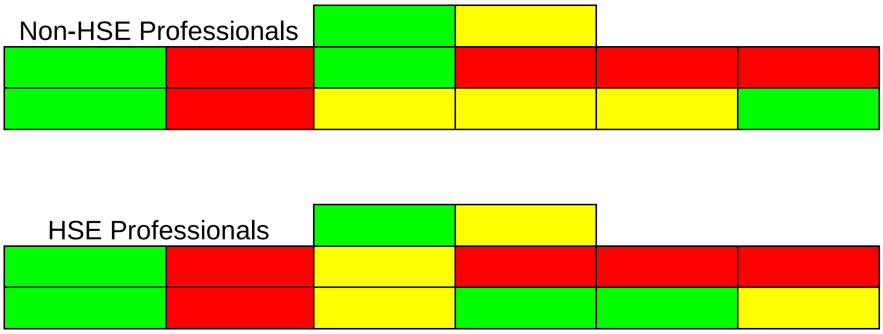


Figure 7.8 Comparison between HSE and non-HSE participants.

There is a 60% agreement on the most important screens, there is 100% agreement on the least important. While the participants may have been swayed by the input from the author during each of their sessions, it is suggested that 6 HSE specialists with a total of nearly 200 years' combined experience would not have been quite so easily influenced by the opinions of a single individual. The strong agreement between both groups, therefore, provides further evidence of the effectiveness of the SCLE in bringing lay people to a higher level of knowledge in terms of evaluating safety culture.

7.3 Annual culture report analysis

At the end of every year (1 hour 36 minutes) the participants were required to submit their annual safety culture reports to the board of directors. With 5 years and 17 participants, this resulted in 85 reports. Yin's (1994) recommendation that the researcher should bring his own expertise to the case study proved particularly applicable in the analysis of both the annual culture report and the open questions from both interview sessions.

Given the subjective nature of report evaluation, a marking template was produced in order to score each report as impartially as possible. In addition to the marking template, a peer review (section 4.4) of the marking template and a peer review of a sample of reports was carried out.

The scores for each annual report for each participant were subjected to a least squares linear regression. A graph of the improvement of all individual participants is given in Appendix 7 to illustrate the wide variation in their personal performance in safety culture reporting. While individually most participants exhibited improvement, when the information is analysed by group, a clearer picture emerges.

7.3.1 Annual culture reports grouped by discipline

The first analysis looked at the improvements exhibited by the HSE, finance and general management groups. As might be expected, the HSE professionals began with an advantage over the other two groups given their backgrounds (Figure 7.9). What is interesting about this plot is that, at the end of the 5 years exposure to the learning environment, all three groups had reached more or less the same level of culture reporting ability.

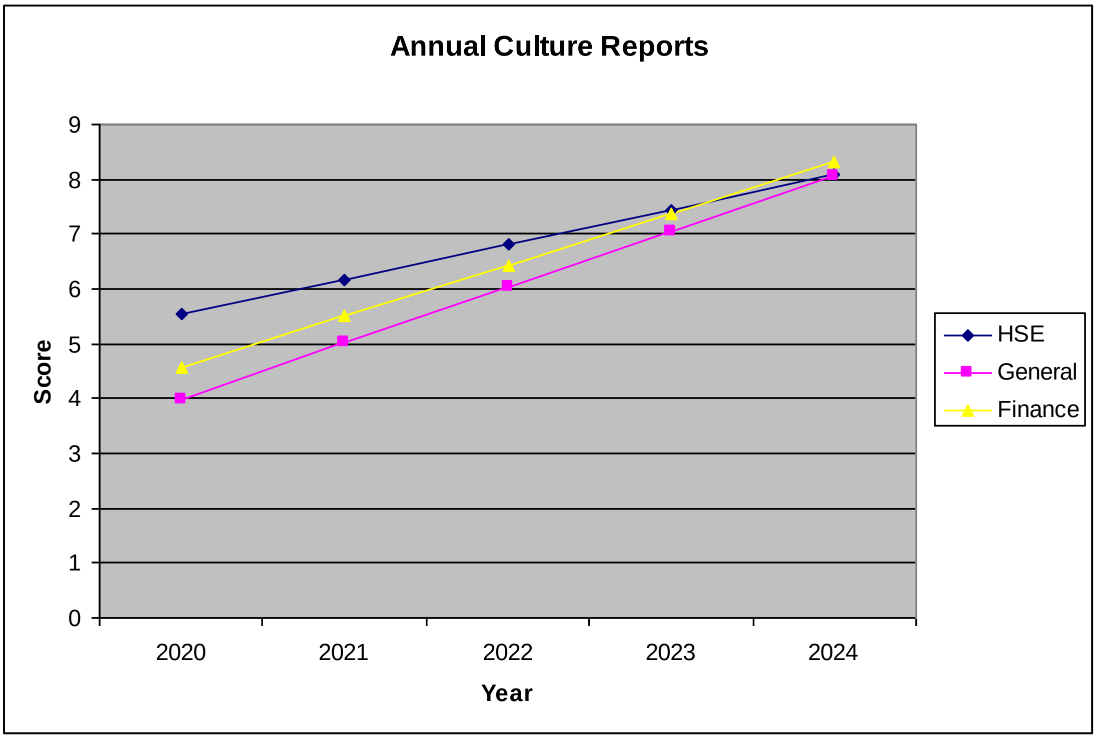


Figure 7.9 Culture reporting improvement HSE, finance and general management.

7.3.2 Annual culture reports grouped by background

In the comparison between oil and non-oil related backgrounds, the oil industry group initially scored higher than the non-oil group (Figure 7.10). Over the 5 years of the session, the oil group's rate of improvement was slightly less. Intuitively, this is what might be anticipated. The group comprising only people from an oil industry background is possibly more accustomed to the concept of, and need for, safety culture than those coming to the learning environment from industries which do not operate in high risk environments. While the non-oil participants began with lower scores on average, their rate of improvement was slightly higher than participants from the oil business.

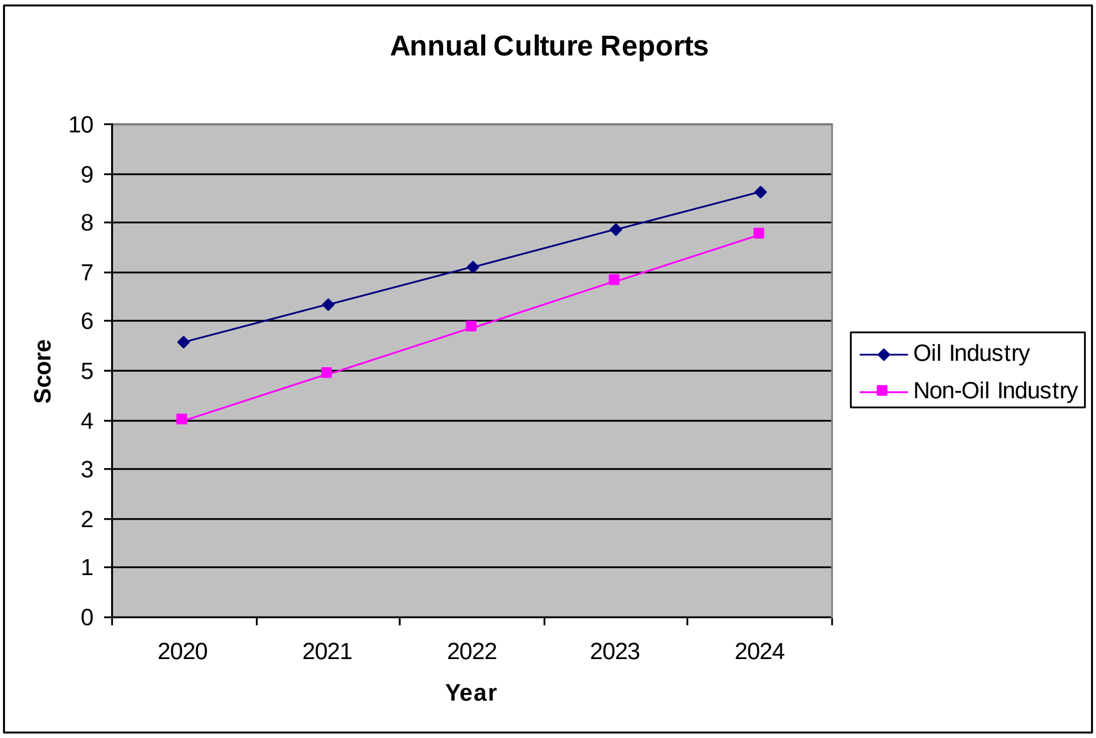


Figure 7.10 Culture reporting improvement oil versus non-oil.

7.3.3 Annual culture reports grouped by industry seniority

Finally, in this section, the groups comprising senior, middle and junior level staff regardless of their industrial backgrounds was examined.

As can be seen in Figure 7.11, senior management exhibit a steeper learning slope than either junior or middle management levels which have almost identical learning slopes. Once again, intuitively, this might be anticipated if senior management really do comprise the best abilities in industry then one might reasonably expect them to grasp new concepts more quickly. There are, however, valid questions which can and should be raised with this interpretation. It is possible that the backgrounds/past exposures of the senior managers enabled them to absorb and apply the new knowledge they had gained to greater effect. Certainly, individuals who have risen to senior levels in organisations might reasonably be assumed to have acquired greater communications skills during their careers and have achieved greater mastery in how to effectively respond to situations presented to them.

There may also be a question around the relationship between the educator with his background/managerial experience which facilitates improved communication of knowledge with senior management rather than the more junior participants.

The answers to these questions are not possible within the bounds of this project due mainly to the sample size involved. The objective of the project was to establish whether a tool could be created to train management in how to evaluate safety culture within an organisation and not to evaluate why particular groups within the study performed better or worse than others. There are also too few participants in each management classification to draw meaningful conclusions in respect of why one classification performed better than another. In its goal, the project succeeded in that all of the management levels demonstrated improvement albeit at differing rates. The question does, however, open up the possibility for future work to establish how or why one level performed better than another in terms of experience, background or even relationship with a particular educator who may exhibit greater synergy with one organisational management level than another due to similarities in their respective backgrounds.

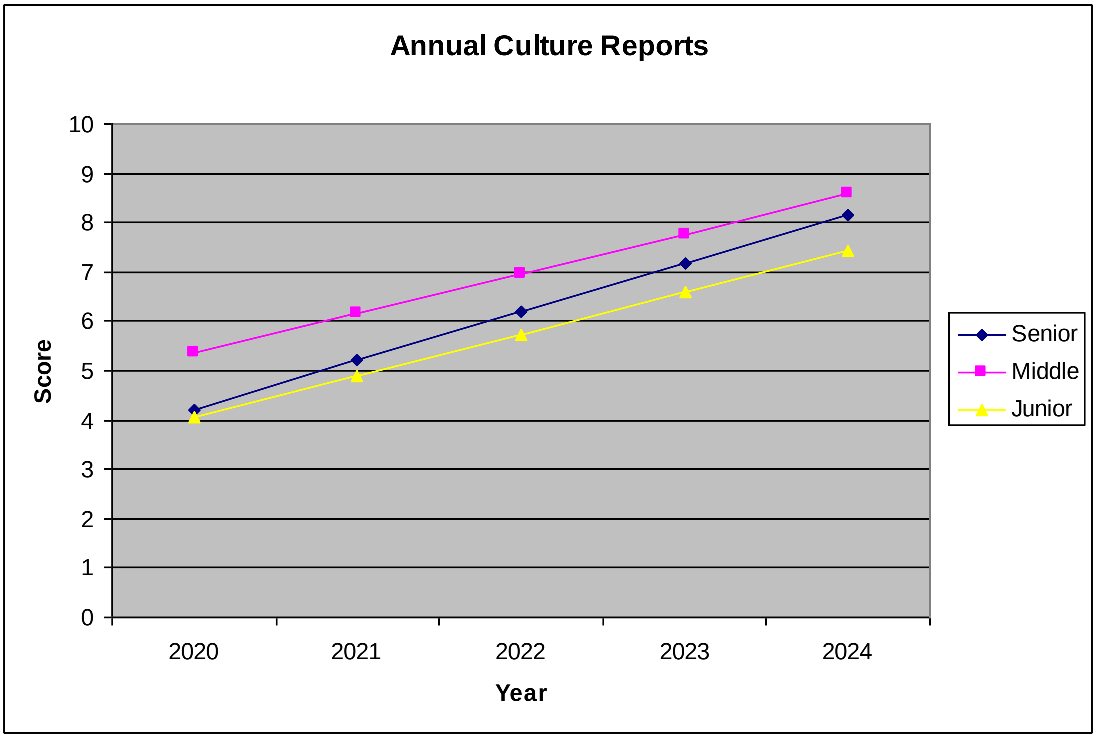


Figure 7.11 Culture reporting improvement senior, middle and junior levels.

7.4 Interview analysis

Each of the participants was interviewed using a pre-prepared format both before and after the session as described in Chapter 4. On completion of all of the sessions, each interview was transcribed. Examples are presented in Appendix 4. Only 16 of the participants were able to complete the second interview. One participant declared soon after the start of the second interview that he was completely mentally exhausted and unable to continue. The interview was immediately stopped and, along with his pre-session interview, has been excluded from this section. This is, however, the only analysis component in which he does not appear.

The pre-session interview asked two sets of questions. The first set established what their belief system was with regard to safety culture. Set 2 asked a series of question pairs. The first question in the pair was a closed question intentionally chosen to generate binary responses of 'yes' or 'no' for numerical evaluation. Part two invited the participants to elaborate on their selection of opinion. At the end of the session, the first two sets of questions were asked again with 4 additional questions included as part of the feedback process.

7.4.1 Closed question analysis

A total of 11 question pairs were asked relating to –

1. HSE management system
2. Accident triangle
3. Contractor HSE performance
4. Action tracking
5. Annual HSE goals
6. Unsafe act/unsafe condition reporting
7. HSE training
8. Leading indicators
9. Total recordable injury rate
10. Poisson distribution
11. Accident investigation

From the participants' perspectives this project was to evaluate the safety culture of an organisation. It might have been natural, therefore, for them to assume that all of the topics included in the second question set were important and so to respond with a 'yes' automatically. For this reason, of the 11 questions, 3 (Poisson ratio, accident investigation and total recordable injury rate) were deliberately included, not for analysis, but to attempt to avoid the situation where the participants automatically answered 'yes' to every question. For the other 8 questions included in the analysis, these were intended to identify at the outset what the participant believed was important in evaluating safety culture.

As with the annual safety culture reports, the individual responses to the interviews were particularly ‘noisy’ and did not provide many useful insights other than that every participant exhibited positive changes in their beliefs as to which of the topics provided knowledge of safety culture. When grouped into the same sets as those used in the annual culture analysis, a clearer picture emerged. The changes in belief are presented as pie charts. The green portion represents the total ‘yes’ responses while the red represents the total ‘no’ responses.

7.4.1.1 Beliefs by HSE, finance and general management

Comparing the groups in this arrangement, the participants with HSE backgrounds believed slightly more of the 8 items contributed to evaluating safety culture than either the finance or general industry participants. Figure 7.12 shows that none of the groups thought that every one of the 8 items in the question list was a useful provider of safety culture information.

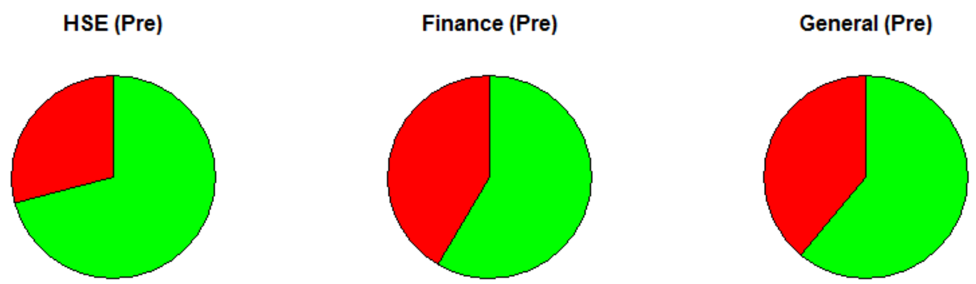


Figure 7.12 Discipline group pre-session beliefs.

By the end of the session, all three groups had moved much closer (Figure 7.13) to a 100% belief that all of the 8 items were of use in safety culture evaluation.

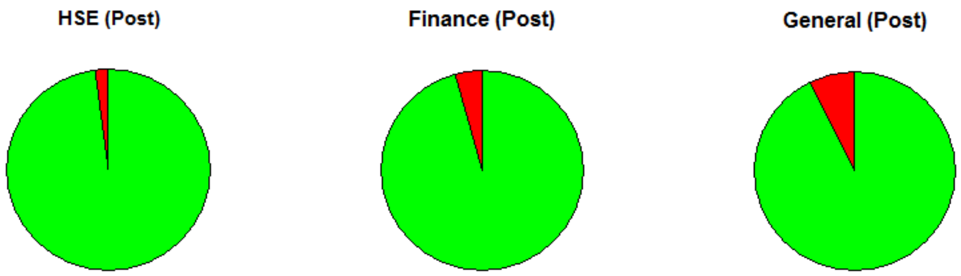


Figure 7.13 Discipline group post-session beliefs.

Not surprisingly, the HSE group started the session more closely aligned with the ultimate conclusions than the other two groups although by the end, there was not a lot of difference in their views.

7.4.1.2 Beliefs by oil and non-oil

The oil versus non-oil groups (Figure 7.14 and Figure 7.15) exhibited a similar pre-session picture as the discipline groups. The participants from an oil background did perceive a few more of the items to be important in assessing safety culture than the non-oil participants prior to the session start.

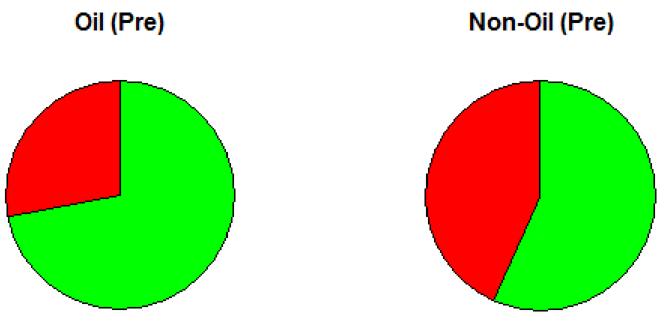


Figure 7.14 Oil versus non-oil group pre-session beliefs.

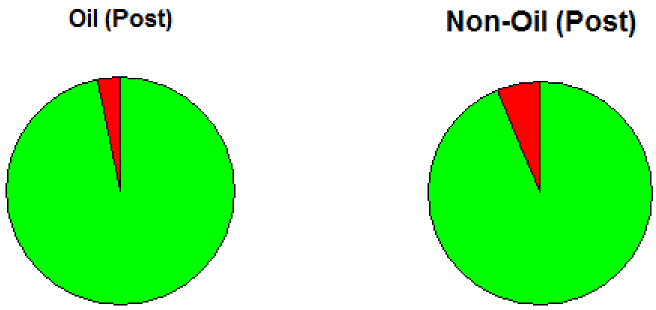


Figure 7.15 Oil versus non-oil group post-session beliefs.

Once again, the group with an oil industry background started from a more closely aligned position than did the non-oil group. This too is not a surprise as they are likely, given the high risk nature of their working environment, to be more aware of safety culture than non-oil personnel, none of whom came from high risk operations.

7.4.1.3 Beliefs by seniority

The final grouping (Figure 7.16 and Figure 7.17) was by corporate seniority. There was very little to choose between any of the three management levels both prior to the session and after.

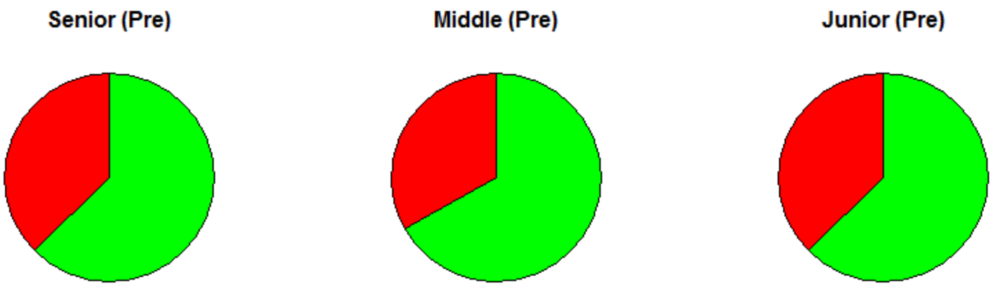


Figure 7.16 Seniority level group pre-session beliefs.

