Linda Drupsteen-Sint

Improving organisational safety through better learning from incidents and accidents

Centre for Industrial Production
Aalborg University
PhD Thesis, 2014

Improving organisational safety through better learning from incidents and accidents

Linda Drupsteen-Sint

The Centre for Industrial Production (CIP) was established in 1999 as a part of the Faculty of Engineering and Science. Since then we have been committed to serve as a national center of world-class excellence in industrial manufacturing research.

Our mission is to develop and disseminate business engineering knowledge. We accomplish this by doing application-oriented research addressing current and future challenges in (Danish) industry. Therefore, we do all our work in close collaboration with our industrial partners and develop theories based on reality.

CIP is based in both Aalborg and Copenhagen. During the past year CIP has expanded considerably in Copenhagen and is expected to grow even more the coming years.

In January 2011 CIP merged with Department of Business Studies and formed Department of Business and Management, which is a cross-faculty department linking together The Faculty of Social Sciences (Department of Business Studies) and The Faculty of Engineering and Science (CIP). By bringing together these two faculties the scene is set for an institution with the professional focus on and strength for rethinking traditional subjects and methods by combining knowledge about different disciplines.

Title: Improving organisational safety through better learning from incidents and accidents

Author: Linda Drupsteen- Sint

Supervisors:
Professor Peter Hasle, CIP/Department of Business and Management, Aalborg University, Denmark

Professor Gerard I.J.M. Zwetsloot, Nottingham University, United Kingdom & TNO Innovation for Life, The Netherlands

Review Committee:
Associate Professor Jan Vang (Chair), CIP/Department of Business and Management, Aalborg University, Denmark

Associate Professor Heikki Laitinen, Lappeeranta University of Technology, Finland

Associate Professor Kirsten Jørgensen, DTU Management Engineering, Technical University of Denmark, Denmark

ISBN: 978-87-91831-64-5

Printed by: Ipskamp Drukkers, Enschede, The Netherlands

Centre for Industrial Production, Aalborg University

Improving organisational safety through better learning from incidents and accidents

PhD Thesis, 2014

To be presented for public examination on November 28th 2014 at 10.00

at Aalborg University, A.C. Meyers Vænge 15 | 2450 Copenhagen SV, Denmark

List of publications

I. Drupsteen L. and Guldenmund F.W. (2014) What is Learning? A Review of Safety Literature on Learning from Incidents. *Journal of Contingencies and Crisis Management*, *22 (2),* pp. 81 - 96.
II. Drupsteen L., Groeneweg J., Zwetsloot G. I. J. M. (2013) Critical steps in learning from incidents: Using learning potential in the process from reporting an incident to accident prevention. *International Journal of Occupational Safety and Ergonomics, 19 (1)*, 63-77.
III. Drupsteen L. and Hasle, P. (in press) Why do organizations not learn from incidents? Bottlenecks, causes and conditions that create a failure to effectively learn. *Accident Analysis and Prevention*.
IV. Drupsteen L. and Wybo, J-L. (in press) Assessing propensity to learn from safety-related events. *Safety Science*.

The studies are referenced in the dissertation by their Roman numerals

Other related publications

- Drupsteen L., Zwetsloot, G.I.J.M., Groeneweg, J. (2012) Learning from events: a process approach *International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, 11-13 September 2012, Perth, Australia*.
- Drupsteen L., Bos E., Groeneweg J., Zwetsloot G.I.J.M. (2013) Increasing the Learning Potential from Events: Case studies. *Chemical Engineering Transactions 31,* 433-438.
- Meyer-Larsen N., Drupsteen L., Gräf G., Maier L., Müller R. (2013) *Sustainability and Collaboration in Supply Chain Management: A Comprehensive Insight Into Current Management Approaches, 16*, 221.
- Rasmussen H.B., Drupsteen L., Dyreborg J. (2013) Can we use near-miss reports for accident prevention? A study in the Oil and Gas industry in Denmark. *Safety Science Monitor 17* (2), article 1.

Contents

Acknowledgements

I started this PhD study about five years ago, hoping to gain a more in-depth knowledge to help organisations prevent accidents and improve safety. While working in the field of occupational safety, I became more and more convinced that better use could be made of accident investigations and other available knowledge, and this motivated me to start investigating the ways in which organisations learn from incidents and accidents.

Performing this study and calling myself a PhD student, created new opportunities: I was able to join a network of PhD safety students, to attend safety science workshops, to visit many conferences, and to publish with several inspiring co-authors. In addition, learning from incidents is a subject that interests many safety practitioners and I am happy that I could collaborate with them, discuss issues and good examples, and that I am continuously challenged by the practitioners that should benefit from this research.

In the end I gained much more from this PhD study than just knowledge and skills: I have met many inspiring colleagues and new friends. It is tempting simply to say: *"thanks to all of you, now let's get back to normal life"* but, this wouldn't do right by all those people who supported me, and I have been told that some people find the acknowledgments the only interesting part of most dissertations.

So, thank you Ageeth, Annemarie, Carlo, Corine, Ingrid, Elisabeth, Elise, Henk&Dien, Janneke, Hanna, Laura, Mama, Marjolein R. en Marjolein J., Marloes, Martin, Kirsten, Nicolien, Oma, Papa, Rik, Ruud, Sifra, Shelley and Tialda, for making my life so much more fun in the hours that I am not working. This hobby took up much of the evenings and weekend, but my friends and family have never complained, always shown interest and they helped me to keep my feet on the ground.

Also a huge thank you to Frank Guldenmund, Jean-Luc-Wybo, Victor Roggeveen, Hanna Rasmussen and the ESReDA project group on learning, for the challenging discussions and the inspiration. Hanna, I cannot thank you enough for helping me with the summary of my dissertation.