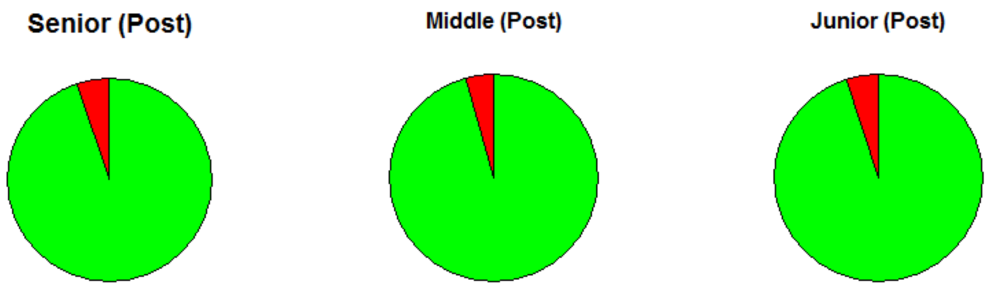


Figure 7.17 Seniority level group post-session beliefs.

By the end of the session, a similar change in belief was demonstrated in this grouping to the changes exhibited by the other groups.

7.4.1.4 Group belief change comparison

In terms of which group changed their beliefs the most, the percentage change for each between the start and the end of the session was calculated and the results are shown in Figure 7.18.

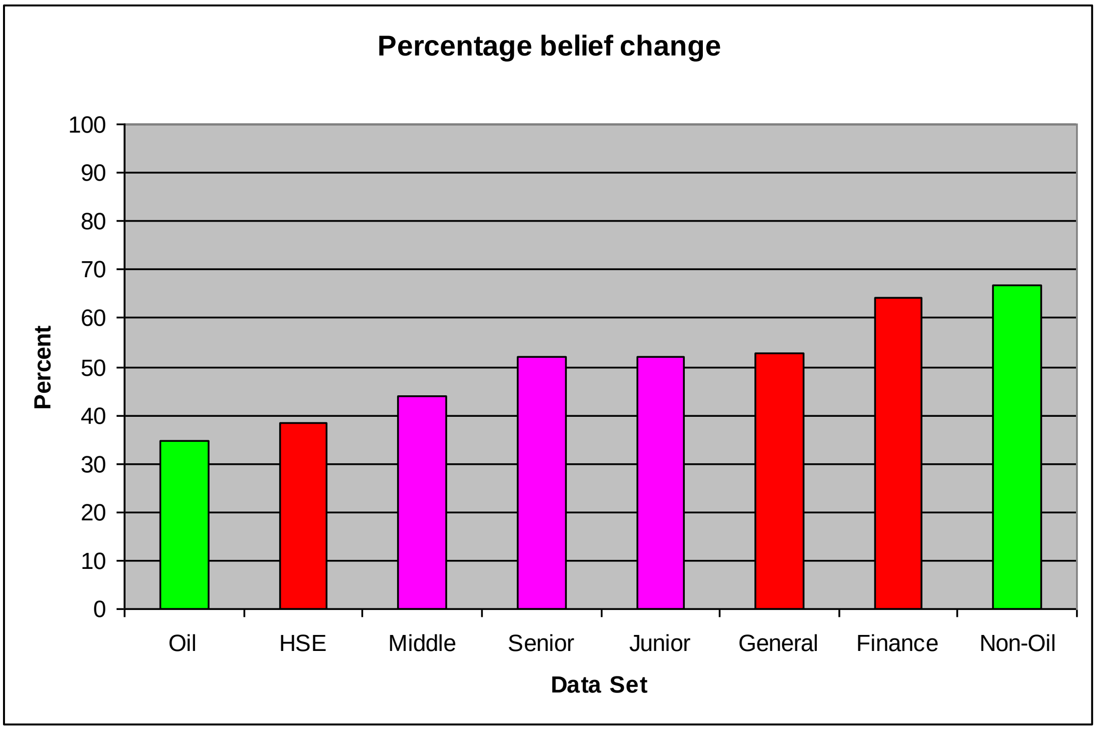


Figure 7.18 Percentage change in group beliefs.

Once again, the learning environment appears to have delivered the maximum change to the participants with the least experience. Non-oil and finance altered their beliefs the most with a trio of general industry, senior and junior management just behind. Oil and HSE exhibited the lowest percentage change in beliefs, most likely because they were already more familiar with safety culture concepts.

Regardless of group, all participants arrived at very similar post-session levels; this is another positive indication that the learning environment is delivering on its intended purpose.

7.4.2 Open interview question analysis

Regardless of whether participants answered ‘yes’ or ‘no’ to the closed questions, they were asked to explain their view. Individual participant responses from members of each group were distilled down as far as possible to a ‘bullet point’ level. This distillation is presented in Tables 7.4 – 7.11 and represents the consolidated responses for each of the participants in each group to each of the 8 questions. Included in each table are 4 pie charts for each question. The top two pie charts illustrate the magnitude of the belief change by the group being evaluated. The bottom 2 pie charts enable a comparison between the group beliefs before and after training with all of the participants combined into a single group.

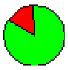
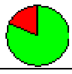
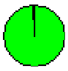
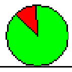
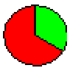
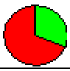
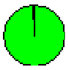
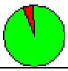
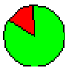
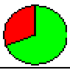
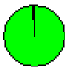
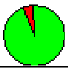
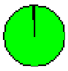
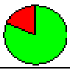
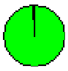
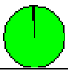
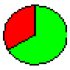
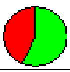
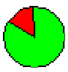
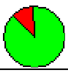
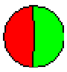
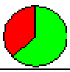
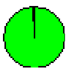
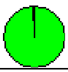
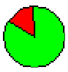
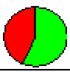
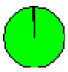
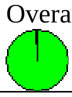
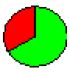
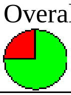
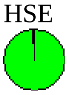
Group	Num	Question	Pre-Session Y/N	Post-Session Y/N	Pre-session Theme	Post-session Theme
HSE	1	What insight do you think monitoring HSE management system Implementation Levels provides and how?	HSE  Overall 	HSE  Overall 	Implementation equates to risk assessment. Some culture insight. How to measure	Definitely provides overview as long as measurement is good.
	2	What insight do you think monitoring the accident triangle provides and how?	HSE  Overall 	HSE  Overall 	Little culture insight.	Enormously useful. Huge insight.
	3	What insight do you think monitoring Contractor HSE Performance provides and how?	HSE  Overall 	HSE  Overall 	Needs policing. Depends on contractors	Good insight. Helps with departmental monitoring.
	4	What insight do you think monitoring Action Tracking provides and how?	HSE  Overall 	HSE  Overall 	Some input but more reactive. Speed reveals a bit about attitudes.	Very useful. Valuable approach Proactive
	5	What insight do you think monitoring Annual HSE Goals provides and how?	HSE  Overall 	HSE  Overall 	Unclear and depends on goals. Different goals may affect culture.	Not completely convinced that insightful. Need to change regularly.
	6	What insight do you think monitoring unsafe act/unsafe act reporting provides and how?	HSE  Overall 	HSE  Overall 	Limited use. Numbers synthetic driven by bonuses. Limited cultural insight.	Useful information. Highly valuable. Clear input to culture assessment.
	7	What insight do you think monitoring HSE Training provides and how?	HSE  Overall 	HSE  Overall 	Must be more than talk. Investment sends message.	Good helpful information. Definite influence on culture perceptions.
	8	What insight do you think monitoring Leading Indicators provides and how?	HSE  Overall 	HSE  Overall 	Difficult to quantify. Needs open culture to begin with. Limited progress so far.	Difficult to interpret. Need to be chosen well but valuable.

Table 7.4 HSE group interview analysis.

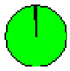
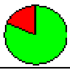
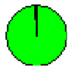
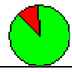
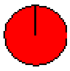
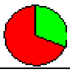
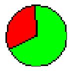
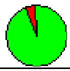
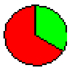
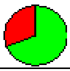
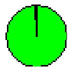
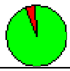
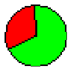
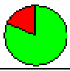
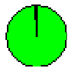
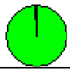
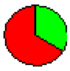
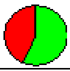
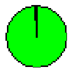
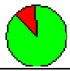
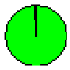
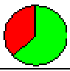
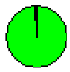
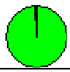
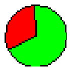
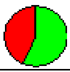
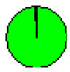
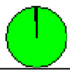
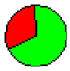
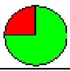
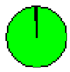
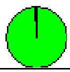
Group	Num	Question	Pre-Session Y/N	Post-Session Y/N	Pre-session Theme	Post-session Theme
Finance	1	What insight do you think monitoring HSE management system Implementation Levels provides and how?	Finance  Overall 	Finance  Overall 	Good indication if adopted by all. Buy-in essential Fairly important	Can tell if well implemented. See where we are and where we are going.
	2	What insight do you think monitoring the accident triangle provides and how?	Finance  Overall 	Finance  Overall 	Does not say much. Shows history. Shows how many accidents.	Good when you know how to use it. Shows reporting culture.
	3	What insight do you think monitoring Contractor HSE Performance provides and how?	Finance  Overall 	Finance  Overall 	No indication of their culture May indicate if they have procedures in place	Shows that HSE culture must include contractors
	4	What insight do you think monitoring Action Tracking provides and how?	Finance  Overall 	Finance  Overall 	Backward looking but with proactive intent	Very important demonstrates where truly proactive or reactive.
	5	What insight do you think monitoring Annual HSE Goals provides and how?	Finance  Overall 	Finance  Overall 	Possible may show something but not sure.	Tell a lot about attitudes and that company has realistic and positive goals
	6	What insight do you think monitoring unsafe act/unsafe act reporting provides and how?	Finance  Overall 	Finance  Overall 	Difficult to track but indicates good culture. Very important.	Lots of reports indicates good culture. Indicates an open reporting culture.
	7	What insight do you think monitoring HSE Training provides and how?	Finance  Overall 	Finance  Overall 	Depends on receptive staff. If tick box or not. If for sake of training then not good.	Shows culture down to department and even individual's level.
	8	What insight do you think monitoring Leading Indicators provides and how?	Finance  Overall 	Finance  Overall 	Depends on departments but doing them is good sign	Really useful. Clear indication of positive approach.

Table 7.5 Finance group interview analysis.

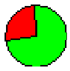
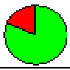
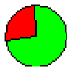
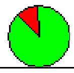
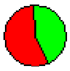
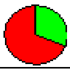
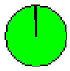
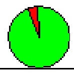
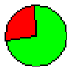
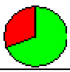
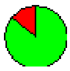
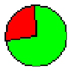
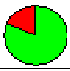
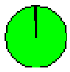
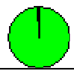
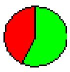
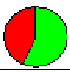
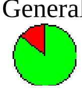
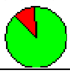
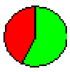
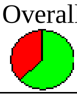
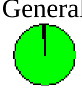
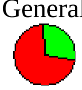
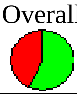
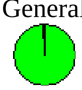
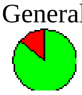
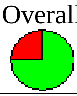
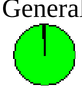
Group	Num	Question	Pre-Session Y/N	Post-Session Y/N	Pre-session Theme	Post-session Theme
General	1	What insight do you think monitoring HSE management system Implementation Levels provides and how?	General  Overall 	General  Overall 	Don't tell much. Culture more important than document in a file.	Some indication of culture but not 100% convinced.
	2	What insight do you think monitoring the accident triangle provides and how?	General  Overall 	General  Overall 	No culture message. Need to understand causes. Might show what people record.	Quick visual check. Highlights reporting culture and deficiencies.
	3	What insight do you think monitoring Contractor HSE Performance provides and how?	General  Overall 	General  Overall 	A little bit. Need to understand contractor performance	Need to align both cultures.
	4	What insight do you think monitoring Action Tracking provides and how?	General  Overall 	General  Overall 	Not a lot but does show that company wants to do something.	Clearly see if proactive or reactive. Very clear cut.
	5	What insight do you think monitoring Annual HSE Goals provides and how?	General  Overall 	General  Overall 	Information not obviously useful.	Delivery reveals culture info if achieving and smart goals.
	6	What insight do you think monitoring unsafe act/unsafe act reporting provides and how?	General  Overall 	General  Overall 	Depends why they are being reported. Lots of reports means not trying to improve.	Shows commitment to culture. More reports means better culture.
	7	What insight do you think monitoring HSE Training provides and how?	General  Overall 	General  Overall 	Not very much. The fact that it is done might say something.	Training part of furthering culture. Shows management commitment
	8	What insight do you think monitoring Leading Indicators provides and how?	General  Overall 	General  Overall 	Depends on the indicators but doing something is better	Absolutely yes. Shows clearly a bit about safety culture.

Table 7.6 General group interview analysis.

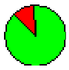
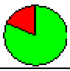
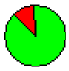
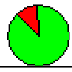
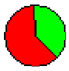
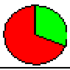
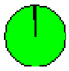
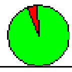
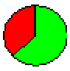
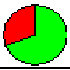
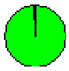
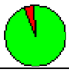
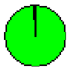
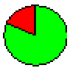
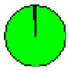
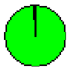
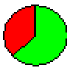
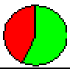
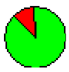
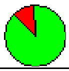
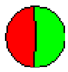
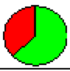
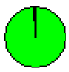
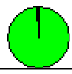
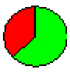
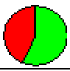
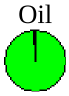
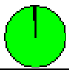
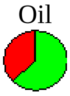
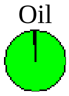
Group	Num	Question	Pre-Session Y/N	Post-Session Y/N	Pre-session Theme	Post-session Theme
Oil	1	What insight do you think monitoring HSE management system Implementation Levels provides and how?	Oil  Overall 	Oil  Overall 	Measurement problems. Associated with risk. Only a snapshot.	Measurement is key. Points out the obvious. Some useful information.
	2	What insight do you think monitoring the accident triangle provides and how?	Oil  Overall 	Oil  Overall 	Performance but perhaps not always culture. Insight into reporting.	Enormously, immensely powerful. Identify honest [reporting] culture.
	3	What insight do you think monitoring Contractor HSE Performance provides and how?	Oil  Overall 	Oil  Overall 	Performance not culture. Depends on contractors. Needs heavy policing.	Powerful, particularly useful insights Reflects follow-up by company
	4	What insight do you think monitoring Action Tracking provides and how?	Oil  Overall 	Oil  Overall 	Limited use but does indicate commitment. Speed of resolution useful knowledge.	Valuable. Useful. Provides clear information on proactive versus reactive culture
	5	What insight do you think monitoring Annual HSE Goals provides and how?	Oil  Overall 	Oil  Overall 	Fluffy and may be vague, Might be resented. Depends on goals	Measure of intent. Don't always reflect culture. Need to be achievable
	6	What insight do you think monitoring unsafe act/unsafe act reporting provides and how?	Oil  Overall 	Oil  Overall 	Unreliable. Might give an indication of culture	Good useful info. Bottom of the triangle Valuable in creating culture
	7	What insight do you think monitoring HSE Training provides and how?	Oil  Overall 	Oil  Overall 	OK as long as it is taken seriously and not just lip service.	Useful info. from Mgmt. uptake but can double edged sword.
	8	What insight do you think monitoring Leading Indicators provides and how?	Oil  Overall 	Oil  Overall 	Leading indicators difficult to monitor. Indication of culture.	Need careful selection. Valuable contribution to safety culture.

Table 7.7 Oil group interview analysis.

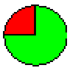
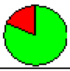
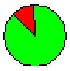
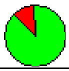
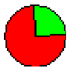
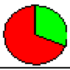
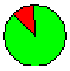
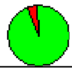
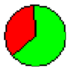
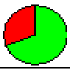
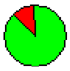
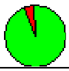
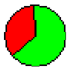
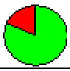
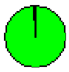
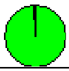
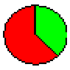
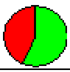
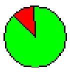
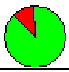
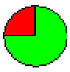
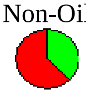
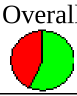
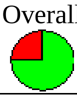
Group	Num	Question	Pre-Session Y/N	Post-Session Y/N	Pre-session Theme	Post-session Theme
Non - Oil	1	What insight do you think monitoring HSE management system Implementation Levels provides and how?	Non-Oil  Overall 	Non-Oil  Overall 	Culture is more important than a file. Not a lot. Implementation = pro-activity.	Good measurement gives good insight Can see if performance is better.
	2	What insight do you think monitoring the accident triangle provides and how?	Non-Oil  Overall 	Non-Oil  Overall 	Not cultural Might indicate commitment. Better to understand causes.	Valuable when understood. Highlights reporting culture. Quick visual check.
	3	What insight do you think monitoring Contractor HSE Performance provides and how?	Non-Oil  Overall 	Non-Oil  Overall 	An indication possibly. Shows company cares about more than its own staff.	Impact of contractors on culture. Impact of culture on contractors.
	4	What insight do you think monitoring Action Tracking provides and how?	Non-Oil  Overall 	Non-Oil  Overall 	Tracking history. Not much about culture. Know if you are taking actions.	Very important Absolutely know if the organisation is proactive.
	5	What insight do you think monitoring Annual HSE Goals provides and how?	Non-Oil  Overall 	Non-Oil  Overall 	More about performance. Says what org. wants not delivers. Who sets is important	Verifies good culture. Need to be smart and achievable goals.
	6	What insight do you think monitoring unsafe act/unsafe act reporting provides and how?	Non-Oil  Overall 	Non-Oil  Overall 	Many reports may indicate problems. What is done with the information? Might give some insight.	Good reporting culture if reported. Employee buy-in. Insight into attitudes.
	7	What insight do you think monitoring HSE Training provides and how?	Non-Oil  Overall 	Non-Oil  Overall 	Depends on the reason for the training. Not much input to safety culture.	Monitoring gives insight into safety .Uptake = good culture indicator
	8	What insight do you think monitoring Leading Indicators provides and how?	Non-Oil  Overall 	Non-Oil  Overall 	Indicator dependent. Needs monitoring.	Good insight. Definite 'yes'. Tells you what is actually happening.

Table 7.8 Non-Oil group interview analysis.

Group	Num	Question	Pre-Session Y/N	Post-Session Y/N	Pre-session Theme	Post-session Theme
Senior	1	What insight do you think monitoring HSE management system Implementation Levels provides and how?	Senior Overall	Senior Overall	Issues with quantification and presentation	Good when measurement achieved.
	2	What insight do you think monitoring the accident triangle provides and how?	Senior Overall	Senior Overall	Issues with causes and recording	Provides confidence and Trust in good reporting culture.
	3	What insight do you think monitoring Contractor HSE Performance provides and how?	Senior Overall	Senior Overall	Problems with monitoring, checking and policing.	Provides some insight Shows contractor influence.
	4	What insight do you think monitoring Action Tracking provides and how?	Senior Overall	Senior Overall	Just Lip service Backward Facing Reactive	Proactive Informative Vital
	5	What insight do you think monitoring Annual HSE Goals provides and how?	Senior Overall	Senior Overall	No belief in goals.	Verification of healthy culture. Good insights
	6	What insight do you think monitoring unsafe act/unsafe act reporting provides and how?	Senior Overall	Senior Overall	Cynical and not convinced any use No belief it works	Promotes reporting culture Insight into attitudes.
Senior	7	What insight do you think monitoring HSE Training provides and how?	Senior Overall	Senior Overall	Show you are Serious and willing to invest. Not just tick-box	Key to furthering culture. Demonstrates true buy-in.
	8	What insight do you think monitoring Leading Indicators provides and how?	Senior Overall	Senior Overall	Difficult to monitor. Depends on the indicators.	Shows culture. Commitment by Management.

Table 7.9 Senior group interview analysis.

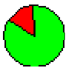
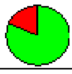
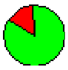
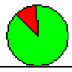
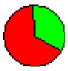
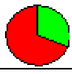
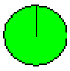
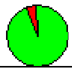
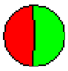
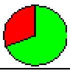
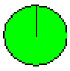
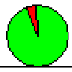
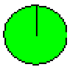
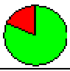
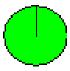
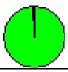
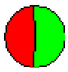
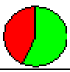
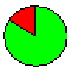
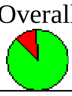
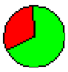
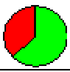
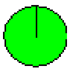
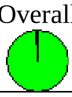
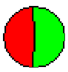
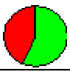
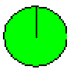
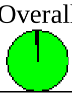
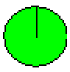
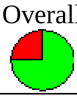
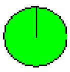
Group	Num	Question	Pre-Session Y/N	Post-Session Y/N	Pre-session Theme	Post-session Theme
Middle	1	What insight do you think monitoring HSE management system Implementation Levels provides and how?	Middle  Overall 	Middle  Overall 	Implementation relationship to effectiveness	Good measurement essential. Gives focus direction and insight
	2	What insight do you think monitoring the accident triangle provides and how?	Middle  Overall 	Middle  Overall 	Tells the obvious Shows if open culture	Enormously powerful. Immensely powerful. Honest culture
	3	What insight do you think monitoring Contractor HSE Performance provides and how?	Middle  Overall 	Middle  Overall 	Difficult to monitor. Shows performance not culture.	Valuable focus tool. Reflects Dept. Managers focus.
	4	What insight do you think monitoring Action Tracking provides and how?	Middle  Overall 	Middle  Overall 	Shows whether doing what you are saying	Definitely proactive. Very valuable Shows if you are doing what you say.
	5	What insight do you think monitoring Annual HSE Goals provides and how?	Middle  Overall 	Middle  Overall 	Not particularly useful as depends on the goals. Fluffy	Measure of intent. Need goal for culture. Whether they are realistic.
	6	What insight do you think monitoring unsafe act/unsafe act reporting provides and how?	Middle  Overall 	Middle  Overall 	Whether contributing to accidents Shows open culture and whether safe.	In itself helps create culture. Shows pro-activity. Getting a just culture.
	7	What insight do you think monitoring HSE Training provides and how?	Middle  Overall 	Middle  Overall 	Must be more than lip service. Depends on employees	Double edged sword. Illustrates culture. Good leading indicator.
	8	What insight do you think monitoring Leading Indicators provides and how?	Middle  Overall 	Middle  Overall 	Can only survive in open culture. Depend on departments understanding.	Useful. Valuable. Need to be carefully chosen.

Table 7.10 Middle group interview analysis.

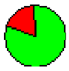
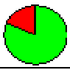
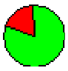
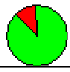
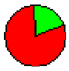
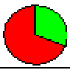
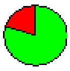
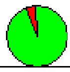
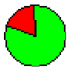
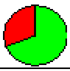
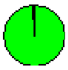
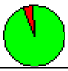
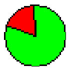
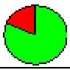
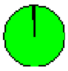
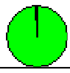
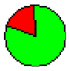
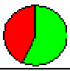
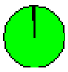
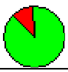
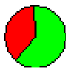
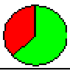
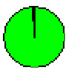
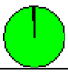
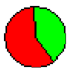
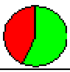
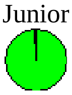
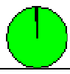
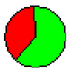
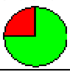
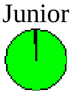
Group	Num	Question	Pre-Session Y/N	Post-Session Y/N	Pre-session Theme	Post-session Theme
Junior	1	What insight do you think monitoring HSE management system Implementation Levels provides and how?	Junior  Overall 	Junior  Overall 	How to know if implemented.	May flag where investigation required.
	2	What insight do you think monitoring the accident triangle provides and how?	Junior  Overall 	Junior  Overall 	Just numbers. No cultural message	Insight into reporting culture. A numbers game.
	3	What insight do you think monitoring Contractor HSE Performance provides and how?	Junior  Overall 	Junior  Overall 	Treating contractors as less important? Are contractors taking responsibility?	Contractors need to be aligned with corporate.
	4	What insight do you think monitoring Action Tracking provides and how?	Junior  Overall 	Junior  Overall 	Shows desire to improve. Shows company cares.	Vital to see if proactive or not.
	5	What insight do you think monitoring Annual HSE Goals provides and how?	Junior  Overall 	Junior  Overall 	Depends on who sets them. Not much help if not adhered to.	Related to culture. Smart goals important. Help reduce accidents
	6	What insight do you think monitoring unsafe act/unsafe act reporting provides and how?	Junior  Overall 	Junior  Overall 	Notoriously hard to track. Lots of reports is not good. Indicates if people thinking.	High volume is good. Indicates culture. Indication of accidents.
	7	What insight do you think monitoring HSE Training provides and how?	Junior  Overall 	Junior  Overall 	Need to know why people are going on training. Not good if only for sake of going.	Limited uptake by management not good
	8	What insight do you think monitoring Leading Indicators provides and how?	Junior  Overall 	Junior  Overall 	Not sure. Doing things to improve safety should mean good culture.	Indication of caring about HSE performance.

Table 7.11 Junior group interview analysis.

The responses in the previous tables are a distillation of approximately 7 hours total interview time and indicate a change in beliefs by all groups to all questions regarding the main elements of the learning environment. This is reinforced by the closed question (section 7.4.1) analysis.

7.4.3 Final post-session questions

The last questions pertained to the learning environment itself and so were only put to the participants on completion of the session.

Participants were asked –

1. What would you change in regard to simulator content to improve the training experience and benefit?
2. What would you change with regard to the overall non-computer content of the course to improve the training experience and benefit (e.g. presentations)?
3. How do you feel about the length of the session?

In general, the response to question 1 indicated a high level of satisfaction with the existing content. Several participants mentioned items such as wanting advanced information and labelling of screens.

Non-simulator content was considered to be at the right level, although one participant did feel that being asked to make a presentation as the very first activity on a subject they knew nothing about did engender negative emotions about the experience to come. He suggested that that particular activity should be dropped.

As far as the length of the session was concerned, again, the majority of participants (15 out of a total of 17) felt that, while very intense, the length was appropriate as splitting the material over two days might risk a drop in enthusiasm for a return on day two. All believed that the e-mails were at about the right level of frequency to keep the mental activity high, although, at the end, all felt emotionally and intellectually drained. Two participants expressed the opinion that the course could be run over two days; however, in one of these, it was because he felt that management would be able to handle even more demanding training, enabling the experience to be intensified.

The comments and observations from these questions were exactly what one might expect when asking a diverse group of people for their opinions. While one or two had ideas, thoughts or suggestions, as could be expected, for the most part, the group felt that the content was good and of the right quantity, that the presentations were 'acceptable' and that the duration was about right.

7.5 Job description analysis

At the start of the session, one of the first e-mails that the participants receive is in connection with the hiring of an HSE manager who will report directly to them in their role as managing director. Included with that information is a copy of the job specification and candidate profile that they used to find an appropriate appointee.

Shortly before the end of the session, the HSE manager tenders his resignation. As a consequence, the HR department inform the participant that it will be recruiting a replacement and ask if the participant has any comments or observations regarding the previous job specification/profile which it intends to use once again. The participant is invited to submit modified requirements in the form of a revised specification/profile.

The inclusion of this topic was prompted by over 11,000 job adverts which the author reviewed over the three years of this research. Recalling the work by Fennell (2006) and his graph in Figure 1.2, for industry to achieve the last step toward the utopia of an accident free workplace, different approaches are needed from those which brought industry to where it is today. On average, between 60 and 80 job adverts were reviewed every week and this revealed that less than 5% of the advertised positions specifically require skills in safety culture, behavioural safety, safety data analysis, etc. The vast majority seek individuals with the skill-sets which have brought industry to where it is today, however, while these skills will always be needed, in order to progress, new skills are required.

The participant is being asked to modify/approve a job specification for a replacement HSE manager to ascertain whether this message has been taken on board as a consequence of his exposure to the issues presented to him in the learning environment.

A copy of the job description is provided in Appendix 8 along with an example of the modifications made by one of the participants by way of illustration. It should be noted that the job description used in the learning environment was sourced from a variety of locations on the internet. It is a generic job description and appears to have circulated widely throughout the world. As such, it is possible to establish neither its origins nor its ownership.

As with the assessment of the annual culture reports, a marking template was created and each of the job descriptions scored against the template. In this case, the criteria were simpler as the key points of interest in the job description were whether the participants had gained an awareness of the importance of recruiting an HSE manager with particular skills conducive to helping them achieve the same level of monitoring and analysis with which they had become familiar in the learning environment.

The 8 skills (or similar) identified for the marking template which needed to be included in addition to those described in the previous document were –

- Ability to conduct statistical analysis of data
- Experience in designing and implementing behavioural safety programmes
- Knowledge and skills in evaluating behavioural safety programmes
- Understanding of safety culture and its development
- Ability to interact with senior management on safety culture issues
- Promotion of safety culture
- Ability to innovate
- Familiarity with forward-looking performance measurement

Each new job description was reviewed and scored 1 point whenever one of the items mentioned above was included in the revised job specification. A percentage score was calculated with 100% identifying that a participant had mentioned all of the 8 skills identified above, down to a possible 0% had they not referred to any of the skills.

The results (Figure 7.19) indicate that the participants who recognised the greatest need for a change in profile came from the two groups Oil and HSE. The most surprising result was the very low recognition of key skills by the General Industry group. Nevertheless, there is an encouraging indication that the participants as a whole accepted the message that additional skills were required of their next HSE manager.

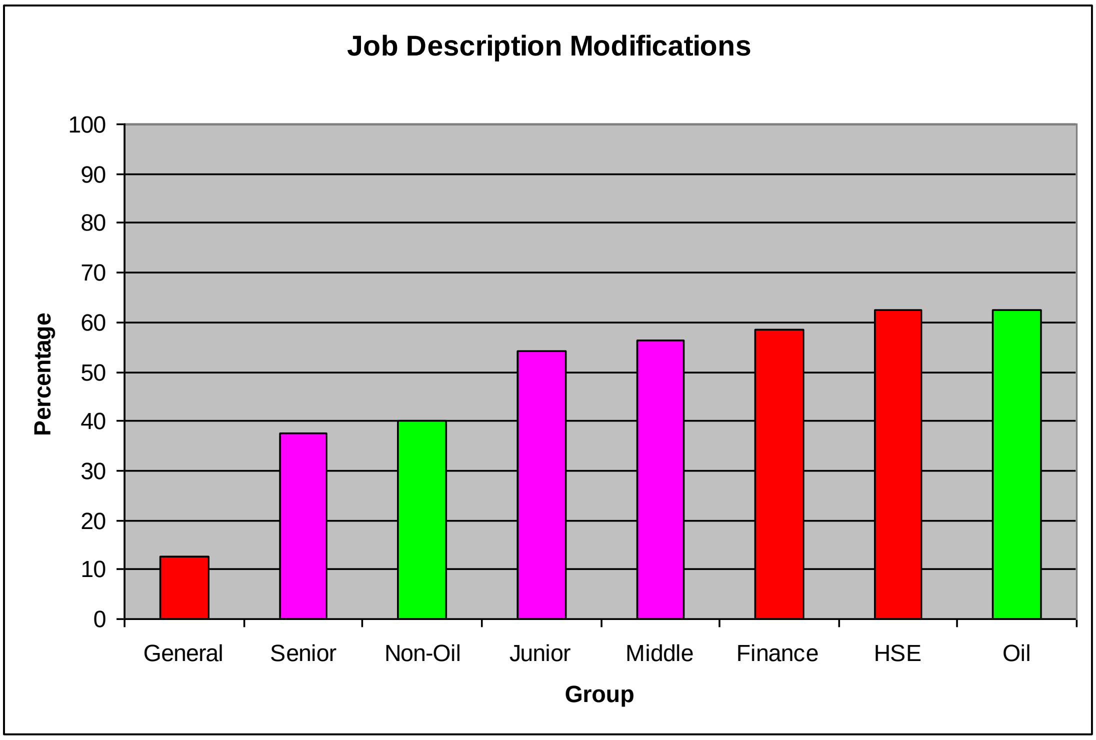


Figure 7.19 Job description modifications.

Overall the participants scored 52%; an average of 4 additional skills. If 4 additional skills requirements were incorporated into 11,000 advertised HSE positions, it is suggested that industry may reasonably expect an improvement in the approach to safety culture.

7.6 Participant feedback

As important as any of the analysis carried out was the actual feedback from the participants. Each of them was asked to provide a short summary of their thoughts regarding their experience and what they had gained from the experience. It would be excessive and a waste of valuable ‘word space’ to display each of them. Instead, in keeping with the group approach to this study, a full statement from a participant in each of the groups is included here. The statements presented in section 7.6.1 were selected because they were provided by the particular participants in a format which did not require any editing by the author in order to make them suitable for inclusion in this thesis. Some of the participants provided extensive feedback which not only referred to their experience but also suggestions on how they would have constructed such a tool and occasionally, personal observations on their own careers and other non-related information. While much of their feedback was extremely interesting and useful, in order to incorporate these statements, a degree of subjective editing would have been required by the author and this was deemed unacceptable due to the potential risk of introducing bias. The feedback presented here is, therefore, the unaltered responses of the participants concerned.

7.6.1 HSE, finance and general industry feedback

7.6.1.1 HSE

Provided by a former mid-level, oil industry HSE manager now a consultant.

> *“It was an exhausting, at times stressful, but overall extremely instructive day. It very soon becomes obvious that much of the ‘traditional’ reactive or lagging safety statistics collected by businesses is not especially useful in preventing accidents, nor is it a gauge of the all-important safety culture within an organisation.*

"As a former HSE manager in major projects and operations, I found the tool a real eye-opener in how it can change one's perceptions on the importance of certain management actions and the usefulness of certain safety data. This was especially true of how leading, proactive data can provide real insight into how a company's safety culture is developing (or not!) and how it can ultimately lead to greatly improved safety performance.

"Having spent a day with the tool, I don't believe its main benefit is for HSE managers or middle managers. Rather, it should be experienced by CEOs and other senior managers of a company. It is only they who can affect safety culture of their organisation by leading by example, setting standards for safe behaviours, by their requirements for meaningful proactive safety data and by holding line managers accountable for their actions (or inactions).

"I have no hesitation in recommending it to senior management, as I believe it will be of immense benefit in improving the safety culture and hence safety performance of their organisation."

7.6.1.2 Finance

Provided by a director-level finance specialist in a non-oil industry organisation.

"The learning environment is an impressive and powerful system which harnesses a wealth of data and uses innovative technology to create a comprehensive learning experience.

"With material being delivered both via the computer systems and by interaction with the trainer, the participant is led through several years in the life history of a virtual company. The experience is intense, challenging and thought provoking, and I found myself looking at things in a completely different way and gaining a real appreciation of the key factors in safety culture.

"The format of the learning enabled a significant amount of information to be absorbed in a short space of time. I found the experience demanding but enjoyable and immensely valuable in helping to formulate my thinking on HSE culture."

7.6.1.3 General management

Provided by a Public Limited Company (PLC) size board-of-directors-level participant from a non-oil related company.

"The bottom line for this learning environment is that it gets the message across that developing a safety culture is going to be more effective at reducing accidents and deaths than all the obvious things that managers do, like writing more procedures and having sanctions. Related to that last point is that it becomes abundantly clear that much of the accident data routinely collected and reported in the energy industry accident data is completely useless - the data that are important are clearly identified.

"As an education programme, it works well for getting senior managers to have a better understanding of the nature of safety and how to develop a safe working environment. The model for the day includes the critically important working relationship between safety specialists and operational, line managers, and how each role can and should support the other.

"As the focus of the programme is the development of a safety culture, the point is well made that the actions that are required of senior managers are all FREE - that is no actual costs attach to them - other than their time, of course.

"The overall conclusion is that the session is excellent, and with huge potential to help senior managers change their mental models about safety."

7.6.2 Oil, non-oil feedback

7.6.2.1 Oil industry experience

Provided by a change management consultant within the oil and gas industries.

"The learning environment moves beyond theory and case-studies, and puts the participant 'in the hot seat' of making decisions about both 'what' to do in response to real trends in real safety and operational data, as well as 'how' to act. I was surprised how quickly I became immersed in the experiential development offered within the learning environment. By observing trends in data, and how these may respond over time to leadership interventions, I gained a depth of experience of safety leadership

that is hard to find in anything but the real world of an operational leadership role."

7.6.2.2 Non-oil industry experience

Provided by a former mid-level manager, non-oil related experience.

"Overall, I believe the package has the potential to be a very useful tool in helping train people working in the oil industry and (with some small changes) beyond that industry into others of a similar nature. In particular, I believe it has the potential to raise safety issues up the agenda and so improve the safety record in industry for the good of the employees, the organisations, and the environment."

7.6.3 Senior, middle, junior management feedback

7.6.3.1 Senior management

Provided by a senior HSE manager in the upstream oil and gas industry.

"It was one of the most useful and impressive days I have spent in recent years. As erstwhile 'Manager of Engineering Development' and 'Manager of HSE' for a major oil company, and current owner of an HSE Consultancy company consulting to the boards of some of the biggest companies in the world for the last 15 years, I am not easily impressed by HSE initiatives but this one is an exception.

"The manager participating in this teaching is led to confront the HSE consequences of his actions as well as the financial and short term business

ones. The pointlessness of focusing on LTIs as a guide to risk exposure from the less frequent, higher consequence, events emerges; as does the high value of training and of company culture (driven by management example and leadership), as drivers of risk reduction.

"The system has real credibility, being derived from actual clinical observation and recording of company Safety Culture development. An impressive tool in development, and one that every manager serious about his effect on Safety Culture, and on ways to measure it, should experience."

7.6.3.2 Middle management

Provided by a mid-level HSE specialist now a consultant on HSE related matters.

"I participated in the learning environment as part of its proving trials. I came to it with 30 years' experience in the technical aspects of major accidents and my own thoughts about HSE culture and its management. It was clear that I knew both too much and too little. This is not for HSE professionals, those who seek to comply with rules and regulations or run the HSE processes. Rather, it [is] for those who make the real difference to life and death; those who manage the company; its people, the resources and most of all, the attitudes of both staff and contractors. It examines the way you recognise and approach key decisions and the effect of your actions in altering them. In my work, I talk about the ability to 'read' a plant. This is about opening participants' eyes and enabling them to understand how the people think, the motives behind their actions and the effects they have on

accidents. It is based on an immense amount of data and gives an excellent insight into how individuals and their behaviours have either a beneficial or adverse effect.

"While we set great store on measurable statistics, this examines the more subtle unquantifiable issues that are the real influences behind the statistics. This is not for the faint hearted. It is the most intensive and stressful training that I have ever undertaken, but I also learned more in the time than in any other situation. Most of what I learned was about me. It is better to call it an assessment; a self-assessment of your own attitudes, perceptions, complacency and particularly your blind spots."

7.6.3.3 Junior management

Junior level finance specialist with a background in mathematics.

"Not having an HSE background, I wasn't sure what to expect from the day, however I was not disappointed. Overall it was an intense, but extremely informative session. I enjoyed the metrics driven nature of the course and found the application of analytical methods to safety innovative and insightful. The pace of the course was quick, but felt natural and the rate of new information was good. There was also a good balance between gaining knowledge, and applying that knowledge within the simulation. My only request would have been to highlight/reiterate some of the key messages to take back with me. This way the impact it made on me would have been more digestible for feeding into my own organization. I would certainly

recommend this course to managers to raise understanding of safety, and believe it would prove invaluable to HSE professionals with the scope to implement such a system."

7.7 Perceived usefulness

At the end of every final interview, each participant was asked to score the SCLE, from their perspective, on its use as a teaching tool for management. It was stressed that this score was not intended to reflect how much they personally had gained from the experience but how useful they believed it would be in industry. The results from all of the participants were tabulated as in the other sections according to the different groups and are presented in Table 7.12.

Units of Analysis	Average Score for the Unit
Junior Management	9.2
HSE	9.2
Senior Management	8.9
Oil Industry Experience	8.9
Non-oil Industry Experience	8.8
General Management	8.7
Finance	8.7
Middle Management	8.6

Table 7.12 Participants' perceived usefulness of SCLE as a teaching tool.

All of the groups scored the SCLE between 8.6 and 9.2 on a scale of 1 to 10 (4 of the 17 participants scored the tool 10). With a variance of only 0.6 between the top group score and the lowest, there was little information to be derived other than that all of the participants scored the SCLE very highly as an effective teaching tool. The most significant insight from this simple scoring test was that the HSE professionals scored the tool the highest. Given that the combined experience of the top 5 of this group totals over 150 years then their opinion represents a significant endorsement of the usefulness of the SCLE as a safety culture teaching tool.

7.8 Thematic analysis

A thematic analysis of the observations/comments from the 17 participants in reaction to their experiences was carried out. This analysis identified 7 main themes. The information was synthesised from both their verbal responses (from the audio-visual records) and their written feedback post-session. The results are presented in Table 7.13. What is immediately apparent is that the positive observations far outweigh the negative ones; nevertheless, there were some negative reactions and opinions concerning the SCLE.

7.8.1 Initial reactions

Almost half of the participants expressed negative reactions to the magnitude of the task they were about to undertake. What is important to note is that, while this ‘initial reaction’ theme has been classified as negative, in the actual learning sessions, once the participants had overcome these negative feelings regarding the volume of data and the presentation mechanisms they were required to understand and evaluate, they quickly forgot their initial reactions.