I'd also like to thank my colleagues at TNO and at CIP. I am proud of the two logos on the front of this dissertation. They not only represent Aalborg University and my employer TNO, but for me they represent two groups of inspiring and supporting colleagues who I would like to thank for that support and for their interest. I would especially like to thank Jop Groeneweg, and my two supervisors, Gerard Zwetsloot and Peter Hasle. I have doubted many times whether I would be able to write this dissertation on top of a regular job, but these three men always seemed convinced that I was capable of doing so. I am lucky to have two supervisors who are so patient and so constructive in writing their feedback, and a colleague who kicks my arse when necessary. Gerard was involved in this research from day one, and I could not have found a better supervisor. Thank you Gerard, for your patience, your support, your ideas, your comments, and for always taking the time to answer my questions. I would like to thank Jop for challenging me on my findings and for taking the time to listen when I was about to give up. And Peter, in addition to thanking you for reading and commenting on all previous versions, thank you for welcoming me as your PhD student, in the department, and in Denmark.

Last, and most importantly: I could not have done this without Roel. Thank you for bearing with me, your support means everything to me.

Summary

Learning from incidents is an important aspect of sustaining and improving safety in organisations. Incidents that have occurred in the past provide valuable lessons for preventing future incidents. Unfortunately, many organisations fail to successfully learn from incidents, even when the underlying lessons have been identified. This dissertation addresses this gap by investigating the main research question: "how can organisations improve their learning from incidents?"

The research questions in this dissertation are:

- How do organisations learn from incidents?
- What are the difficulties in learning from incidents in organisations?
- What are the underlying factors that make it difficult to learn from incidents in organisations?
- Under what conditions is learning likely to be successful?

In practice, learning from incidents often refers only to the identification of lessons through incident investigation, and not to the process of improvement that should follow. In this dissertation, '*learning from incidents*' refers to an entire process, including the use of lessons identified for improvement and the evaluation of effectiveness (of the actions for improvement and of the process itself). By using a model in five phases, based on the Plan-Do-Check-Act cycle, this dissertation increases insight into the follow-up steps that are necessary for learning successfully from incidents. The five phases of learning from incidents are: acquiring information, investigating and analysis, planning interventions, intervening, evaluating. Altogether these phases of the model of learning from incidents contain 13 steps. The model proved to work well for the analysis of learning from incidents in organisations and for the identification of difficulties in this process, and shows how even minor problems impede all consequential steps, and therefore strongly reduce the overall success of learning from incidents.

This dissertation summarises and discusses four sequential studies that were performed to contribute to answering the research questions:

Study I (Drupsteen and Guldenmund, 2014) reviews the literature about learning from incidents. The study categorised the identified articles according to their main topic, before comparing them with the organisational learning theory of Argyris and Schön (1979). Study I found three gaps in the literature: (a) there is limited research into the follow-up steps after incident investigation; (b) the conditions for successful learning need further investigation; and (c) there is only limited empirical research available on learning from incidents. This dissertation addresses these research gaps.

Study II (Drupsteen, Groeneweg and Zwetsloot, 2013) considered the difficulties by using the five-phase model of the learning from incidents process in a survey, and in three explorative case studies. This study identified the main bottlenecks in the learning from incidents process, the steps at which the learning process is impeded. The findings showed that bottlenecks particularly occur in the planning and evaluation phase, and that as a result most of the information from incident analysis is not effectively used for improvement in many organisations.

Study III (Drupsteen and Hasle, 2014) built on the insights of Study II. Study III aimed to identify causes and conditions underlying the difficulties in the learning process. The findings are based on seven focus group interviews in industrial and construction organisations and show five

categories of causes and conditions for ineffective learning: time-issues, fear of negative consequences, beliefs or mental models, lack of knowledge and competence of the people involved, and lack of a sense of urgency.

Study IV (Drupsteen and Wybo, 2014) proposes a set of indicators that organisations can use to determine beforehand whether they are likely to learn from incidents and other negative events. These indicators are: attitudes towards sharing information; attitudes towards performing the learning process; systems that facilitate sharing information; systems that facilitate the learning process; management commitment and systems perspective; openness, communication and knowledge transfer.

Taken together, the findings of this dissertation contribute to the growing body of knowledge on learning from incidents, by providing a framework of analysis and by providing empirical findings about how organisations learn, what difficulties there are, and the underlying causes of these difficulties. More importantly, this research project provides a method for systematically studying learning from incidents.

Another major finding from this research is the distinction between the direct and indirect causes of ineffective learning from incidents. Not only the difficulties (direct causes), but also the underlying issues that contribute to these difficulties can be assessed. Addressing the direct causes is likely to improve a single step in the learning process whereas addressing the indirect or underlying causes has an effect on the learning process as a whole. In order to structurally improve learning from incidents, the underlying causes need to be addressed.

The research project also provides a set of indicators that can be used by organisations to assess the conditions for learning from incidents. Through creating and sustaining the conditions in which successful learning is likely to occur, the ability of an organisation to learn improves.

Dansk Resumé

Læring fra hændelser er et vigtigt aspekt af opretholdelsen og forbedringen af sikkerheden i organisationer. Hændelser, der fandt sted i fortiden, giver værdifulde erfaringer til at forhindre fremtidige hændelser. Desværre er der mange organisationer, som fejler ved succesfuld læring af hændelser, selv om de underliggende årsager er blevet klart defineret. Denne afhandling fokuser på den manglende læring fra hændelser ved hjælp af hovedforskningsspørgsmålet: ”Hvordan kan organisationer forbedre deres læring fra hændelser"

Underspørgsmålene i afhandlingen er følgende:

- • Hvordan lærer organisationer af hændelser?
- • Hvad er problemerne med læring fra hændelser i organisationer?
- • Hvad er de underliggende faktorer, der gør det svært at lære af hændelser i organisationer?
- • Under hvilke betingelser er læring succesfuld?