7.8.2 Emotional reactions

Approximately two-thirds of the participants referred to how exhausted and drained/tired they became during the actual session. While all acknowledged that their abilities to distil information from the SCLE screens improved rapidly, they still expressed feelings of exhaustion and stress. This is not necessarily a bad thing and researchers are looking into exactly how stress affects learning. Some (Joëls et al. 2006) have predicted that future research will show that *"stress experienced within the context of a learning experience will induce focused attention and improve memory of relevant over irrelevant (later) information".* Work is currently underway at Bristol and Exeter universities seeking to provide greater insight into the effects of stress on learning.

7.8.3 Positive themes

By far the most common belief/opinion/feeling/expression throughout the analyses of the feedback fell into the category of 'highly positive'. All of the candidates stated in one way or another that they had learned an enormous amount during the day and that they saw great potential for the SCLE (tempered by the reservations discussed in section 7.8.4) as a teaching tool.

7.8.4 Post-session reservations

What is of most concern is the negative reaction at the end of the session where a quarter of the participants expressed reservations about the possibility of the tool not being embraced by industry due to a variety of factors. Comfort can, and should, be taken from the fact that these reservations are not about the tool or its capabilities, but about the receptiveness of an industrial world which might not be as amenable to change as could be hoped for. In the words of Anton Ego in Disney's Ratatouille - *"The new needs friends".*

+ve/ neutral /-ve	Theme	Key Observations	% of Participants
	Initial Reaction	*"Daunting"; "Initial Sense of Panic"; "Overwhelming"; "Threatening"; "Strange"; "Switch-off".*	41% (7/17)
	Effectiveness as a teaching tool	*"Fundamental key, perfectly demonstrated"; "Powerful"; "Extremely instructive/informative"; "Changing perceptions"; "Eye-opening"; "Comprehensive learning experience"; "Gained depth of experience"; "Extremely successful"; "Immersed in the experience".*	94% (16/17)
	General impression of the overall learning environment	*"Impressive"; "Insightful"; "Proactive"; "innovative"; "Demonstrative"; "Challenging"; "Highly credible".*	88% (15/17)
	Emotional reaction(s) during the learning experience	*"Very stressed"; "Exhausting"; "Head Buzzing"; "Drained"; "Demanding".*	65% (11/17)
	Usefulness of the learning environment to improving safety culture awareness	*"Immense benefit"; "Excellent"; "Huge potential"; "Invaluable"; "Immensely valuable".*	59% (10/17)
	Key messages surrounding applicability of the learning environment	*"Potential to raise safety issues"; "Improving safety performance"; "Improving safe behaviours"; "Is an education tool and not a training tool"; "Will help understand safety culture"; "Will help improve safety culture"; "Contributing to mindfulness".*	76% (13/17)
	Reservations concerning the future of the tool as an aid to improving safety culture in industry	*"Newness may be a risk to acceptance by industry"; "May be a step too far for senior management to commit to"; "Those who need to attend may not"; "Lacks credibility given source".*	24% (4/17)

Table 7.13 Thematic analysis of participant feedback.

Figure 7.20 illustrates the positives and negatives from the thematic analysis in bar chart form.

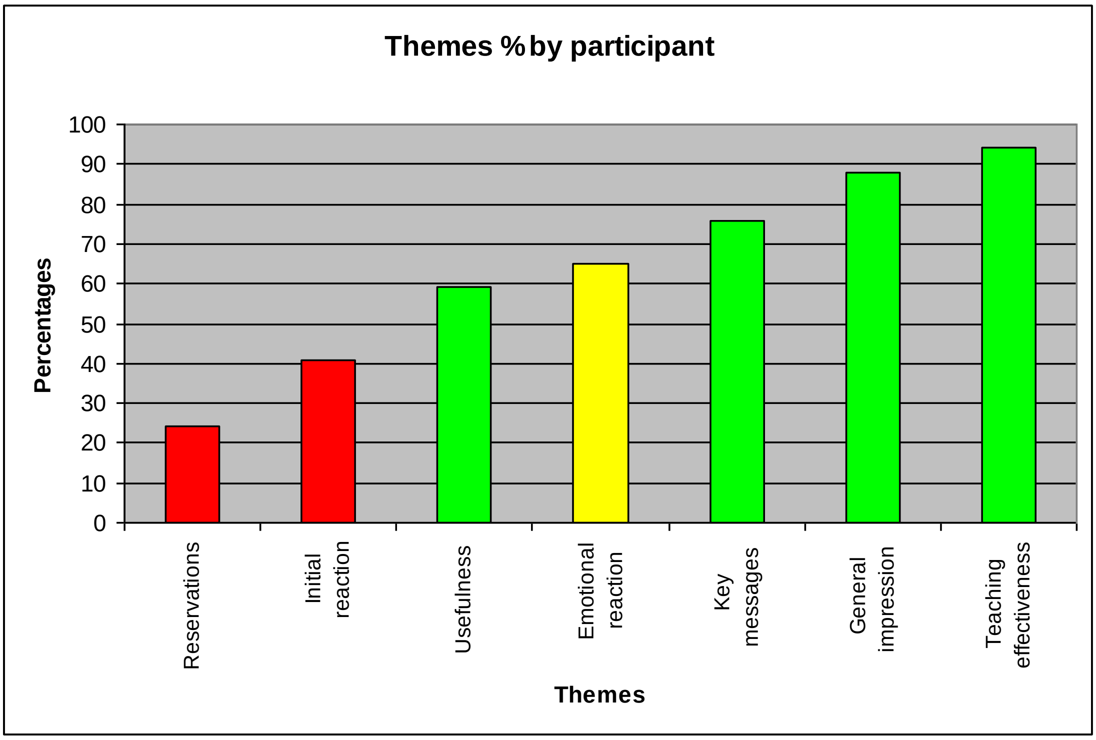


Figure 7.20 Themes expressed by percentage of participants.

7.9 Triangulation

The data analyses showed that there had been either a demonstrable change in abilities or that there had been a measurable shift in beliefs. In the first instance, the submitted annual culture reports demonstrated a clear improvement in the content of participants' annual reports (Figures 7.9 – 7.11). In the second, the differences recorded between the pre- and post-interview questions clearly demonstrated an increase in belief regarding the contribution of the various elements of the SCLE towards evaluating organisational safety culture (Figures 7.12 – 7.17) with further detail in Tables 7.4 – 7.11.

As expected, and in this respect it reinforced the effectiveness of the SCLE as a tool to teach management how to evaluate safety culture, the greatest improvements were in the groups who had had least exposure in their careers to the oil industry and to safety and safety culture. Figure 7.18 illustrates that the non-oil personnel exhibited almost twice the change in belief (as measured from the pre- and post-interviews) as the oil industry group.

The analyses of the participants' opinions of the importance of the individual screens were similar to the author's with, again, the expected closest matches to be found in the senior, oil industry HSE participants which is the same profile as the author (Figure 7.6).

The improvement that all of the participants exhibited in their annual safety culture reports and their changes in their perceptions of how various safety related topics affect organisational safety culture is supported by the high scores that all groups gave (Table 7.12) in terms of their view of the usefulness of the SCLE as an effective teaching tool

Further support for the case that the SCLE delivers improved safety culture awareness came from the feedback from the participants themselves. Though entirely subjective in nature, their observations were unanimously positive in terms of the knowledge they had gained as a result of their experiences and the benefits they believed the tool would bring to industry in terms of improving management's awareness of safety culture issues. The thematic analysis of participants' responses from both the audio-visual records and their written feedback provides strong support to the 8.9 score given that 94% (16/17) of the participants expressed very positive opinions on the SCLE's usefulness as a teaching tool.

Finally, the average score of all 17 participants on the SCLE's usefulness as a teaching tool was 8.9. While in no way direct proof in itself, this score provides support to the conclusion that the SCLE does answer both research questions. The data incorporated into the SCLE providing the answer to question 1 and the improvement to the participants' understanding of safety culture evaluation through presentation of this data by means of the technology answering question 2.

7.10 Climate or culture

In Chapter 3, the 9 couplets that formed the basis of the safety climate in the conceptual model were introduced. It might seem obvious that the participants should have been requested to assess the safety culture of the organisation in terms of these couplets. Asking them to do this was considered and subsequently rejected on the basis that these couplets represent the instantaneous safety culture, i.e. safety climate [based on Wiegman et al.'s (2002) synthesis] and, therefore, they are not representative of the long term safety culture. As the participants were providing an annual culture report and not an instantaneous climate report, there was no need to confuse the issue (and possibly the participants) by requiring that they present the information structured around the safety climate definition. That is not to say that there is not the possibility for researching further into how such an approach may be developed in the future.

7.11 Summary

This chapter began by looking at the data collected from the various sources: audio-visual, reports, e-mail traffic, pre- and post-session interviews and participant feedback. The data were analysed using a variety of approaches. In the case of the audio-visual material, it was reviewed second by second. The reports (which were a key source of information regarding the effectiveness of the SCLE) were subjected to a peer review analysis using a marking template which had also been peer reviewed. Whenever an opportunity arose either through closed interview questions prompting a 'yes' or 'no' response, or by asking for specific scoring, a quantified approach to the analysis was carried out.

While analysis of the audio-visual material provided little in terms of useful outputs, the analysis of the data deriving from the various sources indicates that the Safety Culture Learning Environment, given the limited number of participants available, does appear to be achieving its primary purpose, which is to provide the knowledge to management on how to measure, evaluate and understand the safety culture of their organisations. Many of the results are intuitively what one would expect given the differing backgrounds and experiences of the participants. Rather than suggest that the tool is not offering anything new, this result should serve to increase the 'comfort factor' that the tool is actually performing as required and that in situations where there have been clear gains in levels of knowledge or understanding by some of the non-specialists that these are genuine improvements.

The feedback from all of the participants has provided further support to the findings described above as has the high scoring by all (8.9/10) on their views regarding the usefulness of the SCLE as a safety culture teaching tool.

Chapter 8 Discussion

8.1 Review

Organisations are under increasing pressure from both society and the law to minimise the risk of accidents to both the workforce and the public. For several decades, much progress has been made toward achieving this goal and, with each new approach to improving safety so performance has improved in parallel (HSE [3] 2013). Since the latter part of the 20th century, however, improvements in safety performance have slowed as previous safety management initiatives have accomplished much of what they set out to achieve (Fennell 2006, HSE [2] 2013, OGP 1997- 2013).

Following the Chernobyl disaster, the concept of a safety culture began to enter into everyday parlance and major efforts were expended both in academia and industry to identify mechanisms to quantify the safety culture of an organisation. The most popular approach to achieving this goal was the safety culture survey. Here, a set of questions are developed on particular safety culture topics of interest and then presented to a sample group chosen to represent the organisation being investigated The results of the survey are then analysed using appropriate statistical tools and the findings published with the expectation of corrective actions being taken based on the findings to improve the safety culture of the organisation.

For over 15 years, experts have been highlighting the fact that safety culture questionnaire surveys are an unreliable mechanism to measure organisational safety culture (section 2.5). A variety of factors are quoted in support of this position including such issues as rating scales (Friedman & Amoo 1999, Schwarz et al. 1991), question ordering (Holbrook et al. 2007, Hyman & Sheatsley 1950, Jordan-Zachery & Seltzer 2011, Keeter 2014, Link 1946, McFarland 1981, Schuman & Ludwig 1983, Schuman & Presser 1981), question bias (Choi & Pak 2005, Friedman & Amoo 1999, Paulhus, 1991), sample selection (Fernandez-Muniz et al. 2009) and more. Allied to the problems inherent in safety questionnaire surveys is the issue with identifying an agreed definition of safety culture. This difficulty has been compounded by the inclusion of the term 'safety climate', which carries its own range of diverse definitions which have further obfuscated a common perception of either term.

The need for a different approach to evaluating safety culture has been clearly understood (Glendon & Stanton 2000) though none to date has been forthcoming. This research set out to answer two questions both of which are important in the search for a viable solution to the problem of measuring and evaluating organisational safety culture.

1. *"How can safety culture be modelled effectively from existing data?"*
2. *"How can management be educated in the measurement and evaluation of safety culture of their organisations?"*

By itself, an answer to question 1, while certainly useful as an end product, would fall short of the real goal which is identifying ways, not only to measure safety culture, but ways to improve it at the same time. This can only be achieved by addressing the real influences driving corporate safety culture, i.e. management and most notably, chief executives themselves. This resulted in the second research question which sought to establish whether a ‘safety culture training tool’ was an achievable objective and if so, how such a tool could be designed, implemented and evaluated.

Wiegmann et al.’s (2002) synthesis of safety culture definition provided the launching pad for a data-driven solution reinforced by the Center for Chemical Process Safety (2011) observation that the true safety culture of an organisation is how it behaves “*when no-one is watching*”. These provoked the theory that there existed an opportunity to evaluate safety culture from an alternative perspective. By examining the typical safety related data held within most, if not all, organisations operating in high risk environments, it was possible to identify the various safety culture pointers which the organisation produced, unknown to itself, yet which, on analysis, yielded much of what was required to piece together a picture of the organisation’s safety culture. These cultural ‘jigsaw’ pieces, while revealing little in isolation, when brought together provided an overall picture of corporate safety culture to the trained eye.

Having located the answer to research question 1, the next step was to address how this knowledge could be imparted most effectively to those who have the most influence on corporate safety culture - the management of the organisation. Experience takes time to acquire and time is a commodity that many executives do not possess in abundance. Any solution would therefore need to be effective and efficient in terms of demands on their available time. The initial idea that some form of corporate safety simulator might be the best vehicle to deliver the requisite solution was dismissed due to the inability to link managerial initiatives to the occurrence of specific events. A review of different approaches (Thomas 2003) saw all but one of them being rejected immediately leaving the development of an emulator as the only apparently viable solution. This approach, however, had one major drawback; the idea that individuals of the calibre and capability of chief executives might be prepared to sit attentively through potentially several hours of passive presentation rendered this solution unworkable.

The work of Mezirow (1997) offered promise and further investigation of his theories led to the idea that the solution to research question 2 would be to develop a novel tool. The Safety Culture Learning Environment was designed to offer participants the opportunity to interact with their company while accepting the requirement that the knowledge base, through necessity, had to remain unaltered during the session in order to preserve the underlying databases, which were designed to present the various safety culture concepts to the participants.

By using commercially available tools to facilitate a rapid prototyping approach to the proof of concept, it was possible to construct, in a very short time, a robust, stable and effective tool which, as Horton and Radcliffe (1995, p. 12) conclude should – *"lead to new insights or answers to the questions, but will also lead to adaptations and evolutions to address new issues discovered during and after the creation of the prototype"*. It should be noted that, even though the evaluation component of the project is complete, work has continued on new developments to address new opportunities and ideas. Examples include a 'reporting culture index' which will enable a historical picture of the reporting culture of the organisation to be displayed for any department or the organisation as a whole and the inclusion of a GPS (Global

Positioning System) module which will facilitate assessment of certain operational integrity issues.

The solution to the problem of how to present the large quantities of information identified from the analysis of Wiegmann et al.'s. (2002) synthesis of safety culture to the participants was inspired by the use of video walls in such locations as operational control rooms and financial trading rooms. In light of the apparent success of this approach in these situations, the decision was made to present most of the information via a video wall.

Following the decision on the presentation style, the databases which would be used to power the SCLE were created. Where any possibility existed, no matter how remote, that the data could be confused with real events, people, companies or locations, a thorough data anonymisation exercise was carried out in accordance with recognised procedures (Edgar 2003).

During the construction of the SCLE, attention was paid to the look and feel of the tool in order to minimise the confusion participants may experience with regard to data interpretation. This included the SCLE colour scheme and chart design. Finally, when all of the modules were in place and final testing completed a search for suitable participants began in earnest.

Participants were chosen in order to represent as broad a spectrum as realistically achievable given the constraints of time, location and cost. After establishing the minimum acceptable sample population, a 'diagonal slice' approach was adopted to source suitable candidates. The ‘diagonal slice’ meant that participants representing different disciplines, experiences and seniority levels would be included. This helped ensure as far as possible that the evaluation of the SCLE would be based on a diverse range of corporate and managerial experiences in order to ascertain the SCLE’s applicability to different industries, managerial levels and professional backgrounds.

With the exception of some fine-tuning in regard to SCLE timings, all development work on the tool was suspended when the first participant started his session. This was done in order to present a consistent learning environment to all individuals. The consequence of this decision had an impact on the selection of an appropriate research methodology. Initially, the two strongest candidates were the ‘action research’ and ‘design science research’ methodologies. Both of these involve a feedback loop, to introduce improvements identified through use of the artefact, back into the design followed by a re-evaluation of the artefact (sections 4.2.1 and 4.2.2). This was not possible in this project due to the need to maintain a common learning environment for all participants.

Attention turned to evaluation and case study methodologies as possible approaches. Both offered clear advantages. The model on which the SCLE was based was constructed from the author’s knowledge and experience. The author also needed to be involved in role playing during all sessions as well as fulfilling the role of educator. These two issues meant that it was unlikely that subsequent evaluation of the SCLE as a viable teaching tool would survive a critical review if based on an evaluation methodology approach. For this reason, the final decision to adopt the case study methodology was made due to the clear requirement for researcher impartiality in the evaluation methodology.

According to Yin (1994), the case study is an appropriate methodology when the research questions begin with ‘how’ as is the case in this project. The case study methodology also welcomes the researcher’s involvement (Yin 1994). For these reasons, and others identified in section 4.2.4, the case study methodology was adopted. The particular form of the case study followed Yin’s definition of a ‘single-case, holistic’ study (Yin 2014); the single case being the answer to research question 1, with the unit of analysis being the groups into which the 17 participants (units of observation) were classified.

In order to avoid participants sitting through a passive emulation, but rather involve them in an active learning environment, a mechanism to generate their involvement was required. This was achieved through the use of a built-in e-mail server which delivered over 250 e-mails to the participants during the 8 hour session. The e-mail system was a key component of the learning environment and realism was considered critical to engaging participants by reducing, as far as possible, any ‘exercise unreality’ as described in section 4.3.5.

E-mails were divided into 3 categories depending on whether they were providing passive information such as accident notification, asking for management intervention in on-going safety issues in the company or finally, requests from the board of directors which the participant was required to answer. It was the last of these categories that provided the bulk of the data on which the effectiveness of the SCLE as a teaching tool was evaluated.

Data were collected in a number of ways. All participants were made aware from the start, and all agreed, that the entire session would be filmed with backup audio recording on the basis that it remain strictly confidential. In addition to the audio-visual record, all e-mail traffic was routed to the educator's inbox regardless of the participants' intended recipients. Finally, at the end of every learning environment 'year', participants were required to submit an annual organisational safety culture report to the fictitious chairman of the board. The accumulated data amounted to over 130 hours of audio-visual material in addition to hundreds of written communications in the form of the aforementioned reports and other e-mail communications.

From the analysis of the data, there is evidence to support the conclusion that the SCLE does deliver useful insights into how to measure, evaluate and understand safety culture. It is also clear that more can be done to enhance the tool and develop the environment and it is anticipated that this will happen, should the tool succeed in making the leap from a research project to actual industrial application. Some of the most interesting insights are discussed in section 8.2

The picture emerging from this project and the evaluation of the participants' performances is that safety culture can be effectively modelled from existing data and that a tool can be produced that can help inform managers, from a broad range of experiences and seniority levels, how to measure and evaluate the safety culture of their organisations. Additionally, several ideas have been generated for possible future research, not only in to how to improve the tool itself but also into how this type of teaching approach can be improved upon. These are described in more detail in section 8.3.

The choice of a case study approach when reconsidered at the end of the project remains the best choice. Of the best alternative contenders, the need for a feedback loop in both the action research and design science research approaches would have meant that direct comparisons between the different participant groups would have been impossible and any attempt to do so might have adversely affected the outcome of the project. It should be noted that, with the evaluation of the tool as a method for imparting knowledge to participants complete, at least as far as this project is concerned, future action research/design science research projects could be conducted using the tool to identify further improvements in the actual design, construction and delivery approaches.

8.2 Discussion topics

8.2.1 Role of the HSE personnel in the future

Analysis of the modifications made by each participant to the HSE manager's job description at the end of the session suggests that the message delivered throughout the session on the need for specific skills in the areas of human factors, behavioural safety, safety culture, etc. had not fallen on deaf ears. The extensive review of over 11,000 (oil industry related) job adverts/descriptions placed over the last three years combined with the two plateaus that the global oil industry has experienced since 2002 as shown in Figure 1.4 adds weight to the proposal by Fennell (2006) that the next step in safety performance improvement will require much more in the way of a human factors approach to safety. If the success in modifying participants' views on the importance of these skills in their HSE manager can be translated into a similar thirst for change by industry through the use of tools such as the SCLE then a major step towards the next level of safety performance improvement may be within reach. This does not mean that existing skill-sets should be ignored. These are the skills which helped propel industry to where it is today and they will continue to be needed in the future to prevent industry reverting to previous poor safety performance levels. Additional skills in the cultural/human factors/behavioural safety arenas are essential to further improvement.