I praksis refererer læring af hændelser ofte kun til identifikation af erfaringer undersøgt gennem hændelsesgranskning, og ikke til forbedringsprocessen, der følger efter det. I denne afhandling, henviser »læring af hændelser« til en kompleks proces, herunder også brugen af identificerede erfaringer for forbedring og evaluering af effektivitet (af aktionerne til forbedring af selve processen). Afhandlingen fokuserer på de opfyldende trin, der er nødvendige for en vellykket læring fra hændelser ved hjælp af en fem-fase model, baseret på en Plan-Gør-Tjek- Handl cyklus. De fem faser af læring af hændelser er: indsamling af informationer, undersøgelse og analyse, planlægning af interventioner og evaluering. Tilsammen indeholder modellen 13 trin. Modellen viste sig at fungere godt til analysen af læring fra hændelser i organisationer og til at identificere problemer i denne proces. Desuden viser modellen, at selv mindre problemer i et enkelt trin hindrer alle følgende trin, og derfor kraftigt reducerer den samlede succes for læring af hændelser.

Afhandlingen sammenfatter og diskuterer fire studier, som bidrager til at besvare forskningsspørgsmålet.

Studie I (Drupsteen og Guldenmund, 2014) er en litteraturgennemgang af undersøgelser med fokus på læring fra hændelser. Artikler brugt i gennemgangen blev kategoriseret efter deres emner og efterfølgende sammenlignet med den organisatoriske læringsteori af Argyris og Schön (1978). Undersøgelsen fandt tre mangler i litteraturen: (a) opfyldende skridt efter hændelsesundersøgelser er undersøgt i meget begrænset omfang; (b) der er behov for yderligere undersøgelser af betingelserne for en vellykket læring og (c), der er kun begrænset empirisk forskning om læring af hændelser. Denne afhandling fokuserer netop på disse mangler i forskningen.

Studie II (Drupsteen, Groeneweg og Zwetsloot, 2013) undersøgte vanskeligheder ved at bruge fem-fase modellen af læring fra hændelser gennem en spørgeskemaundersøgelse og i tre eksplorative casestudier. Undersøgelsen har identificeret de trin, hvor læringsprocessen hæmmes. Resultaterne viser, at vanskeligheder især opstår i planlægnings- og evalueringsfasen. Også til sidst, i mange organisationer anvendes de fleste af oplysningerne fra hændelsesanalyser ikke effektivt, som følge af flaskehalse i processen.

Studie III (Drupsteen og Hasle, submitted) bygger videre på resultater fra studie II. Studie III havde til formål at identificere årsager og baggrunden for vanskelighederne i læringsprocessen.

Resultaterne er baseret på syv fokusgruppeinterview i industri-og byggeorganisationer. Resultaterne viser fem årsager og betingelser for ineffektiv læring: tidsmæssige problemer, frygt for negative konsekvenser, overbevisninger eller mentale modeller, mangel på viden og kompetence af de involverede mennesker, og manglende følelse af vigtighed.

Studie IV (Drupsteen og Wybo 2014, offentliggjort i Safety Science) foreslår et sæt indikatorer, som organisationer kan bruge til på forhånd at afgøre, om de er tilbøjelige til at lære fra hændelser og andre negative begivenheder. Indikatorerne er: holdninger til deling af informationer; holdninger til udførelse af læreprocessen; systemer, der letter udveksling af information; systemer, der letter læreprocessen; ledelsens engagement og systemets perspektiv; åbenhed, kommunikation og videnoverførsel.

Tilsammen bidrager resultaterne af denne afhandling til viden om læring fra hændelser, ved at skabe en ramme for analyse og ved at give empiriske resultater om: hvordan organisationer lærer, hvilke vanskeligheder er der, og hvad årsagerne til disse vanskeligheder. Endnu vigtigere er, at forskningsprojektet giver en metode til systematisk undersøgelse af læring af hændelser.

En anden vigtig konklusion fra denne forskning er sondringen mellem direkte og indirekte årsager til ineffektiv læring fra hændelser. Det er ikke kun selve vanskelighederne (direkte årsager), men også de underliggende årsager, der bidrager til vurderingen af disse vanskeligheder. Vurdering af direkte årsager vil kunne forbedre et enkelt trin i læringsprocessen, mens fokus på indirekte eller underliggende årsager har en effekt på læringen som helhed. For at forbedre læring fra hændelser strukturelt er det vigtig med fokus på de underliggende årsager.

Forskningsprojektet giver også et sæt indikatorer, der kan bruges af organisationer til at vurdere betingelserne for læring af hændelser. Ved at skabe og opretholde de betingelser, under hvilke vellykket indlæring er sandsynlig, stiger evnen til at lære i en organisation.

1.Introduction

Every 15 seconds, 160 workers have a work-related accident, states the International Labour Organization (ILO) on their website (ILO, 2014). This means that worldwide, in one hour, more than 38,000 persons are involved in an accident, and almost 6.5 million people in one week, which is more than the population of Denmark. Employers have a legislative responsibility to look after the health of workers (EU Directive 89/391 EEC) and many employers also want to prevent injury or loss. '*Safety is always our top priority*' (Royal Dutch Shell), '*We work safely, or we don't work*' (translated from Tata Steel NL), '*All accidents are preventable*' (BAM international) and '*Every worker has the right to a safe and healthy workplace*' (Apple) are only four of many statements used by companies to illustrate the importance of a safe workplace. In recent decades there have been many developments in the field of safety (Hale and Hovden 1998; Swuste, van Gulijk and Zwaard 2010; Swuste, van Gulijk, Zwaard and Oostendorp 2014), and several studies have suggested that in the past two decades accident frequencies have decreased (Benavides, Benach, Martínez, González 2005; Jørgensen 2008; Hämäläinen et al. 2009). Unfortunately, many incidents and accidents do still occur (Eurostat 2012; ILO 2014).

Accidents are those events that lead to injury or damage (Heinrich, 1931). Well-known accidents are the Piper Alpha disaster in 1988, the Texas City explosion in 2005, the Deep Water Horizon oil spill of 2010 or the sinking of Costa Concordia in 2012. An example from the Netherlands is the fire accident at a chemical company in Moerdijk in 2011. These high impact accidents are, however, only a small sample of the total number of accidents in which workers are involved, as is illustrated by the quote from ILO at the start of this introduction.

Whereas the term 'accident' refers only to those events that lead to injury or damage, the term 'incident' refers also to events that did not cause injury or damage, but had the potential to do so (OHSAS 18001, 2007). Although some events result in more severe consequences than others, their origins are similar (De Fretes, 1986). As van Vuuren (1998, p6) noted: incidents and accidents are "preceded by the same set of failure causes and only the presence or absence of defences and recovery mechanisms determines the actual outcome (e.g. normal situation, near miss or accident)".

In recent years, both researchers and practitioners have become increasingly interested in "learning from incidents" as a strategy to further reduce the numbers of incidents and accidents (Lindberg, Hansson and Rollenhagen, 2010; Lukic, Margaryan and Littlejohn, 2010; Le Coze, 2013b). Learning from incidents implies that incidents are studied - to identify the causes and weaknesses that contributed to the incident - and that this information is used to prevent future incidents (Kletz, 1988; Kjellén, 2000). Learning from incidents that have occurred can further improve the current safety level of organisations, by providing valuable insight into the weaknesses in organisations, and ways to prevent similar situations (Kletz, 1988; Reason, 1990). Even though not all incidents are reported (e.g. Mancini, 1998; Sanne, 2008; Rasmussen, Drupsteen and Dyreborg, 2013), incidents are understood to be more numerous than accidents (Heinrich, 1931; van der Schaaf, 1992). Beginning to see the large number of incidents as learning opportunities is thus important in order to improve worker safety in all industries (Jones, Kirchsteiger and Bjerke, 1999; Kjellén, 2000; Kletz, 2001).

Interest in learning from incidents as a research field has increased in recent years (e.g. Carroll and Fahlbruch, 2011; Lindberg et al., 2010; Le Coze, 2013b). Early research on learning from incidents was mainly focussed on what could be learned from the incidents, meaning the specific

lessons (Herbert, 2010; Kletz, 2008; Sepeda, 2006; Stave and Törner, 2007). Accidents and incidents were studied to identify the causes and weaknesses that contributed to the incident. Although the aim was to address causes and weaknesses, most of the research was limited to the identification of these causes and weaknesses (Herbert, 2010; Kletz, 2008; Sepeda, 2006; Stave and Törner, 2007) and to methods by which to identify lessons from incidents and accidents (Pasman, 2009; Kontogiannis, Leopoulus and Marmaras, 2000; Le Coze, 2008; Sklet, 2004). Studying incidents is in itself not sufficient, however, if the aim is to address weaknesses and through this to prevent future incidents and improve safety (Kletz, 1988; Hale, Heming, Carthey and Kirwan, 1997; Kjellén, 2000). Recent developments in studies into learning from incidents have therefore emphasised the need for follow-up steps after the incident (Carroll and Fahlbruch, 2011; Lindberg et al., 2010; Le Coze, 2008; Wahlström, 2011).

Despite the growing body of research on the subject, many organisations are in practice not able to successfully learn from incidents (Hopkins, 2008, Jones et al., 1999, Kjéllen, 2000, Kletz, 2001). Hopkins (2008) investigated the explosion at the BP Texas City refinery in 2005, in which 15 employees were killed and over 170 people injured. He showed that the recommendations made by the US Refineries Independent Safety Review Panel were similar to recommendations that were already widely available prior to the explosion. This example illustrates the gap between theories on learning from incidents, and learning in practice. It illustrates how, in the safety field, learning from incidents often still refers to the identification of lessons, and not to the process of improvement that should follow from the identification of lessons. In practice many organisations that aim to improve their learning from incidents invest in reporting systems and accident investigations, but persistent issues that have been identified through earlier incident investigations are not always addressed (Kjéllen, 2000; Körvers and Sonnemans, 2008; Jacobsson, Sales and Mushtaq, 2009), and as a result, learning from incidents is not successful. This dissertation addresses this problem by investigating the following main research question: “how can organisations improve their learning from incidents?”

To improve learning in practice and to make better use of the lessons from accidents and incidents, it is necessary to define how organisations learn from their incidents, the difficulties that organisations run into with respect to learning from incidents, and why they run into these difficulties. Identifying the learning difficulties and the conditions required for learning enables organisations to improve their learning from incidents. This improved learning ability means they can make more effective use of the information they already have, and so help to prevent future incidents and improve safety. By increasing knowledge about learning from incidents in practice, this dissertation aims to contribute to improved learning and to accident prevention, and thus to the field of safety.

This dissertation examines four research questions in order to study learning from incidents in practice:

1. How do organisations learn from incidents?
2. What are the difficulties in learning from incidents in organisations?
3. What are the underlying factors that make it difficult to learn from incidents in organisations?
4. Under what conditions is learning likely to be successful?

A model is presented in this dissertation for the learning from incident process, and used to study learning from incidents in organisations. The model represents learning from incidents as a complete process, from collecting information on incidents and studying that information, to the use of identified lessons for the improvement and the evaluation of effectiveness (of the actions for improvement and of the process itself). The dissertation builds on four studies that address the research questions through the use of this model. The overall structure of this dissertation

takes the form of six chapters, including this introductory chapter. Chapter Two discusses the theoretical background of the four studies, including insights from safety management, accident causation and learning theory. The chapter concludes by synthesising theory into the process-model of learning from incidents. Chapter Three provides an overview of the methodology and study context. Chapter Four summarises the main findings of the four studies. Chapter Five draws upon the entire dissertation, connecting the theoretical and empirical insights from the four studies before the findings, limitations of the methodology and areas for further research are discussed. The dissertation is concluded in Chapter Six. Papers reporting on the four studies described in the dissertation, are included at the end.

2.Theoretical background

This chapter describes and discusses the theories on which the four studies of this dissertation are built. What follows is a discussion of previous research on learning from incidents, safety theories, and the organisational learning theory of Argyris and Schön (1979). The final section of this chapter combines these theories into a theoretical framework to study learning from incidents. Before describing the theories used to study learning from incidents, the first sections focus on the information from which we learn, the incidents.