8.2.2 Management system contribution to safety culture assessment

Possibly the biggest surprise of this project was the almost universal dismissal of safety management system deficiencies as a useful source of information regarding corporate safety culture. Apart from the obvious surprise that this information was not deemed as useful as all of the other information, this view may also have an impact on the validity of safety culture questionnaires as an effective tool to establish organisational safety culture. In section 2.6, the work of Flin et al. (2000) identified 18 different safety climate surveys. The overlap of the themes from these surveys with the sections in a typical safety management system was highlighted in Table 2.7. If the participants, in their roles as Managing Directors of Lancaster Oil Ltd. dismissed the input from safety management system failures as useful pointers to organisational safety culture, does this then mean that they are dismissing what could be considered as the foundations of safety culture/climate surveys? If so, then, not only are the contents of these questionnaires in doubt, as highlighted in section 2.5, but even had they not been in question, the foundations on which they may have been based seem to have been rejected by the participants in this project.

8.2.3 Participant use of data screens

It had been anticipated that there would be some form of link between screen access and culture analysis. As it turned out, this was not the case. One reason for this may have been the low number of participants and the variety of backgrounds and experiences and even, possibly, ages. Perhaps there may be patterns in how people use this sort of system which can be traced back to such factors as experience, technical awareness, age, etc., but, as already stated, discovering these patterns was not the objective of this research though a suggestion for future research is included in section 8.3.

8.2.4 Generalisation to other industries

The model used to build the SCLE was based on a fictitious oil company. It could, therefore, be argued that the model has little or no validity when applied to other industries and, from one perspective, that might be perceived as a valid opinion. There is, however, a large ‘but’ associated with that observation and it is centred around what exactly comprises the model. An accident is an accident is an accident. OHSAS 18001 was not developed for the oil industry alone. It was developed for all industries, from a small 20-man factory to an industry the size of a global mining company possibly employing over a hundred thousand staff. The principles of safety are consistent across all segments of industry/society so whether the distribution of accidents/incidents is in a construction company or a nuclear plant or a mining company is completely irrelevant. Managers who are not committed to safety are not confined to the oil industry alone, neither are major industrial disasters as shown in Table 1.1.

Any discussion on the use of the SCLE needs to be considered from two different perspectives. The first is whether the tool as it stands can be used to teach personnel from non-oil companies. The second is whether the tool itself can be converted to model an organisation operating in a different type of high risk environment.

The answer to the first question is that the evidence from this research is that the tool can be used to teach people from any industry. Two-thirds of the participants in this project were not from an oil industry background, yet the analysis did not provide any suggestion that they had not learned as ably or as much as their oil industry colleagues. Figures 7.9 and 7.10 clearly demonstrate that the non-oil, general management and finance groups learned more quickly than the oil experienced groups despite knowing nothing at all about the industry in question.

As far as answering the second question is concerned, all that is required to convert this tool to one which has equal applicability to other industries is to change the corporate structure (few construction companies have ‘well operations’ departments) to mirror a typical company in the particular industry sector. A change would also be required to the e-mail text to reflect typical terminology specific to other industrial sectors and finally, photographs (included in accident reports) would need to be changed. With these sorts of changes in place, the SCLE becomes immediately applicable to a different industry.

8.2.5 Repeatability

This study looked at a small sample of professionals from a variety of industries, managerial levels and job disciplines. From the evidence obtained through the various analyses, the Safety Culture Learning Environment does appear to deliver what is expected of it in terms of improving participants' abilities to evaluate organisational safety culture based on existing operational data. As a useful tool for industry in general, the results obtained in this project would need to be repeatable. In reality, the results have already been shown to be repeatable on the sample of 17 participants. It was not the case that all of the individuals sat down together and went through the entire session at the same time. Participants took part in the research at different times over a period of approximately 1 year.

The repeatability of the results can be seen in the graph in Appendix 7 which shows the improvements exhibited by most of the individual participants. While there is little insight from this plot in terms of patterns within the data, one observation which can be made is that 14 of the 17 participants clearly improved in their abilities to evaluate and report on the safety culture of the organisation over the 5-year period of the SCLE. Of the three who did not show improvement, only one showed a marked decrease in performance and this was the same individual who was unable to continue the final interview (section 7.4) due to an inability to think about the subject any further.

Industry is not populated by individuals of identical intellectual and analytical abilities and so the fact that some of the participants did not glean as much as might be hoped from the experience is more a function of the make-up of this sample of participants rather than the effectiveness of the SCLE.

8.2.6 Validity

This project set out to identify a pragmatic and novel solution to a historical problem in the domain of safety culture measurement and evaluation. It would appear from the analysis of the data from the 17 sessions run over the period of a year that the tool does deliver increased abilities in all participants (with varying degrees of success as is normal with a diverse population). Whether the knowledge that the tool is capable of imparting will actually make a difference in industry by improving organisational safety culture can not, at this stage, be guaranteed although there are encouraging pointers in both the data and the participant feedback. Certainly, the perennial question of how much of the learning participants will retain and what they can implement in their own organisations on their return can not readily be quantified until the tool makes the transition to industry. Finally, safety culture change does not happen in a day. The only way to begin to have an insight on whether the tool works as desired will be to take a long-term view (a number of years) of the safety performance of participants' companies and even then, it will most likely be extremely difficult, if not impossible, to identify future organisational changes or improvements that can be definitely attributed to previous participation in the SCLE.

Stake (1980 cited in Myers 2000, p. 1) proposes that *"inquiry be directed toward gathering information that has practical and functional uses rather than the cultivation of persistent pedantic laws"*, with a further suggestion that *"such methods may be in conceptual harmony with the professional reader's experience and thus be* *a natural basis for generalization.*" This is very much the case with this research project. There are no specific 'laws' to cultivate. Myers (2000) comments on the fact that future 'subjects' will undoubtedly be different and as a consequence, the results from their learning experience may differ. The objective therefore should be to produce research that can inform and enhance readers' understanding. It is the author's personal belief that this project has achieved that aim.

8.2.7 Impact of this project

The project will impact on three areas –

- Industry
- Academia
- Training

Industry has sought to improve safety performance for many decades and this tool can contribute not only to the development of different approaches to measuring safety culture but also to the next generation of teaching tools aimed at the less well-defined aspects of safety management. This should be expected, in the long term, to help improve industrial safety performance through increased awareness of critical components of organisational safety management. It is hoped that the development of the SCLE will encourage further research into the use of this approach in the field of safety training.

Finally, this project has resulted in a new way of educating management on the subject of safety culture. On the basis of the feedback from the participants the technique has received unanimous approval as an effective way to deliver safety culture training. If this can be brought to industry then the benefits to the health and safety of the workforce may be enhanced through improved awareness and safety management skills.

As it stood during the evaluation phase, the SCLE was only able to accommodate one participant at a time and required a large amount of equipment as identified in section 4.3.4. Since then the SCLE has been successfully migrated from the personal computers used during the evaluation to small (8 inch) tablet computers. While the equipment list is not significantly different, the space required has been dramatically reduced. This means that it is now possible to provide 14 screen video walls which will fit comfortably on individuals' desks thus enabling multiple participants to be trained at the same time by providing a synchronised SCLE to each simultaneously. The consequence of this is that it is possible to include a much deeper level of organisational management in the learning experience, thereby reinforcing the understanding of safety culture at a correspondingly deeper level in the organisation.

As mentioned in the observations regarding generalisation across multiple industries, work is also under way to identify what needs to be done to incorporate other types of organisations. The mining and construction industries are good candidates and the belief is that there should be little difficulty in migrating the concept from oil to these industries. What is important is to create a familiar environment in which management from other industries will be 'comfortable' with the safety topics and interactions with which they will be presented. A credible model of, for example, a mining company, will require appropriate department titles, work types, jargon, etc. What will not need to vary, however, will be the underlying data such as - accident frequencies, accident severities, training uptake, pro-activity metrics, sub-contractor influences, HSE goals, etc. These are applicable to all activities in all industries.

8.3 Ideas for further research

One of the benefits of putting several participants through such a project is the opportunity to obtain suggestions from them on how the actual training experience can be improved from their unique perspective. The participants scored the SCLE very highly; a quarter of them giving it 10/10 as a teaching tool. Notably, two of these scores came from the two most experienced HSE participants. While in no way representative of how industry may view the SCLE, it is nevertheless much more reassuring to receive opinions at this level of the approval scale rather than the alternative.

Suggestions on how to improve the tool referred not only to the content of the learning environment but also to how it was constructed and how it was used. The researcher, by definition, is close to the subject on a continuous basis so the opportunity to view the work through many different pairs of eyes is not one which was to be squandered. Only a sample of the suggestions accompanied by some of the author's thoughts, are presented in the following sections as possible areas for future research on this type of teaching tool.

8.3.1 Designing charts and graphs for video wall teaching

The maxim put forward by Tufte "*Above all, do no harm"* (1998, p. 81) was very much to the fore during the design of the learning environment. Graphs and charts were kept as simple as possible and all attempts to 'jazz up' the displays were resisted.

It would be interesting to see how the way data are presented in this type of teaching tool affects the ways in which the participants both use and learn from them.

8.3.2 Learners' use of the information being displayed

An interesting, if somewhat irritating, problem that was noted throughout all of the sessions was the universal acceptance of the data being displayed as the only data available. Without exception, all of the participants had to be continually coaxed into clicking on the tabs to display some of the other 40 pages of data that were not initially displayed on the 14 available monitors.

As the day progressed, the participants did show small signs of wanting to explore further by selecting other data pages although this was not a consistent pattern. It is unclear whether this apparent reluctance to look at the additional information was due to information overload early on in the session, unfamiliarity with the system as a whole, fear of clicking on the wrong button or whether the adage 'out of sight, out of mind' contributed to the participants not voluntarily using all of the data available to them.

In the role of educator, the author regularly made comments such as *"There is some very good news concealed in the data"* or *"Something is happening that would be keeping me awake at nights were I you"* or similar comments to encourage them to explore to see if they could find the answer.

8.3.3 Absorption of data by learners in a fixed period of time

The SCLE was described by all participants during their second interview using various expressions such as - *“highly stressful”*, *“intense”* and *“very demanding”*. All declared that they had learned an enormous amount about safety culture and management, yet it is unlikely that they had absorbed anything like the total amount of knowledge that was available to them. There is little point in developing the SCLE to deliver even more information if participants are unable to absorb it.

8.3.4 Data usage changes over time

The review of the screen access data did not in itself reveal any patterns in how the participants accessed the information on the various screens and pages. Intuitively however, it feels as if there should be some sort of changing pattern of data usage as participants’ knowledge increases about what the data are telling them and where the information can be accessed (different screens and pages).

With such a small and diverse sample, it is possible that usage patterns may be too indistinct to uncover. Perhaps a larger study, specifically targeted at understanding how the participants use the data screens, may reveal information that could be used to improve the effectiveness of the learning environment interface so maximising the level of absorption by the participants.

8.3.5 Distribution of information on video wall for teaching purposes

With the exception of the two screens displaying the HSE MS deficiencies (organigram and radar) being placed adjacent to each other, the layout of the screens on which the data were displayed was completely random. It is not clear, and there was no indication from the analysis of screen access, whether there were any patterns in participant access to the information. It would have been interesting to observe participant behaviour in respect of how they accessed the various elements of the video wall to see if there is an optimum layout to maximise their learning opportunities.

While purely coincidental, the layout selected for the research placed the two most useful screens (as decided by the participants) immediately beside the two screens unanimously defined as the least important. Whether this, or any other aspect of the layout, affected participant learning is unknown.

Two participants did suggest changing the layout of the screens to facilitate their abilities to glean knowledge from the data being presented. While interesting as isolated opinions, it does not necessarily follow that all participants would feel the same.

8.3.6 The use of online avatars as virtual staff in learning environments

Online avatars were made available as described in Chapter 6. The fact that they were never once used was mildly surprising. Is there a reason why people do not use online avatars? Do they have little faith in them? Do they rely on the presence of the educator? The answers might be interesting for the future development of such teaching tools.

8.3.7 Industrial and academic applicability

Despite being designed as a ‘proof of concept’, the SCLE, as it stands today, is ready for introduction to the wider industrial/academic arena. The improvements exhibited by the various groups illustrate that the tool has application in all areas of industry though it is most applicable to those operating in high risk environments. There is also the possibility of the SCLE being used as a teaching tool within the context of safety training or even in Masters of Business Administration programmes in academic institutions as a way to educate Chief Executive Officers (CEO) of the future. In either case, the SCLE can be implemented immediately and without modification in either situation. One UK university has already expressed interest in examining the possibility of using the SCLE in one of their specialist courses.

8.3.8 Management system failure analysis

All failures are equal but it may be that some are more equal then others. Each failure of the safety management system that allowed an accident to take place was given the same score when it came to weighting the contributions to the various graphs and charts. It is not clear whether this is the best approach or whether management system failures could/should be numerically weighted according to how important they are in contributing to an accident. For example, is ‘inadequate supervision’ more than, less than or equally important as ‘lack of education/experience’. Being able to get more accurate ideas about which parts of the safety management system are the most significant in accident causation and so need to be addressed first may go some way to supporting effective safety management.

8.3.9 Adapting the learning environment for multiple participants

The challenges surrounding teaching multiple participants simultaneously are very different from those concerned with individual training. While the migration of the software to run on tablet computers (enabling 1 video wall per participant) was relatively straightforward from a technical perspective, designing a suitable form of interaction with a group of participants will require much investigation. For example, how to answer questions and provide feedback may need to be done without the other participants becoming aware of the information exchange as this may detract from their own personal learning experiences. The rate of the passage of time within the learning environment will also continue the same as in the individual session; multiple participants, however, will undoubtedly require more time on some topics. This may cause a problem with session timing overall. These, and probably other issues not yet identified, mean that scaling the learning environment up to accommodate multiple participants will probably not be as simple as just adding more chairs, desks and computers. Work needs to be carried out on how to best scale this tool for the wider audience.

8.3.10 Development of a process safety culture learning environment

As was mentioned in Chapter 1, the SCLE developed during this project focused specifically on the issues relating to organisational safety culture. There have, however, been many events which were attributable to failures in process safety.

The data required to effectively model process safety culture is very different from that used in organisational safety culture. More information relating to leaks, equipment failures, unplanned shutdowns and general process safety culture attitudes is required. As an example of the last item, an e-mail trail (BP 2002) provided in Appendix 9, from the Texas City investigation, clearly illustrates that process safety issues may result from decisions made years before the ultimate disaster manifests itself. In this example, BP management made a clear decision not to invest ("Bank the savings now") in new equipment despite the issue being raised by the HSE personnel. A decision that ultimately contributed to the Texas City disaster a few years later (U.S. Chemical Safety and Hazard Investigation Board 2007 p.24)

One issue that would need to be addressed in the development of a process safety culture learning environment would be data availability. An issue that has confronted the author throughout his career in HSE management is "What constitutes an HSE related event?" By way of example, consider a pressure relief valve which operates correctly as the result of an over-pressure incident. In some operations, this is seen as an operational incident and is not reported in the safety statistics of the organisation (U.S. Chemical Safety and Hazard Investigation Board 2007 p.75). If the same event resulted in an explosion with fatalities it would then be considered as being within the domain of the HSE department. Yet in both cases, the root cause analysis of the original event and most of the lessons which can be learned remain the same.

Collecting data and information to successfully populate a process safety culture learning environment will therefore most likely require input from other operational departments in addition to HSE records.

Whether it is possible to combine process safety related data into the existing operational safety culture learning environment is a matter for consideration. The

SCLE contains over 250,000 data items on 54 pages of data. E-mails relating to organisational safety culture flow to the participant in a steady stream for 8 hours. Adding a much greater volume of information to the existing environment may result in overloading the participant.

Data availability, presentation to the participant, inclusion in the existing SCLE or the development of a new tool are all possible areas for future research.

8.3.11 Post-training follow-up

Training that does not produce positive results when the participants return to their normal work locations would not be considered particularly beneficial. In the wider domain of industrial application of this type of training tool, post-training follow-up and analysis may provide valuable information about how participants translated the knowledge they had gained during the training to their own particular circumstances.

8.3.12 International languages and audiences

The SCLE was developed to incorporate the option to present the data in languages other than English. The rationale behind this decision was that the tool could be used in a variety of different environments and cultures. More work will be required in order to evaluate how effective the tool, as it stands, is in providing the same level of training to different international cultures.

In addition, the SCLE was developed to train management (normally senior) in safety culture assessment. It may be that the level of commitment in terms of time that is required in the tool's current format is perceived by some to be too high. A 'distilled' or ‘cut down’ version of the tool which presents perhaps less detailed information yet succeeds in communicating the salient points might be possible; this could open use of the tool to a wider audience. Further research will be required to investigate how such a tool should be constructed and presented.

8.3.13 Adapting to alternative industrial operations

The SCLE was developed specifically around the day-to-day operations that might be encountered in a land-based, oil production operation. While the fundamentals of safety management and culture are effectively the same, the actual structure of organisations in fields such as mining, nuclear, construction, etc. are almost certainly going to be different. Similarly, while interpersonal communications may be similar, they will again most likely contain industry-specific references which participants from these particular industrial areas will expect to encounter in the e-mail traffic. In the case of accident reports, again, while the outcomes may be broadly similar (e.g. a broken arm is a broken arm regardless of the industry), the contributing factors leading up to the event may be different.

Before any SCLE can be developed to address the issues of differing industries, a degree of investigation will be required to identify the appropriate data around which an alternative, industry-specific SCLE could be constructed.

In addition, the educator’s profile will also need to be examined as it is unlikely that an educator from the oil industry will have the experience and knowledge to play a credible role in any other industry. Without specific knowledge of other industries, it is not possible for the author to comment on the existence or otherwise of ‘sub-cultures' in these industries. It is a fact that sub-cultures do exist in the oil industry; for example, the safety culture within a drilling department is often very different from the safety culture within other disciplines in the same organisation. The SCLE as it was developed for this project was designed to bring these sub-cultures to the attention of the participants. Any future developments aimed at producing a similar learning environment for other industrial disciplines would need to explore/evaluate the existence of sub-cultures within these industrial arenas.

8.4 Conclusions

This project set out to produce a novel solution to the challenge presented by the inadequacy of traditional survey questionnaires in evaluating corporate safety culture. In that quest, the project has been successful in that it has identified how an organisation's safety culture is reflected in its data, which can easily be collected. It has also produced a tool (Safety Culture Learning Environment) which has been demonstrated to improve participants' understanding of and ability to evaluate safety culture.

This SCLE approached the evaluation of safety culture from a completely different direction to traditional safety culture questionnaires inspired as it was by the observation by the CCPS (2011, p. 1) that organisational safety culture is what happens *"when no-one is looking"*. Using typical, readily-available data, a unique learning environment was constructed which demonstrates the effectiveness of this approach in educating participants in the understanding of safety culture as shown in Chapter 7.

As a teaching tool, the Safety Culture Learning Environment was rated highly by all of the participants for the manner in which it had 'opened their eyes' to the subject of safety culture and how it could be evaluated. Four of the 17 participants awarded it a score of 10/10. While this is clear testament to the opinions of the participants, they were nevertheless only a small diagonal slice sample of the general industrial management population, and there is always the possibility that others might find the SCLE less effective. Only more exposure within industry will help identify whether the participants' opinions are shared with the wider industrial community.

All of the issues surrounding questionnaire design and interpretation have been eliminated, and replaced with a picture of how an organisation actually functions on a day-to-day basis. The approach to safety culture evaluation and the training provided by the SCLE are intended to give participants the capacity to return to their own companies and customise the knowledge and insights they have gained to their own particular circumstances. As the tool has not yet been applied in an industrial environment, no data exist on how participants have applied their new abilities to actual functioning organisations. Following up how this knowledge is applied has been identified as a possible future investigation project in section 8.3.11. This tool would appear to have the potential to provide a viable solution to the traditional safety culture evaluation challenge. The SCLE is not perfect, however, and development work will always be on-going.

There are some potential barriers to be overcome before the SCLE is fully integrated into current management practices/training. The biggest obstacle to acceptance in industry is most likely to be fear. The initial view is that the learning environment is ‘daunting’ and ‘intimidating’. Comments have been made that senior management may be ‘put off’ by the thought of having to come to terms with all of the information that the tool feeds to them during the session. This was certainly an emotion that was expressed by some of the participants during the practical component of this project. In subsequent discussions with other parties who have not actually participated in the training similar expressions of ‘nervousness’ were forthcoming. This is not necessarily a reaction which can be successfully addressed. Regardless of the safety statistics, the author is never going to voluntarily jump out of an aircraft with a parachute no matter how low the probability of an accident might be. It is possible that there are some managers who are simply not going to risk placing themselves in a position where they fear they may be found wanting.

Time may also be an issue, as it may be difficult to persuade senior management to give up a full day of their time to devote to the subject of safety culture training. Regrettably, it may require progress in the domain of corporate (and personal) criminal proceedings, driven by increases in societal intolerance of work-related accidents, to persuade management of the importance of addressing safety culture as an equal to other management issues they currently deal with on a daily basis.

It remains to be seen how effective the tool may be in the wider industrial environment and this will be the next major challenge to be overcome. If the results from the analysis of the data collected for each participant are valid and the feedback from the participants is replicated by others in industry, then the SCLE could bring benefits in helping companies understand their prevalent safety culture; providing, that is, that there is an appetite in industry to consider safety culture from a different perspective. As Howard Aitken is quoted as saying - *"Don't worry about people stealing an idea. If it's original, you will have to ram it down their throats."*

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Appendix 1 HSE Management System

Lancaster Oil Ltd.

HSE Management System

Issue 1.0

H S E M S

Contents

Introduction

The successful operation of Lancaster Oil is dependent on us maintaining the highest standards of Health, Safety and Environmental performance. The Health and Safety of all of the individuals who work for Lancaster Oil- employees, contractors, partners or other third parties - is of paramount importance.

This HSE Management System document sets out the requirements described in the Lancaster Oil HSE Policy document.

While HSE is the direct responsibility of line management, without support from all the parties mentioned above, our goals will not be achieved and our efforts will have been wasted.

The management of Lancaster Oil is committed to integrating this HSE Management System into all operations and at all levels throughout the Company. Minimising risk, reducing loss and protecting the environment in which we live and work and which affects those around us, is critical to our success.

Mission

Our HSE Mission is to ensure that Health, Safety and Environmental issues are viewed by line management, our employees and contractors as being of the highest priority.

By treating Health, Safety and the Environment as key business drivers, we seek to minimise risk, reduce loss and establish continuously improving HSE performance both now and in the future.

Vision

To conduct our operations in a manner which encourages active participation by all management, employees and contractors in the process of continuous HSE improvement.

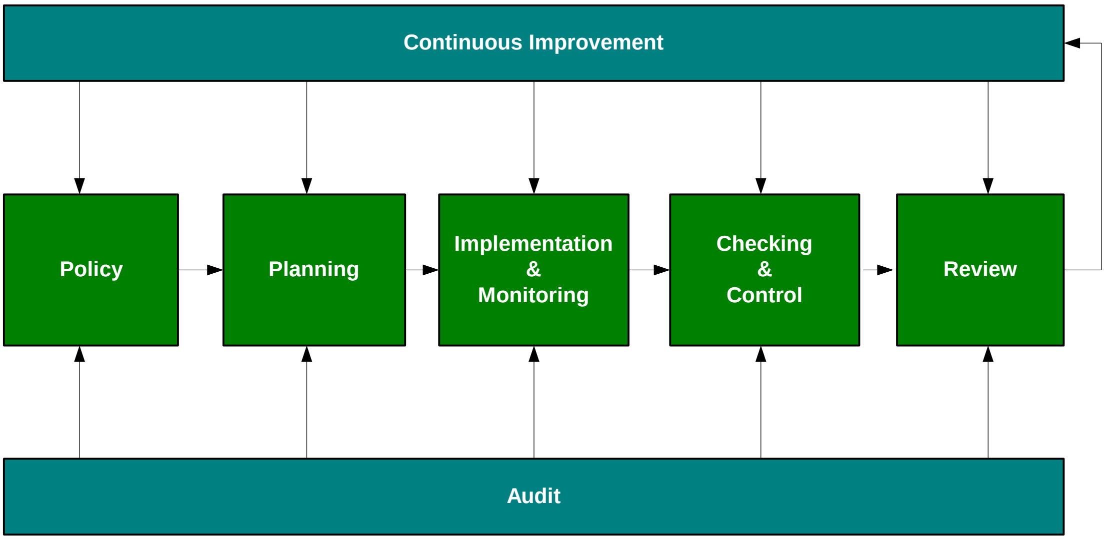
We shall realise this vision by: -

- Visible Leadership & Commitment from Senior Management
- Promoting a ‘no blame’ culture
- Encouraging reporting of all accidents and incidents (actual or possible)
- Adapting to changing demands placed on the Company
- Providing appropriate HSE training as required
- Incorporating HSE as an accepted component of all our operations
- Empowering everyone associated with our operations to take a proactive approach to HSE
- Defining clear HSE objectives and performance targets
- Fostering an open communications environment among Management, Employees, Contractors, Partners and other relevant third parties

HSE Management System

This Health, Safety & Environmental Management System (HSE MS) provides the structure within which Lancaster Oil will manage its HSE activities. The HSE MS will be implemented both at head office and in the field thereby providing a common HSE management philosophy at all locations.

This Management System shall be communicated to all of our employees and contractors. All our contractors will be required to demonstrate that their own HSE management systems comply with the requirements set out in this document.



Policy

Goal

There shall be an Occupational Health, Safety & Environmental policy authorised by senior management which clearly states the Company's commitment to Health, Safety & the Environment.

Processes

Policy

Management is responsible for developing Health, Safety & Environment policies applicable to Lancaster Oil requirements at all locations.

Strategy

The Company's HSE strategy will be defined by line management and communicated to all of our employees, contractors and other third parties associated with our operations.

Planning

Goal

The Company shall establish and maintain procedures for the ongoing identification of hazards, the assessment of risks and the implementation of necessary control measures.

Processes

Risk & Hazard Assessment

Systems shall be developed and implemented to identify the hazards associated with our operations and the associated level of risk.

Risk assessment shall be an integral component of all of our activities and systems shall be implemented to ensure that risk assessment is carried out at every appropriate stage in a project.

The risks associated with the use or transportation of every product used by the Company in every area of its operations shall be assessed and appropriate mitigation measures taken to minimise them.

Prevention & Mitigation

Prevention and mitigation measures shall be implemented as necessary. Processes to verify the effectiveness of these measures shall be established and applied.

Legal & Other Requirements

Procedures shall be implemented to identify and assess the legal HSE requirements applicable to the Company.

All information shall be maintained up-to-date and relevant information shall be communicated to employees, contractors, partners and other interested parties as appropriate.

Objectives

Clear HSE objectives shall be identified and defined. Everyone connected with our operations shall be informed of these goals and what is required from them to assist us in achieving them.

Implementation & Monitoring

Goal

The Company shall ensure that HSE objectives are met and activities carried out in compliance with defined and approved standards.

Processes

Structure & Responsibility

Line Management

Line management is responsible for all aspects of HSE.

All those with management responsibility shall demonstrate their commitment to the continuous improvement of HSE performance.

Management shall provide the resources essential to the implementation, control and improvement of this HSE MS.

Individuals

The roles, responsibilities and authorities of personnel who manage, perform and verify activities having an effect on the HSE risks of the Company's activities, facilities and processes shall be defined, documented and communicated in order to facilitate HSE management.

HSE Function

The Company will maintain an HSE function to support Line Management's HSE roles and responsibilities.

The HSE function shall ensure that the HSE MS requirements are established, implemented and maintained.

The HSE function shall report to senior management on the performance of the Company with regard to the HSE MS. Such reports will contribute to a process of continuous improvement in HSE performance.

Competence, Awareness & Training

Competence

Personnel shall be competent to perform tasks that may impact on HSE in the workplace. Competence shall be defined in terms of appropriate education, training and / or experience.

Awareness

The Company shall establish and maintain procedures to ensure that its employees, contractors and other third parties working at each function and level are aware of: -

The importance of conformance to the HSE policy and procedures and the requirements of the HSE MS.

The HSE consequences (actual or potential) of their work activities and the HSE benefits of improved personal performance.

Their roles and responsibilities in achieving conformance to the HSE policy and procedures and to the requirements of the HSE MS including Emergency Preparedness and Response requirements.

Training

Training programs shall take into account differing levels of: -

- Responsibility
- Ability
- Literacy
- Risk

Consultation & Communication

Procedures shall be implemented to ensure that relevant information relating to HSE issues is communicated to and from employees, contractors and other third parties.

Employee, contractor and third party involvement shall be documented and interested parties informed.

Employees / Contractors / Third Parties shall be: -

- Involved in the development and review of policies and procedures to manage risks.
- Consulted where there are any changes that affect workplace HSE
- Represented in HSE matters.
- Informed as to who is their HSE representative.

Documentation

- Appropriate HSE documentation shall be maintained in a form which: -
- Minimises the volume to improve effectiveness and efficiency
- Facilitates access
- Describes the core elements of the HSE Management System
- Describes the interactions between the various documents within the overall HSE MS

Document & Data Control

The Company shall establish and maintain procedures for controlling all documents and data required by this HSE MS to ensure that: -

- They can be located.
- They are reviewed and revised periodically and approved by the authorised personnel.
- Current versions of relevant documents and data are available at all locations where operations essential to the effective functioning of the HSE MS are performed.
- Obsolete documents and data are promptly removed or otherwise assured against unintended use.
- Documents, which may be required in the future, are archived in a manner which facilitates their retrieval and are suitably identified.

Operational Control

All operations associated with identified risks shall be recorded and control measures applied. These activities (including maintenance) shall be planned such that they are carried out under specified conditions by: -

Establishing and maintaining documented procedures to cover situations where the absence of such procedures could lead to deviations from the HSE policy and HSE objectives.

Stipulating operating criteria in the procedures.

Establishing and maintaining procedures related to the HSE risks associated with products, services and equipment purchased and / or used by the Company and communicating relevant procedures and requirements to suppliers and contractors.

Establishing and maintaining procedures related to workplace design, process, installations, machinery, operating procedures, and work organisation including their adaptation to human capabilities, in order to eliminate or reduce HSE risks at source.

Emergency Preparedness & Response

Emergency Response plans and procedures to cope with all aspects of an emergency shall be created, maintained and exercised on a regular basis.

Individuals responsible for responding to an emergency shall be identified and trained. An

Emergency Response facility shall be set up and maintained at appropriate locations.

Each department will be responsible for creating and managing its own particular Emergency Plans. E.g. Security related emergency plans lie with the Security Dept; Blow Out plans lie with the drilling department etc.

The HSE Dept. will create and maintain an Emergency Response facility and procedures for the mobilisation of a response team.

Contractor & Supplier Management

Evaluation, Qualification & Selection

The selection process for a contractor or supplier shall include an evaluation of their ability to deliver a product or service in a safe, healthy and environmentally acceptable manner.

Management

Contractors and suppliers shall be managed to ensure that their HSE performance conforms to contractual requirements and fulfils all of the requirements of this HSE MS.

A system shall be implemented to ensure the effective management of interfaces between Lancaster Oil and its contractors and suppliers.

Performance

Contractor and supplier HSE performance shall be monitored and contractors or suppliers who fail to deliver good HSE performance or who fail to conform to the requirements of this HSE MS may have their contracts terminated early.

Checking & Control

Goal

To verify that the HSE MS is being fully implemented and that appropriate control measures are implemented to ensure a continuous improvement in HSE performance.

Processes

Performance measurement & monitoring

- Procedures shall be established and maintained to monitor and measure HSE performance on a regular basis. These will provide for: -
- Qualitative and quantitative measures appropriate to the needs of the Company
- Monitoring the extent to which objectives are being met
- Proactive measures to monitor compliance with :-
- HSE MS programme
- Operational criteria
- Applicable legislation
- Regulatory requirements
- Reactive measures to monitor :-
- Accidents
- Incidents (including near incidents)
- Ill health
- Other historical evidence of deficient HSE performance
- Recording of data and results of monitoring and measurement sufficient to facilitate subsequent corrective and preventive action analysis

Accidents, incidents, non-conformances and corrective & preventive action

- Procedures shall be implemented for the reporting and investigation of:- Accidents
- Incidents
- Near miss incidents
- Non-conformances
- Identifying, implementing, tracking and close out of actions to mitigate any consequences arising from the above.
- Monitoring of the effectiveness of corrective and preventive actions taken

Records & Record Management

Procedures shall be implemented for the identification, maintenance and disposition of HSE records including the results of Self-assessments, Reviews and Audits.

Review

Goal

To ensure that the HSE MS remains suitable, adequate and effective.

Processes

HSE MS review

Senior management shall review the HSE MS at intervals which it considers relevant but at a minimum, annually to ensure its continuing suitability, adequacy and effectiveness.

The review shall address the possible need for changes to policy, objectives or other elements of the HSE MS.

Decisions for change shall be taken in the light of HSE MS Audit results, changing circumstances and as a component part of the continuous improvement process.

Continuous Improvement

Goal

To ensure that the HSE MS evolves in response to the need for Continuous Improvement in HSE performance and to meet the changing demands of the Company.

Processes

Self-Assessment

A self-assessment system shall be utilised to enable all managers to establish the effectiveness of the HSE MS implementation within their area of responsibility. The results of this self-assessment shall be used to improve HSE MS implementation and as a component in setting HSE objectives.

Lessons Learned

A Lessons Learned programme shall be implemented throughout the Company. Input to this programme will be from a variety of sources including but not limited to - Inspections, Audits, Reviews, Non conformances, Accident/ Incident Investigations, External Inputs etc.

Lessons shall be communicated to all relevant employees and contractors and may be shared with other Companies as deemed necessary.

Audit

Goal

The Company shall establish and maintain an audit programme and procedures for periodic HSE Management System audits to be carried out.

Processes

Audits

Implementation of and compliance with this HSE Management System will be evaluated by several means including, but not limited, to External and Internal Audits. The frequency of these audits will be proportional to the magnitude of the risk to Lancaster Oil's business

Results

Results of audits will be reviewed and circulated, along with recommendations to all parties directly concerned.

Actions

A system shall be maintained to ensure that all actions arising from an audit (or any other review mechanism) are recorded, prioritised, implemented and closed out.

Lessons learned from Audits will be incorporated into the Company's Lessons Learned programme for dissemination throughout the Company.

Appendix 2 Pre- / Post-training interview questions

The questions below were put to each participant before and after their session.

1. Have you ever carried out an HSE Culture Survey before?
2. If yes, how was the survey carried out and how were the results presented?
3. How would you define the HSE Culture of a company?
4. What aspects of an organisation's HSE performance do you think are influenced by the prevalent HSE Culture?
5. If you were setting out as CEO of a company, what would you want to know in order to be comfortable that you understood your organisation's HSE Culture?
6. For each of the following topics, please explain whether

a) you think that they provide insight into an organisations HSE Culture

b) What insight do you think they provide and how?

- HSE management system implementation Levels
- Accident triangle
- Contractor HSE performance
- Action tracking
- Annual HSE goals
- Unsafe act/unsafe condition reporting
- HSE training
- Leading indicators

7. What would you change in regard to simulator content to improve the training experience and benefit
8. What would you change with regard to the overall non-computer content of the course to improve the training experience and benefit (e.g. presentations)?
9. How do you feel about the length of the simulator training?
10. Final interview only; How useful have you found the simulator in helping you understand HSE Culture and why do you feel that way?

Appendix 3 Marking scheme

Participant Reference	

HSE Professional	

Reference by Participant	**Elements and Scores**	**2020**	**2021**	**2022**	**2023**	**2024**	**Total**
Mention of TRIR or other backward indicators							
Did the participant make reference to TRIR	TRIR Yes = (0) No = (1)						
Did the participant make reference to man hours as part of safety culture.	Man hours since last accident Yes = (0), No = (1)						
Mention of "Safety Culture/Climate"	Yes = (1), No = 0)						
References to UA/UC							
	UA/UC Unsafe Actions Yes = (1), No = (0)						
	Mention of Safer Behaviours Yes = (1), No = (0)						
Individual Manager Analysis							
	Individual Managers Performance Yes = (1), No = (0)						
	Individual Managers Behaviours Yes = (1), No = (0)						
Individual Department Analysis							
	Departments' Performance Yes = (1), No = (0)						
	Individual departmental culture Yes = (1), No = (0)						
Individual Contractor Analysis							
	Contractors' Performance Yes = (1), No = (0)						
	Individual contractor culture Yes = (1), No = (0)						
Reference to Overall Management Commitment	Yes = (1), No = (0)						
Reference to Individual Manager Commitment	Yes = (1), No = (0)						
Recognition of underlying issues	Yes = (1), No = (0)						
	Total						

Appendix 4 Sample interview transcripts

Participant 1 has over 50 years experience in the oil industry more than 30 of which have been as a senior HSE manager and international HSE Consultant to many multi-national companies.

Participant 1		
Question	**Pre-training Response**	**Post-training Response**
Have you ever carried out an safety culture Survey before? If yes, how was the survey carried out and how were the results presented?	Never	
How would you define the safety culture of a company?	The HSE culture is peoples' attitudes to HSE and their confidence that management actually means what it says i.e. safety comes first no blame. etc. whether it is true and employees believe or whether management state and employees think that all the care about is prod.	That attitude to work which if, and only if, supported by fully visible commitment from the top of a company, issues into a course of action and a confidence among the workforce that whatever is done, or if appropriate not done, in the name of safety will be upheld at all times, and will in the long term make the company more successful and more profitable.
What aspects of an organisation's safety performance do you think are influenced by the prevalent safety culture?	Every Aspect	As I said before, every aspect
If you were setting out as CEO of a company, what would you want to know in order to be comfortable that you understood your organisation's safety culture	Number of times prosecuted. Accident rates actions taken against us by other companies or employees	Much more information relating to safety performance knowledge

Contribution of individual learning environment elements to understanding safety culture				
Element	Pre-training response		Post-training response	
	Y/N	How/Why	Y/N	How/Why
HSE Management System Implementation Levels	Y	Definitely but the problem is how to measure it	Y	The information as presented on the screens is useful
Accident Triangle	N	Has always been perceived that numbers of accidents has related to culture so in terms of numbers of accidents then there must be an element of truth in it but you can probably achieve an improvement by heavier policing or by changing their attitudes and beliefs	Y	The new knowledge I got from the triangle was the benefit of differentiating between unsafe acts and unsafe acts, the analysis of UA and UC as the safety culture improved was a new thought to me.

Contractor HSE Performance	Y	But they need heavy policing as they are "in it for the short term" and so need great not likely to share our objectives	Y	Very clear, A powerful tool.
Action Tracking	Y	Only in a very limited way. To the extent that the tracking is a closed loop and the actions don't get taken it tells me that we have a rather poor system.	Y	This was very useful information. Especially useful was the historical progress. The knowledge coming out is vital knowledge. .
Annual HSE Goals	Y	Setting goals every year for the company and for the management of the company though people do not always like that HSE goals should be at the top of the list	Y	Very clear very good very straight forward. Like simply graphs
Unsafe Act/unsafe act reporting	N	Personally I do not have a lot of faith in the value of that. Tried to associate with bonuses and found that their ups and down at the end of the month the numbers that got reported was synthetic. Don't have a lot of belief in it.	Y	This is good. Useful information from trends.
HSE Training	Y	Yes in the sense that to the extent that we are prepared money on HSE training it shows that we take it seriously and to the extent that we don't spend money on it, it shows that we don't take it seriously	Y	I got a lot of useful information from the training analysis which highlighted the percentage of training uptake. I very clear and very useful set of data.
Leading Indicators	N	It is much more difficult to get numbers to put on leading indicators than lagging. I would like to be able to do more but so far we have had limited progress in that direction.	Y	I am less enamoured with that. While I do not like the display, I do think the information is useful. Some of the data takes a bit of getting used to. Some will find the data easier to digest than others.
What would you change in regard to the computer content to improve the training experience and benefit			There is nothing I would get rid of, I found the data to be first class and there is nothing that it I know of that I could add to the data	
What would you change with regard to the overall non-computer content of the course to improve the training experience and benefit (e.g. presentations)?			Nothing	
How do you feel about the length of the training?			It is OK. I was not looking forward to 8 or 9 hours. I would have been quicker at using the e-mail if I had had my own computer.	

Participant 6 has a lifetime's experience of in the region of 40 years as an specialist in safety engineering. He has contributed much to the industry both as a consultant, and as a publisher.

Participant 6		
Question	Pre-training Response	Post-training Response
Have you ever carried out an safety culture Survey before?	N	
If yes, how was the survey carried out and how were the results presented?		
How would you define the safety culture of a company?	Whether is was a compliant or risk aware culture.	Leadership shown by the managers. It is the openness that creates and the total openness to hazards, defects etc. and it is the acknowledgement and the response to defects or whatever is going on. It is the appreciation of the influences to risk and the response to that.
What aspects of an organisation's safety performance do you think are influenced by the prevalent safety culture?	The attitudes of the managers and the attitudes to the individuals. They way we plan to do work. What we expect from people and the way we talk to them. Whether it is openness and peoples' ability to say no and peoples' willingness to report. Whether or not the company wants to know about unsafe acts, defects, things like contractual strategy who we choose as contracting. At the very highest level, it would affect risk and reward.	The likelihood of accidents. That ability to question. The judgement of risk the saying NO when gut feel or indicators say that things are failed or unacceptable.
If you were setting out as CEO of a company, what would you want to know in order to be comfortable that you understood your organisation's safety culture	I would want to know that my managers understood the pattern of hazard and risk that they carry and the level of risk that they carry. The true attitudes of my managers. Whether or not what they say is what is actually going on. I would like some independent way of assessing what that culture was rather than relying on reports directly to me. I would want to see what the level of openness was like. What the reporting of unsafe acts was like. I would like to see how our culture is reflected in our contractors' culture. I would want to know how we assessed the culture in the contractors and from that, I would like to see the actual performance and behaviour of our contractors. I would want to know that my managers were actually walking on site and that they weren't just relying on numbers. That they had a personal opinion of what they thought the culture, the effectiveness of the safety systems was such that	I would want to know the Triangle. The level of reporting at the bottom of the triangle. The long term response in that reporting to the trends of unsafe acts. I would want to see an appreciation of the importance of the primary aspects leading to accidents and a focus by my managers to that.

	if I asked them about their plant, they didn't just give me statistical data, they gave me knowledge of individuals, they gave me knowledge of the plant. I would want to see that the company had said NO. That they had said NO to a contractor. That they had said NO to doing a job. That there were jobs that were actually stopped because risk assessment said NO. I would want to see that we were doing training. That it wasn't just training for ticking the box to say we have had training. I would want to see some feedback on that training to see that it was actually working.	