2.1 Incidents

Before discussing the theories about learning from incidents, this section elaborates on the definition of incidents, which is the input that is used for learning. In practice, the subject 'learning from incidents' often raises questions about what an incident is, and what events are useful for learning. This shows a need to be explicit about the meaning of the word 'incident' in this dissertation. An incident, according to the Oxford Advanced Learner's Dictionary (2010) is an instance of something happening, an event or occurrence. The definition of an incident in the safety field is closely related to that of accidents and of near-misses. The Health and Safety Executive guide on accident investigation (HSE, 2004) uses the term 'adverse events' to include incidents, accidents, near-misses and undesired circumstances. In the categorisation of adverse events by HSE (2004), an accident is defined as an event that results in injury or ill health. Under that categorisation near-misses and undesired circumstances are considered specific types of incidents, meaning events that did not result in injury or ill health, but had the potential to do so. This description aligns with the definition of Koornneef (2000), who refers to incidents as undesirable conditions that have the potential to cause damage or other loss. Incidents are also sometimes considered to be events that *do* lead to damage or injury, but with less severe consequences than accidents (Leung, Chan and Yu, 2012). Examples of such incidents include material damage that can easily be repaired, or injuries such as bruises or cuts.

The most often used definition of the term 'incident' is a broad definition that includes all events that lead to injury or damage, or had the potential to do so (OHSAS 18001, 2007; van der Schaaf, 1992). This dissertation uses this broad definition of incidents, referring to the combined set of occurrences of both accidents and near-misses. The term 'incident' then refers to any unexpected deviation from the normal operational process, that has led (accident) or could have led (near-miss) to damage or injury. In this dissertation, the aim is to contribute to structural safety improvements through preventing the events. Actions aimed at the prevention of consequences, as occurs for instance when the main aim is to reduce fatalities, can also contribute to organisational safety (Peuscher and Groeneweg, 2012).

Incident and accident causes

Identifying what caused an incident is important for learning from incidents, because the same cause may lead to other incidents if it remains unaddressed (Chung, Broomfield and Yang, 1998; Dien, Llory and Montmayeul, 2004). James Reason's Swiss cheese model (Reason 1990) is a well-known theory and it is the most commonly used model of accident causation (Reason, Hollnagel, Paries, 2006; Le Coze, 2013a). This model was developed to facilitate the structural improvement of safety through the study of incidents (Reason 1990), meaning that the model is specifically suitable for learning from incidents. In the Swiss cheese Model, an organisation's defences against failure are modelled as a series of barriers, represented as slices of cheese. The holes in the slices

represent weaknesses in individual parts of the system and continually vary in size and position across the slices. The system produces failures when the holes in the slices momentarily align, permitting 'a trajectory of accident opportunity', so that a hazard passes through holes in all the slices, leading to a failure (Reason 1990). This model includes 'direct' factors manifesting on the operational level and 'latent' factors on the systemic level, where the systemic factors are the underlying reasons for the operational factors. Some theorists argue that the Swiss cheese model is not able to capture the dynamics of the real world (Hollnagel 2004; Leveson 2004 and Rasmussen, 1997), and have presented models that focus on the complexity and interactions that may lead to accidents. Rather than focusing on specific causes or factors, these models aim to identify characteristics of the system 'as a whole' as the origin for incidents and accidents. Despite this difference, both types of model emphasise that the weaknesses in the organisation (or system) allow actions on an operational level to result in an accident. Through learning from incidents, these weaknesses are identified and addressed.

Reason (1997) used the terms 'active failures' and 'latent failures' for the factors that contribute to an accident. Active failures are, in general, errors made at the so-called sharp end of accident causation, such as technical and human failure. These failures are directly related to the incident, whereas latent conditions create the circumstances for active failures to occur, such as through organisational failures or managerial weaknesses (Reason 1990). Latent factors create sub-optimal conditions in an organisation and are the real target for improvement, in order to control the environment (Groeneweg 2002). Latent failures may lie dormant for years before active failures, meaning the operational 'direct' failures create holes in the slices of the Swiss cheese. Other terms commonly used to describe latent failures are 'indirect causes', 'root causes' or 'underlying causes and conditions'.

Although many different terminologies are used for the distinction between active failures and latent failures, various authors (Choularton, 2001; Dechy et al., 2012; Fahlbruch and Schöbel, 2011; Jacobsson, Sales and Mushtaq, 2009) agree on the relevance of addressing both. As stated in Study I of this dissertation, which is a review of the literature: "Addressing the indirect causes or conditions, independent of the people who are operating, creates a safer environment in which more than just one event will be prevented" (Study I: Drupsteen and Guldenmund, 2014, p 87). If only active failures (or only latent failures) are identified, the remedial actions that follow will have a limited impact, and learning is likely to be limited in effectiveness (Kletz, 1988). The distinction is therefore important for the quality of learning from incidents. In this dissertation I apply this concept in a new setting: to explain the causes of ineffective learning from incidents.

To facilitate the identification of active and latent causes, numerous methods for incident analysis are available, as discussed in Study I (Drupsteen and Guldenmund, 2014). Sklet (2004) described and compared some commonly used methods for the investigation of accidents. It is very important in order to learn from incidents that accident investigation and analysis are performed with care, and that the information from which to learn is retrieved. The result of the study of incidents - i.e. the lessons - is the information that is used for improvement. Therefore, if the study (investigation and analysis) is not performed well, the actions that follow are not likely to lead to effective safety improvement. Studying the incidents to identify the causes is, however, not sufficient in order to learn from incidents: for the prevention of future incidents, it is important that the weaknesses that are identified, are addressed (Kletz, 1988; Kjéllen, 2000), meaning that the lessons are applied. This dissertation focusses on learning from incidents as a complete process, including follow-up after investigation and analysis.

2.2 Defining learning from incidents

As pointed out in the introduction to this dissertation, many organisations fail to learn from incidents, even when the underlying lessons have been identified. To consider why learning from incidents is not successful, it is necessary to define what learning from incidents is, and what further steps are necessary for prevention if lessons are identified (see Research Question 1). This section discusses previous research on learning from incidents, similarities between learning and safety management systems, and explains how the organisational learning theory of Argyris and Schön (1979) contributes to defining learning from incidents. Section 2.4 combines these theories in a theoretical framework for studying learning from incidents.

Studies on learning from incidents

In recent years, there has been an increasing amount of literature on learning from incidents (e.g. Lindberg et al., 2010; Lukic et al., 2010; Le Coze, 2013b). Study I of this dissertation analysed the literature on learning from incidents in safety research and demonstrated that multiple processes are involved in learning from incidents. The three main processes are: investigation and analysis of incidents (as explained in the previous section), the use of lessons learned, and sharing and storing information. To improve learning from incidents in companies, the activities involved in these three processes should be optimised. The research questions of this dissertation follow from the review. Firstly, the review showed that aspects of the information from which to learn, the incident and the incident analysis, are more commonly addressed in safety literature than the learning processes. This finding underlines the need to identify follow-up steps after the investigation and analysis of incidents, and thus supports the need to answer Research Question 1 "How do organisations learn from incidents?" The review also shows the need to further investigate hindrances and conditions that facilitate learning, which refers to the second, third and fourth research questions. Section 2.3 elaborates on the hindrances to, and conditions for learning from incidents that have been identified in the review. The review of safety literature demonstrated that despite the number of papers written on the subject of learning from incidents, only limited empirical research is available on how incidents are used in order to learn. This dissertation addresses this gap by studying learning from incidents in practice.

Since learning from incidents is an emerging field of study, and is continuously evolving, new research has been published since Study I. The following sections discuss the main results of Study I, updated with recent studies. The theory on learning from incidents is structured according to two main sections. The first section explains stepwise models of learning from incidents, and the second section discusses sharing and storing information as part of learning from incidents.

Stepwise models of the learning from incidents process

Whereas most of the studies on learning from incidents focus on the analysis of incidents and on specific lessons that can be learned from major events (see Study I), some studies focus on learning from incidents as a process that includes several steps or phases after the identification of lessons (Lindberg et al., 2010; Jacobsson et al., 2010; 2011). Lindberg, Hansson and Rollenhagen (2010) presented steps for learning from incidents in their Chain of Accident Investigation (CHAIN) model of experience feedback. They showed how this chain process as a whole fails if one of its links fails. The first step in the CHAIN process is the reporting of incidents. In the second step a selection of incidents is made for further investigation, based on the reports. The third step is the investigation and then, in the fourth step, the results are disseminated, meaning that lessons are communicated. The fifth and final step is the actual prevention of accidents (Lindberg et al. 2010). The authors explained that this process should be self-reflective

and include evaluation activities that lead to improvements in the process itself. Another model was presented by Jacobsson et al. (2010; 2011), who presented similar steps in a formal incident learning system with a procedure consisting of step-by-step instructions that handles information at all steps. The typical learning cycle, according to Jacobsson et al. (2011) includes: data collection and reporting, analysis and evaluation, decisions, implementations and follow-up. This cycle is derived from the safety, health and environment (SHE) information system of Kjéllen (2000). The benefit of these stepwise models is that they clearly illustrate how incident analysis should be followed by further actions to contribute to incident prevention. The models emphasise a broader view of learning that goes beyond learning lessons through incident investigation and analysis. However, the models presented here are based on theoretical findings and not yet applied within organisations. In this dissertation a similar model is applied in practice to study learning from incident processes in organisations.

Sharing lessons learned

In addition to the importance of follow-up steps in learning from incidents, the review in Study I also showed the importance of sharing lessons. When learning from incidents, many people are involved throughout the process, such as managers, HSE specialists and operational employees. These people act within the learning process, with the aim of achieving changes at an organisational level. The lessons that are learned by a person or a group can be interesting or even significant for the whole organisation (and for other organisations) (Schein, 1992; Koornneef, Hale and van Dijk, 2005; Lukic, Margaryan and Littlejohn, 2010). The lessons might also apply to other situations and it is important to share the information so that people know how an incident is followed up. This need is emphasised by Schein (1992), Koornneef et al. (2005) and Lukic et al. (2010).

Koornneef et al. (2005) discussed the importance of disseminating lessons in a study on near-misses, by noting that if knowledge is shared through an organisation, it can be used to improve work processes, conditions, or behaviour in a wider context than simply that where an incident occurred. Lukic et al. (2010) discussed a more participative approach to sharing, in which learning is embedded in social relations, and knowledge is created by obtaining new ideas from working with others. For instance if an incident occurs, it can be related to other events and occurrences through the discussion of that incident with colleagues (Lukic et al., 2010). According to their research (Lukic, Margaryan and Littlejohn, 2010), theories of organisational learning have either an individual or a social focus. An individual focus means that learning occurs in individuals and this learning becomes organisational through the sharing and transfer of information. According to the social perspective, learning occurs through continuous sharing and participation in practice, meaning that the individual takes part in a collective process (Lukic et al., 2010; Lampel, Shamsie and Shapira, 2009; Liao, Fei and Liu, 2008; Yukl, 2009). An important process that is part of the social learning theory is sense making, which is the process by which people give meaning to experience (Weick, 1979; 1995; Dervin, 1983). Lampel et al. (2009) use the term 'learning about events' for this process, in which information about events is shared and diffused to help create new ideas. When learning from incidents, this occurs, for instance, in toolbox talks, when the aim is reflection on practice.