Contribution of individual learning environment elements to understanding safety culture				
Element	**Pre-training response**		**Post-training response**	
	Y/N	How/Why	Y/N	How/Why
HSE management system Implementation Levels	Y	If you are looking at the implementation, you are testing the effectiveness of the HSEMS so you would be testing risk assessment.	Y	It does give an initial insight to the target areas. But thereafter it provides the initial focus but not something that needs to be reviewed It basically points out the obvious.
Accident Triangle	Y	First of all it would tell you if there was an open reporting culture or not.	Y	Immensely useful. It can tell me whether I have an honest culture where they are actually reporting what I have got.
Contractor HSE Performance	Y	If the contractor's HSE performance is simply Lost Time Accident Rate then No. If there are other ways of assessing the contractors HSE performance if they had leading indicators in it then it would.	Y	That is particularly valuable to help you focus on the contractors and also the particular aspects of the contractors that are leading to the accidents.
Action Tracking	Y	Yes is does. The speed with which actions are tracked.	Y	That is valuable. It reinforced what I was seeing with the drop in accidents. Also interesting to see how much people reacted to accidents.
Annual HSE Goals	N	Not the goals themselves unless the goals are affecting the culture. It depends on the goals.	N	I don't think these are much use at all. We have yet to find a goal which really reflects culture.
Unsafe Act/unsafe act reporting	Y	From the degree of unsafe acts and the quality of that reporting, it will show whether or not you have an open culture	Y	Highly valuable in that it helps to create the culture and then you can tell how open people are being. First of all by the level by creating the culture then the level of reporting and then the trends that come out of that.

HSE Training	N	No	Y	It is a double edged sword. I think that showed that there is a lot of training for the sake of training and in a way you almost have to do less of it to achieve more. The indication there was a lot of unnecessary training that wasn't focused. Used properly and some thought about how the training itself inter blends with culture and then it can be valuable. What I saw today was "we've got lots of training programmes" but perhaps a lot of wasted effort.
Leading Indicators	Y	Oh yes. Leading Indicators and the way we react to them is an indication of the culture. Leading indicators can only really survive in an open, risk aware culture.	Y	They are valuable. They need to be carefully written. For me there was almost too much data there for me to really go through that and study that. The distillation of dashboard because it was giving minute by minute, yes, you could see there were certain trends. Certain trends were improving but I wonder how much smoke there was amongst that as well. I think less is more.
What would you change in regard to the computer content to improve the training experience and benefit			I would like to see something in this that made the managers look at the balance between the frequent and the minor and the less frequent and the more severe.	
What would you change with regard to the overall non-computer content of the course to improve the training experience and benefit (e.g. presentations)?			I thought the balance of the e-mails was right. There is very little I would change on it.	
How do you feel about the length of the training?			It felt OK. The people who are dealing with this could do with double the intensity. CEOs are sharp cookies.	
What would you change in regard to the computer content to improve the training experience and benefit			It has completely opened my eyes to it. It has made me realise that underlying this - well first of all it has made me think a lot more about culture. I thought I did know about culture and there are so many more facets to it that I wasn't aware. This whole question of openness the aspects of basically finding the underlying the bit of the iceberg. It is wonderful.	

Participant 7 brings a strong background covering almost 40 years in many different aspects of the finance business, his portfolio of past employers includes some major blue chip organisations. For the last 10 years, he has been Group Finance and Operations Director for a global organisation. Participant 7 is accustomed to working with the most senior management of some large public limited companies.

Participant 7		
Question	**Pre-training Response**	**Post-training Response**
Have you ever carried out an safety culture Survey before?	No	
If yes, how was the survey carried out and how were the results presented?		
How would you define the safety culture of a company?	I suppose it's the importance that's paid to activities or actions of the company that would have an impact on HSE. The awareness and the involvement of the management of the company in the sort of impact of any actions or activities on health and safety.	I suppose it is the beliefs, the knowledge and the sort of common way of operating that is adopted by an organisation with regards to HSE issues
What aspects of an organisation's safety performance do you think are influenced by the prevalent safety culture?	Unless you have the buy-in of the senior management it's not going to filter down through the organisation. Its got an impact on the whole performance. The HSE culture is there and healthy and the senior management are bought into it, or its not going to be there.	Most aspects. Without a culture which encourages involvement from the top down, you are not going to get the buy in.
If you were setting out as CEO of a company, what would you want to know in order to be comfortable that you understood your organisation's safety culture	I'd want to know what the potential risks were in our activities. I would want to know that the company was monitoring risks, monitoring activities. Making sure that we were avoiding HSE issues. So I need to know that all areas were the responsibility of something like that and ultimately it might be mine but that on a lower level everything was taken care of.	I would want to know what I have seen in the training video wall.

Contribution of individual learning environment elements to understanding safety culture				
Element	**Pre-training response**		**Post-training response**	
	Y/N	How/Why	Y/N	How/Why
HSE management system Implementation Levels	Y	As I was saying there has got to be buy-in from the Mgmt. through the organisation so if management are not implementing the culture then that is going to go down through the organisation.	Y	They certainly give an indication because it covers a number of aspects, planning, policy etc. so basically you can tell what the culture is and the involvement of management.
Accident Triangle	N	It shows the history of your activity but not necessarily the culture.	Y	It would tell you if you have an effective culture. If your reporting was good.
Contractor HSE Performance	N	It is an indication certainly whether they have HSE procedures in place. Again, I am not strictly convinced about the culture per se.	Y	In as much as your culture should extend to contractors you are using as well then yes, performance is likely to be impacted by their culture.
Action Tracking	N	The fact that you are tracking them possibly means that you are slightly more aware than an organisation that is not tracking them but there again, you are tracking history.	Y	It would give you the pro-activity of your departments.
Annual HSE Goals	N	Not in themselves.	Y	They would verify that there was a healthy culture in place by the setting of realistic and positive goals.
Unsafe Act/unsafe act reporting	Y	It is what you are doing with the information	Y	If you have a healthy number of reports being done it is an indication that there is a culture which encourages reporting
HSE Training	Y	Depends whether you are doing it to tick a box or because you believe it should be happening.	Y	If there is management buy-in and HSE training is promoted throughout the organisation rather than a sort of token effort or restricted to a few departments or individuals
Leading Indicators	N	I Don't have enough experience	Y	Because they are telling you what is actually going on within your HSE environment. You can pick up on things that should be happening or shouldn't be happening.

What would you change in regard to the computer content to improve the training experience and benefit		There were a couple of screens where I would have wanted a bit more information.
What would you change with regard to the overall non-computer content of the course to improve the training experience and benefit (e.g. presentations)?		From my point of view, I found it was quite difficult to always do what you were being asked to do in the time. It was a case of knowing what you can ignore or neglect.
How do you feel about the length of the training?		I think it is fairly intense so it is probably about the right length. Having said that, it would be easier to see that you have performed things properly if you had slightly longer in some instances.
What would you change in regard to the computer content to improve the training experience and benefit		It has given me a lot of information I didn't have before and wouldn't have thought of. It is useful and thought provoking.

Appendix 5 Financial ratios

Sales Per Employee	Dividend Yield
Personnel Cost Ratio	Enterprise Value (EV)
Personnel Productivity Ratio	Enterprise Value Multiple
Discretionary Payroll Ratio	EV/EBITDA ratio
Employee Billable Hours Ratio	Gordon Growth Model
Employee Overhead Cost Ratio	Loan-to-Value Ratio (LTV)
Employee Utilization Rate	Net Asset Value per Share (NAVPS)
Existing Clients Revenue Ratio	PEG ratio
New Clients Revenue Ratio	Price to Earnings Ratio (P/E Ratio)
Maintenance Revenue Ratio	Price-to-Research Ratio
Software Revenue Ratio	Price/Book Value Ratio
Large Clients Dependency Ratio	Price/Sales Ratio
Service Revenue Ratio	Stock Price
Hardware Revenue Ratio	Cash Flow Coverage Ratio
Third-Party Revenue Ratio	Cash Flow Management
R&D Ratio	Cash Flow Return on Investment (CFROI)
Sales Expense Ratio	Free Cash Flows / Operating Cash Flows Ratio
Marketing Expense Ratio	Operating Cash flow / Sales Ratio
Administrative Employee Cost Ratio	Price/Cash Flow Ratio
Monthly Sustenance Ratio	Cash Return on Capital Invested (CROCI)
Client Acquisition Costs Ratio	DuPont Formula
Net Income Margin	Earnings Before Interest After Taxes (EBIAT)
Return on Assets	Earnings Retention Ratio
Return on Net Worth	EBIT (Earnings Before Interest and Taxes)
Dept. to Assets	EBITDA
Total Dept.	EBITDARM
Interest Coverage	EBT (Earnings Before Tax)
Cash flow to income	Effective Rate of Return
Cash flow to assets	Gross Profit Margin
Free Cash flow	Net Interest Margin
Acid-Test Ratio	Net Profit Margin
Cash Ratio	NOPLAT (Net Operating Profit Less Adj. Taxes)
Current Ratio	OIBDA
Net Working Capital	Operating Expense Ratio
Quick Ratio	Operating Margin
Working Capital	Overhead Ratio
Working Capital Ratio	Profit Analysis
Operating Margin	Profitability Index
Return on Equity	Relative Return
Return on Sales	Return On Assets (ROA)
Accounts Payable Turnover Ratio Asset Turnover	Return on Average Assets (ROAA)
Capacity Utilisation Rate	Return on Average Capital Employed (ROACE)
Cash Conversion Cycle	Return on Average Equity (ROAE)
Days Inventory Outstanding	Return On Capital Employed (ROCE)
Days Payable Outstanding	Return on Debt (ROD)
Days Sales Outstanding	Return On Equity (ROE)
Defensive Interval Ratio	Return On Invested Capital (ROIC)
Fixed Asset Turnover	Return on Investment (ROI)
Inventory Turnover	Return on Net Assets (RONA)
Receivable Turnover	Return on Research Capital (RORC)
Asset Coverage Ratio	Return on Retained Earnings (RORE)
Capitalization Ratio	Return on Revenue (ROR)
Debt Ratio	Return On Sales (ROS)

Debt Service Coverage Ratio	Revenue per Employee
Debt-to-Equity Ratio	Risk-Adjusted Return
Debt-to-Income Ratio	Long Term Debt to Capitalization Ratio
Debt/EBITDA Ratio	Long Term Debt to Total Asset Ratio
Equity Multiplier	Non-current Assets to Net Worth
Equity Ratio	Total Expense Ratio (TER)
Financial Leverage	Business Valuation
Fixed Assets to Net Worth	Dividend Payout Ratio
Fixed Charge Coverage Ratio	Dividend Policy Ratios
Interest Coverage Ratio (ICR)	

Appendix 6 Example video wall analysis worksheet

				Display Grand Total	Focus Grand Total
Training	Course Passes		x	5600	21
	Dept Totals			7	0
	Mgmt Uptake			152	0
	Percentage Uptake			0	0
	Courses per Month			0	0
	Courses Difficulty			0	0
Triangle	Use time object of study		x	5760	57
Manhours	(Time to shut off)		x	2274	104
Poisson	Use time object of study			0	
TRIR	All Lancaster		x	5760	0
	Drilling 1			0	0
	Drilling 2			0	0
	Gen Ser 1			0	0
	Gen Ser 2			0	0
	Gen Ser 3			0	0
	Cater 1			0	0
	Cater 2			0	0
	Well Serv 1			0	0
	Spec Serv 1			0	0
	Spec Serv 2			0	0
	Spec Serv 3			0	0
Accidents	No of Acc		x	5760	0
	Dept Acc			0	0
	Acc/Inc Rates			0	0
	Acc per Month			0	0
Action Track	Overall		x	3400	63
	Department			2359	133
	Proactivity			0	0
	Action Ratios			0	0
	Closeout			0	0
Gauge	Overall		x	1528	59
	Dept. Perf			58	62
	Dept Pro			614	103
	Lead Ind			3520	409
		Trend		18	27
		Status		17	17
HSE Goals	Use time object of study			5760	0
Dep Con Inf					
	Department		x	1957	75
	Contractor			3780	62
UAUC	Total		x	5760	8
	Total RA			0	0
	UA RA			0	0
	Ann Dep % RA			0	0
	Dept UA RA			0	0
	Dept UAUC			0	0
HSEMS	Overall		x	5630	221
	Cont Imp			0	0
		Cont Imp		0	0
		Lessons		0	0
		Self Ass		0	0
	Policy				
		Policy		0	0
		Policy		0	0
		Strategy		0	0
	Planning				
		Planning		93	93
		Risk & Haz		11	11
		Prev & Mit		0	0
		Legal		0	0
		Object		0	0
	Imp Mon				
		Imp & Mon		35	35
		Str & Resp		0	0
		Cont & Sup		0	0
		Op Contrs		0	0
		Con & Com		0	0
		Docs		0	0
		Em Prep		0	0
		Doc & Data		0	0
		Com & Aw		0	0
	Check Cont				
	Audit				
Radar	Use time object of study		x	5760	189
Climate	Use time object of study		x	5760	245

Display Start	Display End	Total Display	Display Seconds	Focus Start	Focus End	Total Focus	Focus Seconds
00:58:47	02:32:07	01:33:20	5600	02:31:41	02:32:02	00:00:21	21
02:32:07	02:32:14	00:00:07	7			00:00:00	0
02:32:15	02:34:47	00:02:32	152			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
				00:59:03	00:59:12	00:00:09	9
00:58:47	01:36:41	00:37:54	2274	01:01:35	01:02:29	00:00:54	54
00:58:47	02:34:47	01:36:00	5760			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
00:58:47	02:34:47	01:36:00	5760			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
00:58:47	01:55:27	00:56:40	3400	01:43:32	01:43:50	00:00:18	18
01:55:28	02:34:47	00:39:19	2359	01:55:28	01:57:02	00:01:34	94
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
00:58:47	01:23:58	00:25:11	1511	01:23:16	01:23:58	00:00:42	42
01:23:59	01:24:25	00:00:26	26	01:23:59	01:24:25	00:00:26	26
01:24:25	01:24:48	00:00:23	23	01:24:25	01:24:48	00:00:23	23
01:24:48	01:28:32	00:03:44	224	01:24:48	01:28:32	00:03:44	224
02:00:13	02:00:31	00:00:18	18	02:00:13	02:00:31	00:00:18	18
02:00:31	02:00:48	00:00:17	17	02:00:31	02:00:48	00:00:17	17
						00:00:00	0
00:58:47	01:31:24	00:32:37	1957	01:29:40	01:30:27	00:00:47	47
01:31:47	02:34:47	01:03:00	3780	01:31:48	01:32:50	00:01:02	62
00:58:47	02:34:47	01:36:00	5760	01:23:12	01:23:16	00:00:04	4
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
00:58:47	01:16:42	00:17:55	1075	01:13:06	01:16:42	00:03:36	216
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
01:16:42	01:17:41	00:00:59	59	01:16:42	01:17:41	00:00:59	59
01:16:57	01:17:08	00:00:11	11	01:16:57	01:17:08	00:00:11	11
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
01:19:55	01:20:30	00:00:35	35	01:19:55	01:20:30	00:00:35	35
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
1.227894							
				01:20:31	01:23:11	00:02:40	160
				01:33:00	01:35:31	00:02:31	151

Display Start	Display End	Total Display	Display Seconds	Focus Start	Focus End	Total Focus	Focus Seconds
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		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
				01:30:34	01:31:09	00:00:35	35
				01:35:51	01:36:41	00:00:50	50
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
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		00:00:00	0			00:00:00	0
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		00:00:00	0	01:59:30	01:59:36	00:00:06	6
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
01:58:55	01:59:12	00:00:17	17	01:58:55	01:59:12	00:00:17	17
01:28:57	01:29:21	00:00:24	24	01:28:57	01:29:21	00:00:24	24
01:28:32	01:28:35	00:00:03	3	01:28:32	01:28:35	00:00:03	3
01:28:36	01:28:48	00:00:12	12	01:28:36	01:28:48	00:00:12	12
		00:00:00	0	02:23:37	02:23:46	00:00:09	9
		00:00:00	0			00:00:00	0
						00:00:00	0
		00:00:00	0	01:31:19	01:31:47	00:00:28	28
		00:00:00	0			00:00:00	0
		00:00:00	0	01:57:54	01:57:58	00:00:04	4
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
01:17:41	01:19:19	00:01:38	98	01:41:32	01:41:37	00:00:05	5
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
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		00:00:00	0			00:00:00	0
01:19:19	01:19:53	00:00:34	34	01:19:19	01:19:53	00:00:34	34
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
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		00:00:00	0			00:00:00	0
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		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
				01:58:01	01:58:25	00:00:24	24
				01:41:43	01:42:04	00:00:21	21

Display Start	Display End	Total Display	Display Seconds	Focus Start	Focus End	Total Focus	Focus Seconds
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
				01:57:40	01:57:53	00:00:13	13
						00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
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		00:00:00	0			00:00:00	0
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		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
01:59:12	01:59:20	00:00:08	8	01:59:12	01:59:20	00:00:08	8
01:28:49	01:28:57	00:00:08	8	01:28:49	01:28:57	00:00:08	8
01:29:22	01:58:55	00:29:33	1773	01:29:22	01:29:39	00:00:17	17
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
						00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
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		00:00:00	0			00:00:00	0
01:20:30	02:34:47	01:14:17	4457			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
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		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
				02:32:35	02:32:40	00:00:05	5
				01:43:03	01:43:07	00:00:04	4

Display Start	Display End	Total Display	Display Seconds	Focus Start	Focus End	Total Focus	Focus Seconds
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		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
						00:00:00	0
						00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0	02:23:28	02:23:36	00:00:08	8
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0	01:59:36	01:59:40	00:00:04	4
01:59:20	02:00:07	00:00:47	47	01:59:20	01:59:30	00:00:10	10
02:00:07	02:00:13	00:00:06	6	01:43:08	01:43:32	00:00:24	24
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
						00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
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		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
						00:00:00	0
				01:58:26	01:58:52	00:00:26	26

Display Start	Display End	Total Display	Display Seconds	Focus Start	Focus End	Total Focus	Focus Seconds
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
						00:00:00	0
						00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0	02:27:13	02:27:28	00:00:15	15
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
02:24:56	02:25:21	00:00:25	25	01:59:50	02:00:07	00:00:17	17
02:00:48	02:24:56	00:24:08	1448	02:00:07	02:00:13	00:00:06	6
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
						00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
		00:00:00	0			00:00:00	0
						00:00:00	0
				02:23:00	02:23:16	00:00:16	16

Total Displays												Total Focus										
1	0	0	0	0	0	0	0	0	0	1		1	0	0	0	0	0	0	0	0	0	1
1	0	0	0	0	0	0	0	0	0	1		0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	1		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		1	1	1	0	0	0	0	0	0	0	3
1	0	0	0	0	0	0	0	0	0	1		1	1	0	0	0	0	0	0	0	0	2
1	0	0	0	0	0	0	0	0	0	1		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	1		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	1		1	1	0	0	0	0	0	0	0	0	2
1	0	0	0	0	0	0	0	0	0	1		1	1	1	1	1	0	0	0	0	0	5
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0	2		1	1	0	0	0	0	0	0	0	0	2
1	1	1	0	0	0	0	0	0	0	3		1	1	1	1	0	0	0	0	0	0	4
1	1	1	1	1	1	0	0	0	0	6		1	1	1	1	1	1	1	0	0	0	7
1	1	1	1	1	1	0	0	0	0	6		1	1	1	1	1	1	1	0	0	0	7
1	0	0	0	0	0	0	0	0	0	1		1	1	0	0	0	0	0	0	0	0	2
1	0	0	0	0	0	0	0	0	0	1		1	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	1		1	1	0	0	0	0	0	0	0	0	2
1	0	0	0	0	0	0	0	0	0	1		1	0	0	0	0	0	0	0	0	0	1
1	0	0	0	0	0	0	0	0	0	1		1	1	0	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
1	1	1	0	0	0	0	0	0	0	3		1	1	0	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0	2		1	1	0	0	0	0	0	0	0	0	2
1	0	0	0	0	0	0	0	0	0	1		1	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	1		1	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0		1	1	1	0	0	0	0	0	0	0	3
0	0	0	0	0	0	0	0	0		0		1	1	1	1	1	1	1	0	0	0	7