Although learning from incidents was not explicitly defined, Lukic, Littlejohn and Margaryan (2012), seemed in their study of 2012 to be especially interested in these social aspects of learning and in the processes of understanding information and sense making. Lukic et al. (2012) distinguished two types of initiatives for learning: formal and informal learning. Formal initiatives include, for instance, database systems, email dissemination, and safety meetings, whereas informal initiatives refer to personal communication, such as that during shift takeover or toolbox

talks. Most of the safety initiatives that they identified in practice were formal initiatives. Informal learning, which often occurs spontaneously, is more difficult to capture.

With the exception of the studies by Lukic et al. (2010; 2012) and Lampel et al. (2005), social learning and knowledge sharing processes have received limited attention in the literature on learning from incidents. More models for sharing and transfer of knowledge are described in knowledge management and organisational studies, for instance by Nonaka and Takeuchi (1995), Argote and Ingram (2000), and Bontis, Crossan and Hull (2002). Study IV of this dissertation highlights the importance of sharing and storing knowledge for learning from incidents. Whereas Studies II and III specifically focus on performing the steps in learning from incidents, Study IV includes sharing knowledge as an equally important aspect of learning from incidents.

Safety Management Systems

So far, this chapter has analysed the literature on learning from incidents in order to clarify the steps in learning from incidents and the importance of sharing knowledge throughout this process. This section compares the elements of a learning from incidents process with elements of Occupational Health and Safety Management Systems, from now on referred to as Safety Management Systems (SMS). Safety Management Systems are developed to prevent accidents by measuring and controlling weaknesses in an organisation (Cullen, 1990; Hasle and Zwetsloot, 2011; Hale, Heming, Carthey and Kirwan, 1997; Robson et al., 2007). Similar to the learning from incidents process, Safety Management Systems aim to identify and address weaknesses. Although learning from incidents is not explicitly discussed in descriptions of Safety Management Systems, many similarities between the two concepts can be found. SMS are also well-known and widely applied in organisations. Because of the similarities between the two concepts and the wide application of SMS in practice, theories and experience from SMS can contribute to the understanding of learning from incidents in practice. The following sections discuss Safety Management Systems and the similarities with learning from incidents, starting with defining Safety Management Systems.

There is no clear definition of what a Safety Management System is and what its elements are (Hale et al., 1997; Robson et al., 2007), and as a result, many different management systems exist in practice. Hasle and Zwetsloot (2011, p962) state with respect to Occupational Health and Safety Management Systems (OHSM) that: "OHSM systems form a kind of shell which can be filled with different content, depending on the company and its ambitions, culture and history". Elements that are usually an important aspect of such a system are, according to Frick (2011), the identification of hazards and the control of risks.

To create a single unified approach to Safety Management, the Occupational Health and Safety Advisory Services (OHSAS) Project Group was formed in 1999. The worldwide recognised standards of OHSAS 18000:2007 (2007) provide organisations with the elements of an effective Safety Management System that can be integrated with other management requirements and help organisations achieve better occupational health and safety performance and economic objectives[1]. OHSAS 18000:2007 consists of two main elements; OHSAS 180001 and OHSAS 18002. OHSAS 18001 specifies the requirements for a Safety Management System and OHSAS 18002 provides generic assistance for implementing OHSAS. The key elements of OHSAS 18001 (see also Figure 1) are:

- Occupational Health and Safety policy,
- Planning, including risk and hazards assessment;

[1] OHSAS 18000:2007 will be replaced in the near future by the ISO45000 standard

- Implementation and operation;
- Checking and corrective action;
- Management review of the SMS, to ensure its continuing suitability, adequacy and effectiveness;
- Continual improvement of the SMS.

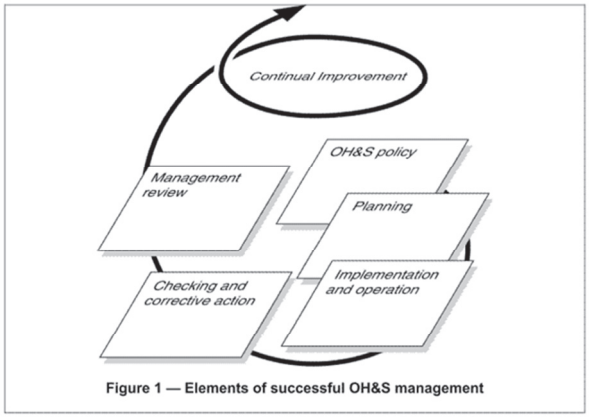

Figure 1. OHSAS 18001.

Many Safety Management Systems, including OHSAS, are based on the same Plan-do-Check-Act (PDCA) model of continual quality improvement (Deming, 1982). In the PDCA cycle, actions are planned, implemented and evaluated and the results from that evaluation may again lead to adaptations or new actions. Continual monitoring, checking risks, and acting upon that are core aspects of safety management. Incident registration is often an important part of this monitoring and checking process, since the incident reports give information on the risks that were not controlled. Table 1 presents the main elements of the SMS in relation to the PDCA cycle. It also shows how the PDCA cycle applies to learning from incidents, and to learning about the learning process itself. The 'learning to learn'- process provides valuable input for continual improvement, because a review of the learning process may lead to actions to improve the process itself and so enable organisations to improve their learning from incidents. Reflecting on the learning process itself, can be compared with the management review of the SMS (OHSAS 18001, 2007; Robson et al., 2007).

Not only are SMS and Learning from Incidents similar to the PDCA cycle, but their purpose is also related. Both SMS and learning from incidents aim to prevent future incidents and increase safety within the organisation. Whereas the Safety Management System is proactive and aims to prevent incidents in general, learning from incidents can only occur if an incident *did occur,* meaning that it was not effectively prevented. The aim of studying incidents, is to identify weaknesses in the organisation that may have contributed to incidents, and this includes weaknesses in safety management. Other factors that are identified through incident analysis should also be used as input for the SMS, so that the newly identified risks can be monitored and responded to. The incident analysis thus creates input for the Safety Management System. Since Safety Management and learning from incidents are such similar processes, integrating learning from incidents with the Safety Management System may increase understanding of the steps in learning from incidents, and the use of learning from incidents in practice. This dissertation uses the PDCA cycle in a model of the learning from incidents process, resulting in a model that fits with the thinking of safety managers and practitioners.