			Display Seconds	Focus Seconds	Display	Focus
Training	Course Passes		9590	324	5	7
	Dept Totals		3170	492	8	8
	Mgmt Uptake		10413	931	10	12
	Percentage Uptake		2113	19	4	2
	Courses per Month		2859	53	3	3
	Courses Difficulty		29	29	1	1
			28174	1848	31	33
Triangle	Use time object of study		28800	948	0	21
Manhours	(Time to shut off)		2274	104	1	2
Poisson	Use time object of study		2699	124	0	0
TRIR	All Lancaster		25726	205	6	17
	Drilling 1		2868	23	2	2
	Drilling 2		10	10	1	1
	Gen Ser 1		0	0	0	0
	Gen Ser 2		11	11	1	1
	Gen Ser 3		0	0	0	0
	Cater 1		0	0	0	0
	Cater 2		0	0	0	0
	Well Serv 1		0	0	0	0
	Spec Serv 1		0	0	0	0
	Spec Serv 2		0	0	0	0
	Spec Serv 3		0	0	0	0
Accidents	No of Acc		6369	47	4	2
	Dept Acc		3527	71	4	6
	Acc/Inc Rates		13198	197	5	5
	Acc per Month		5703	105	4	5
Action Track	Overall		3410	68	2	3
	Department		24902	590	7	25
	Proactivity		0	0	0	0
	Action Ratios		4	4	1	1
	Closeout		476	54	2	3
Gauge	Overall		5992	95	7	6
	Dept. Perf		100	99	7	7
	Dept Pro		11920	357	14	16
	Lead Ind		7535	665	12	11
		Trend	3265	63	7	6
		Status	83	49	4	3
			28895	1328	51	49
HSE Goals	Use time object of study		28800	628	0	20
			28800	628	0	20
Dep Con Inf	Department		17308	724	5	11
	Contractor		11468	297	6	7
UAUC	Total		10025	209	12	11
	Total RA		2318	77	8	5
	UA RA		6054	62	7	6
	Ann Dep % RA		192	99	4	2
	Dept UA RA		4795	184	6	4
	Dept UAUC		5460	165	5	5
HSEMS	Overall		23928	242	11	5
	Cont Imp		23928	242	11	5
		Cont Imp	234	227	2	2
		Lessons	0	0	0	0
		Self Ass	0	0	0	0
	Policy					
		Policy	0	0	0	0
		Policy	0	0	0	0
		Strategy	0	0	0	0
	Planning					
		Planning	1911	220	4	3
		Risk & Haz	486	101	3	4
		Prev & Mit	110	7	1	1
		Legal	0	0	0	0
		Object	0	0	0	0
	Imp Mon					
		Imp & Mon	1765	83	6	4
		Str & Resp	0	0	0	0
		Cont & Sup	216	216	1	1
		Op Contrs	10	10	1	1
		Con & Com	0	0	0	0
		Docs	0	0	0	0
		Em Prep	0	0	0	0
		Doc & Data	0	0	0	0
		Com & Aw	43	43	1	1
	Check Cont		0	0	0	0
	Audit		0	0	0	0
			52631	1391	41	27
Radar	Use time object of study		28800	645	0	14
Climate	Use time object of study		28800	584	0	23

Display Seconds	Focus Seconds	Display Seconds	Focus Seconds	Display Seconds	Focus Seconds	Display Seconds	Focus Seconds	Display Seconds	Focus Seconds
5600	21	2718	229	0	0	0	0	1272	74
7	0	484	109	2311	274	333	74	35	35
152	0	2555	313	3448	225	4197	332	61	61
0	0	0	0	0	0	166	13	1947	6
0	0	0	0	0	0	461	0	2398	53
0	0	0	0	0	0	0	0	29	29
5760	57	5760	286	5760	465	5760	28	5760	112
2274	104	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	2699	124
5760	0	2803	14	5643	94	5760	83	5760	14
0	0	2868	23	0	0	0	0	0	0
0	0	10	10	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	11	11	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
5760	0	602	42	0	0	2	0	5	5
0	0	17	17	0	0	3369	43	141	11
0	0	5135	168	5760	29	2303	0	0	0
0	0	5	5	0	0	86	0	5612	100
3400	63	10	5	0	0	0	0	0	0
2359	133	5588	93	5760	109	5760	108	5435	147
0	0	0	0	0	0	0	0	0	0
0	0	4	4	0	0	0	0	0	0
0	0	158	20	0	0	0	0	318	34
1528	59	0	0	20	18	0	0	4444	18
58	62	25	25	8	3	0	0	9	9
614	103	5736	38	2437	202	3128	9	5	5
3520	409	0	0	82	82	2631	0	1302	174
18	27	0	0	891	2	0	0	2356	34
17	17	0	0	42	8	0	0	24	24
5760	0	5760	150	5760	111	5760	117	5760	250
1957	75	0	0	4554	359	5078	133	5719	157
3780	62	5761	0	1206	0	681	224	40	11
5760	8	489	4	805	133	568	38	2403	26
0	0	2204	5	65	65	21	7	28	0
0	0	4	4	4106	46	1932	12	12	0
0	0	8	8	0	0	182	91	2	0
0	0	52	52	0	0	2904	132	1839	0
0	0	2999	125	781	0	215	1	1465	39
5630	221	2377	4	5404	17	4757	0	5760	0
0	0	116	109	118	118	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
93	93	1818	127	0	0	0	0	0	0
11	11	418	33	0	0	57	57	0	0
0	0	110	7	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
35	35	551	7	236	0	943	37	0	4
0	0	0	0	0	0	0	0	0	0
0	0	216	216	0	0	0	0	0	0
0	0	10	10	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	43	43	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
5760	189	5760	95	5760	229	5760	132	5760	0
5760	245	5760	49	5760	171	5760	94	5760	25

Display	Focus	Display	Focus	Display	Focus	Display	Focus	Display	Focus
1	1	2	4	0	0	0	0	2	2
1	0	1	1	1	3	4	3	1	1
1	0	2	1	2	4	4	6	1	1
0	0	0	0	0	0	2	1	2	1
0	0	0	0	0	0	1	0	2	3
0	0	0	0	0	0	0	0	1	1
0	3	0	2	0	10	0	4	0	2
1	2	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1	0	1	2	2	8	1	4	1	3
0	0	2	2	0	0	0	0	0	0
0	0	1	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1	0	1	1	0	0	1	0	1	1
0	0	2	2	0	0	1	3	1	1
0	0	3	4	1	1	1	0	0	0
0	0	1	1	0	0	1	0	2	4
1	2	1	1	0	0	0	0	0	0
1	5	2	7	1	4	1	5	2	4
0	0	0	0	0	0	0	0	0	0
0	0	1	1	0	0	0	0	0	0
0	0	1	1	0	0	0	0	1	2
2	2	0	0	3	2	0	0	2	2
3	4	1	1	2	1	0	0	1	1
6	7	2	3	4	4	1	1	1	1
6	7	0	0	3	3	1	0	2	1
1	2	0	0	2	1	0	0	4	3
1	1	0	0	2	1	0	0	1	1
0	0	0	3	0	6	0	5	0	6
1	2	0	0	1	4	2	2	1	3
1	1	1	0	1	0	2	5	1	1
1	2	2	1	3	4	4	2	2	2
0	0	2	1	2	2	3	2	1	0
0	0	1	1	2	3	2	2	2	0
0	0	1	1	0	0	2	1	1	0
0	0	1	1	0	0	4	3	1	0
0	0	1	3	1	0	2	1	1	1
3	2	2	1	3	2	2	0	1	0
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0	0	0	0	0	0	0	0	0	0
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1	1	1	2	0	0	1	1	0	0
0	0	1	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1	1	2	1	1	0	2	1	0	1
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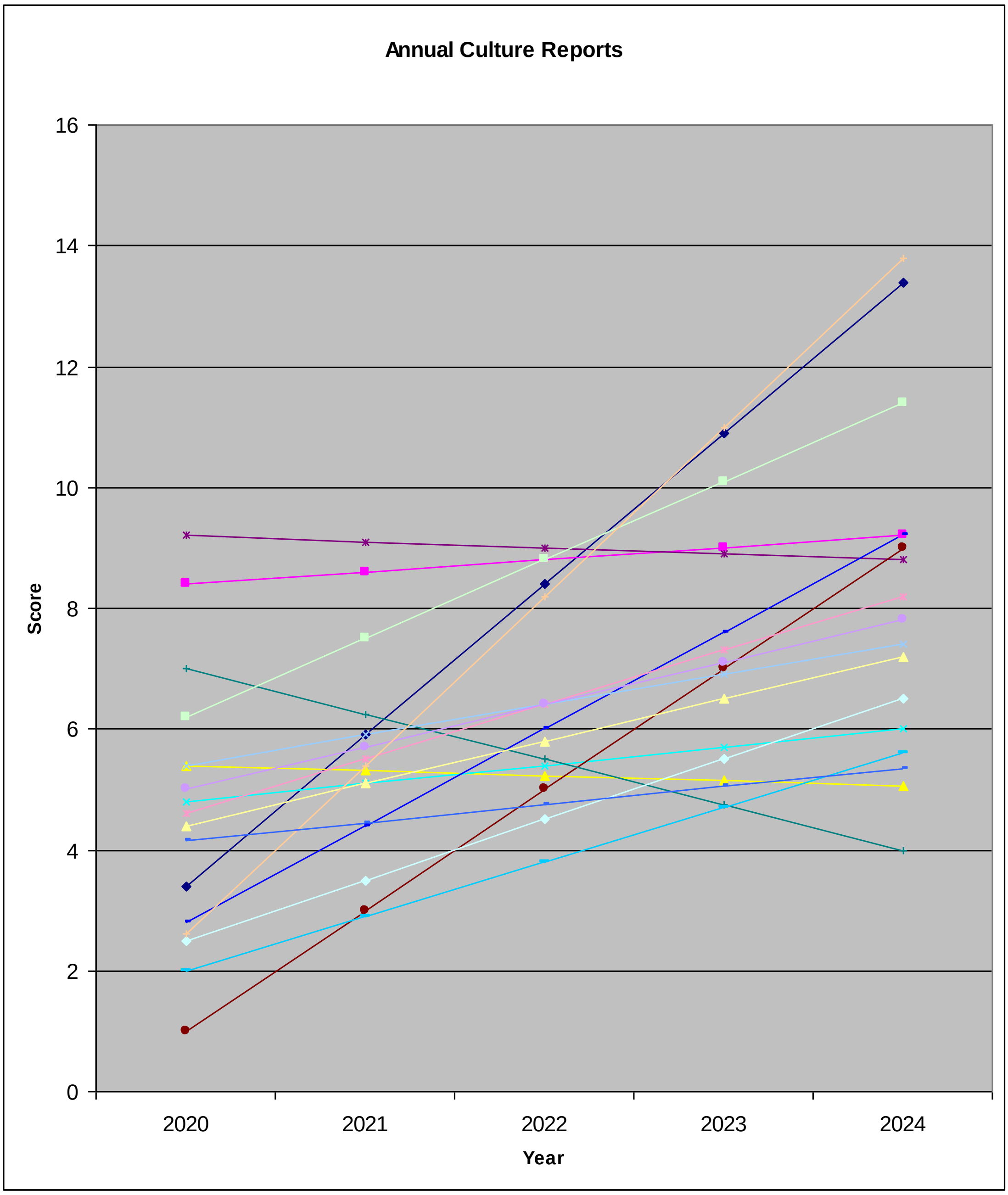
0	0	0	0	0	0	0	0	0	0
0	0	1	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	3	0	6	0	2	0	3	0	0
0	7	0	4	0	4	0	6	0	2

Appendix 7 Annual culture reports: Individual trends



Appendix 8 HSE manager job description

Example feedback from a participant to HR department regarding modifications required to HSE manager's job Description.

"To HR Manager,

Thanks. in interests of time I have included below the previous H&S mgr's JD, but please ensure you add the following points

- *Ability to develop realistic leading KPIs and performance indicators*
- *Ability to track performance indicators - leading and lagging*
- *Abiility to analyse data, performance indicators, and trends*
- *Ability to communicate results of analysis meaningfully to all dept. heads and the workforce.*
- *Abilitity to communicate with all levels of organisation*
- *Deep understanding of accident /incident data*
- *Continuing underpinning of UA/UC reporting and reasons for it*
- *Ability to develop meaningful HSE objectives - leading and lagging*
- *Understanding of incentive schemes to improve all H&S reporting*
- *Understanding of and ability to train in behaviour based safety and human factors*
- *Ability to undertake behaviour based safety audits*
- *Fluency in HSE mgt systems and ability to implement same. Ability to measure success and highlight weak areas.*
- *Experienced in safety climate measurement and interpretation of results*

Thanks

MD"

Original health and safety manager : Job description

The Health and Safety Manager offers expert knowledge and skills in order to generate and promote health and safety awareness in the workforce. This represents a key role in helping control occupational risk.

The HSE manager is responsible for ensuring that all safety legislation is adhered to and policies and practices are adopted. He will take the lead in the development of HSE plans and be responsible for their implementation and monitoring. The HSE manager will monitor and review the protective and preventative measures that the company is required to follow, and will work to minimise operational losses, occupational health problems, accidents and injuries.

Work activities

The duties of the HSE manager are :-

- Ensure that working practices that are safe and comply with legislation.
- Prepare health and safety strategies and develop internal policy(ies).
- Carrying out risk assessments and consider how risks could be reduced.
- Outline safe operational procedures which identify and take account of all relevant hazards.
- Carry out regular site inspections to check policies and procedures are being properly implemented.
- Lead in-house training with managers and employees about health and safety issues and risks.
- Keep records of inspections findings and produce reports that suggest improvements.
- Keep records of incidents and accidents and produce statistics for managers.
- Keep up to date with new legislation and maintaining a working knowledge of all legislation and any developments that affect the employer's industry.
- attending imdustry seminars and reading professional journals.
- Produce management reports, newsletters and bulletins.

- Ensure the safe installation and operation of equipment.
- Managing and Organising the safe disposal of hazardous substances.
- Advising on a range of specialist areas, e.g. fire regulations, hazardous substances, noise, safeguarding machinery and occupational diseases.

Management Responsibilities

This position manages subordinates and is responsible for the overall direction, coordination, and evaluation of employees. In this position, you will be required to carry out supervisory responsibilities in accordance with the Company's Policies & Procedures and any applicable laws.

Qualifications

To perform this job successfully, an individual must be able to perform each essential duty satisfactorily. The requirements listed below are representative of the knowledge, skill and/or ability required. Reasonable accommodations may be made to enable individuals with disabilities to perform the essential functions.

- Education – A bachelor's degree (4 year) or higher in Safety, Engineering, or related technical field.
- Experience – Ten (10) years of upstream safety experience managing project safety.
- Relevant Work Experience – Advanced knowledge of petroleum industry practices, regulatory agency requirements and industry standards. Worked within the petroleum industry,with a preference for relevant upstream experience.
- Communication Skills – Must have very good written and oral communications. Required to speak effectively before groups of Senior Management, clients, subcontractors, and/or employees of the organization.
- Computer Skills – Must have experience with Microsoft Office Programs.
- Reasoning Ability – Use of basic reasoning, thinking "on your feet", and ability to resolve issues quickly with little or no direction from a superior. Ability to interpret a variety of instructions furnished in written, oral, diagram, or schedule format. Good negotiating skills. Ability to make good judgements and render good decisions.

- Certificates, Licenses, Registrations – NEBOSH qualification is mandatory.

Physical Demands

The physical demands described here are representative of those that will be faced by the employee in order to successfully perform the functions of this job. Reasonable accommodations will be made to enable individuals with disabilities to perform the essential functions.

- While performing the duties of this job, the employee is frequently required to stand; walk; used hands to handle/feel objects, tools, or controls; and reach with hands and arms. You are occasionally required to climb or balance and stoop or kneel.
- You must regularly lift and/or move up to 25 pounds. Specific vision abilities required by this job include distance vision, peripheral vision, depth perception, and the ability to adjust focus.
- The position requires that you will visit the site, climb ladders, climb stairs and walk on uneven ground.

Appendix 9 E-mail trail relating to Texas City Disaster

The following e-mail trail is publically available from the U.S. Chemical Safety Board web site at – www.csb.gov/assets/1/19/email_from_George_Carter _1_9_2002.pdf

From: Carter, George R

Sent: *1/9/2002 4:* 13 PM

To: Wundrow, Walt; Scoggin, Gary M; Arnett, David B

Cc: Risinger, Martin; Trapp, Paul W; Kenyon, Mike R; Pickell, Frank W; Batte, David L; Breedlove, David L; Codina, Joaquin (Taylor & Hill, Inc.); Grayson, Mike; Snider, Carl; Yerrell, Scott K; Zeek, Donald E; Hagen, Guy F; White, Danny C.; Robins, Joel H; Izarraraz, Alicia; Carter, George R; Pickell, Frank W

Bcc:

Attachments:

Subject: RE: Line size for NDU flare

We all need to be extremely clear.. ... We are planning on building the project we appropriated on Jan .... As the gatekeeper I would expect to be asked about any scope issues .... Bank the savings in 99.999% of the cases .....

-----Original Message----
From:Wundrow, Walt

Sent: Wednesday, January 09, 2002 10:58 AM

To: Scoggin, Gary M; Arnett, David B

Cc: Risinger, Martin; Trapp, Paul W; Kenyon, Mike R; Carter, George R; Pickell, Frank W; Batte, David L; Breedlove, David L; Codina, Joaquin (Taylor & Hill, Inc.); Grayson, Mike; Snider, Carl; Yerrell, Scott K; Zeek, Donald E; Hagen, Guy F; White, Danny C.; Robins, Joel H; Izarraraz, Alicia

Subject: RE: Line size for *NDV* flare

All,

My counsel is avoid any pre-investment against uncertain future requirements. Further, as such represents work outside the scope of the approved project, it must be brought back to the *BV* for approval. Capex is very tight. Bank to 150k savings now.

Walt Wundrow
Texas City Refinery *BV*
-----Original Message----
From: Scoggin, Gary M

Sent: Tuesday, January 08, 200210:22 PM

To: Arnett, David B

Cc: Risinger, Martin; Trapp, Paul W; Kenyon, Mike R; Wundrow, Walt; Carter, George R; Pickell, Frank W; Batte, David L; Breedlove, David L; Codina, Joaquin (Taylor & Hill, Inc.); Grayson, Mike; Snider, Carl; Yerrell, Scott K; Zeek, Donald E; Hagen, Guy F; White, Danny c.; Robins, Joel H

Subject: RE: Line size for *NDV* flare

There is no doubt that TNRCC is tightening down on upset emissions of hydrocarbons. Exactly where this leads in the next several years in still not sure but the direction is clear. Rather than make this decision in isolation, I think we need to put some heads together, assess our risk and develop some guidelines that cover not just this case but others that arise. We can try to do this fairly quickly if your timing is critical.

When do need a definitive answer?

Gary

Gary Scoggin
Major Capital Project HSE
BP South Houston Integrated Site

-----Original Message----
From: Arnett, David B

Sent: Tuesday, January 08, 2002 3:14 PM

To: Scoggin, Gary M

Cc: Risinger, Martin; Trapp, Paul W; Kenyon, Mike R; Wundrow, Walt; Carter, George R; Pickell, Frank W; Batte, David L; Breedlove, David L; Codina, Joaquin (Taylor & Hill, Inc.); Grayson, Mike; Snider, Carl; Yerrell, Scott K; Zeek, Donald E

Subject: Line size for NDU flare

We are trying to determine the best line size for the NDU flare. Originally, we designed the flare on an estimate from the licensor but after we calculated the flare releases, we discovered that we can reduce the line and save about $150M.

Before we reduce the line size, we want to make sure that we do not need the larger line size for the ISOM when it is required to go to a flare. If the ISOM uses the same line as the NDU, it would save 1000 ft of pipe. This would cost save a substantial amount of money by using the same line.

We asked Danny White what the likelihood of having to divert the material that goes to the ISOM blowdown drum o a flare. His response was that the probability of the ISOM blow down stack having to be routed to the flare within five years to be greater than 80% chance. The complicating factor is that the ISOM RV releases will contain HCL. However, the material will have to be scrubbed if it goes to the AU2 flare or to it's own flare since it will damage most flare tip metallurgy.

Therefore, we need to decide if we want to invest $150M now to save more money later on.

My question to you is how real is the future requirement to send the ISOM blowdown material to a flare.