Table 1
Elements of Safety Management and Learning from Incidents in relation to the PDCA cycle

Steps	Safety Management System	Learning from Incidents	Learning to learn
Plan	Reporting incidents and assessing hazards and risks	Analysing incidents, and planning actions to address identified weaknesses in the organisation	Analysing the learning process and planning actions to address identified weaknesses
Do	Implementation and operation	Implementation of the actions for improvement	Implementation of the actions for improvement
Check	Checking and corrective action	Monitor and evaluate actions (and plans) to determine their effectiveness	Monitor and evaluate the learning process
Act	Take actions to continually improve OSH Performance	Take actions to continually improve OHS performance	Take actions to continually improve learning from incidents

Organisational learning theory

After discussing the similarities between learning from incidents, safety management and the PDCA cycle, this section now moves on to consider how aspects of organisational learning theory can further increase understanding of learning from incidents. Learning from incidents is a process that is aimed at change on an organisational level and can therefore be considered as a

specific type of organisational learning. Be that as it may, organisational learning aspects are seldom mentioned in the literature on learning from incidents, with the exception of a few studies (Chevreau, Wybo and Cauchois, 2006; Sanne, 2012; Jacobsson, Ek and Akselsson, 2011).

The literature on organisational learning is fragmented and there is no consensus on a single definition of organisational learning, meaning that a variety of definitions can be used. An overview of the main theories on organisational learning has been provided by Prange (1999), who analysed and compared these theories, and concluded that there was a lack of consistency in them (Table 2).

Table 2
Definitions of organisational learning (adapted from Prange (1999, p30).

Author(s) (Year)	Definition of OL
Cyert and March (1963)	Organisational learning is the adaptive behaviour of organisation over time
Cangelosi and Dill (1965)	Organisational learning consists of a series of interactions between adaptation at the individual, or subgroup level and adaptation at the organisational level
Argyris and Schön (1979)	Organisational learning is the process by which organisational members detect errors or anomalies and correct them by restructuring organisational theory-in-use
Duncan and Weiss (1979)	Organisational learning is the process within the organisation by which knowledge about action-outcome relationships and the effect of the environment on these relationships is developed
Fiol and Lyles (1985)	Organisational learning is the process of improving actions through better knowledge and understanding
Levitt and March (1988)	Organisations are seen as learning by encoding inferences from history into routine behaviour
Huber (1991)	An entity learns if, through the processing of information, the range of its potential behaviours is changed… Let us assume that an organisation learns if any of its units acquires knowledge that it recognizes as potentially useful to the organisation

This dissertation uses a definition, based on the definitions of Fiol and Lyles (1985) and Argyris and Schön (1979), of a process in an organisation in which information is acquired and used for continual improvement of weaknesses in the organisation. When applied to learning from incidents, this means that the aim is to acquire information on organisational processes, goals and environment (which results from studying incidents), to correct errors, to improve actions and to improve weaknesses in the organisation. The main model for organisational learning that I use to study learning from incidents in this dissertation is that of Argyris and Schön (1979; 1996). This model is particularly useful for this dissertation, because in the theory that was presented in 1979, Argyris and Schön noted the importance of learning as a means to detect and respond to errors and unwanted situations, and this specific theory of learning is still widely accepted. Two main concepts in the theories of Argyris and Schön are particularly relevant for learning from incidents: the 'theories of action' and the 'levels of learning'.

The first concept, the 'theories of action', is the starting point of the theory by Argyris and Schön (1979). They claimed that people have two theories of action that guide their behaviour. One 'theory' is theory-in-use. This theory-in-use guides how people act in practice. It is often tacit, meaning that people are mostly unaware of it, and is for instance visible in routine behaviour. The second theory is espoused theory. This espoused theory is what people say they do, or think

they do. Espoused theory can, for instance, become visible as intended behaviour. Espoused theory contains "the words we use to convey what we do, or what we like others to think we do" (ibid.). If there is a discrepancy between theory-in-use and espoused theory, this means that what is said does not match what is done, and an adaptation of the theories of action may be necessary. The difference between the two theories is illustrated in the auditing of safety management systems. An audit that focusses too much on the documentation of procedures, and does not carefully investigate the actual practice, will not be very effective because it mainly addresses the espoused theories of the organisation and not the theory-in-use.

The distinction between theory-in-use and espoused theory is also visible when learning from incidents. Managers or other organisational representatives often claim that they learn (or intend to learn) from incidents (espoused theory), but this does not necessarily align with actual activities in practice (theory-in-use). When the learning from incidents process is actually performed and put into practice, this is an illustration of a successful theory-in-use. Espoused theory of learning from incidents is illustrated by the formal organisation of the learning from incidents process, for example by systems and procedures. Learning from incidents will be most effective if espoused theory and theory-in-use match.

The second concept, the 'levels of learning', also originates from the theory of Argyris and Schön (1979), and was based on Gregory Bateson's concepts of first and second order learning (Bateson 1972). In their theory, Argyris and Schön (1979, 1996) distinguished between single-loop learning and double-loop learning as optional responses to unwanted situations. In single-loop learning the basic characteristics of the situation remain constant, but the existing situation or processes are improved. Examples of single-loop learning after incidents are, for instance, training employees in particular behaviour or repairing technical equipment. In double-loop learning, the values and assumptions that led to actions are questioned. If these values are changed or modified, double-loop learning occurs. When learning from incidents, single-loop learning means that actions for improvement would focus on *what* went wrong, whereas in double-loop learning, the actions would focus on *why* this went wrong. Single-loop learning is mainly related to addressing active failures or direct causes, whereas double-loop learning is related to addressing the latent failures. Because both active and latent causes have to be addressed to prevent reoccurrence of similar events, both single- and double-loop learning are important when learning from incidents, however, it is through double-loop learning that more generic weaknesses are addressed and a wider array of incidents is prevented.

A specific level of learning is known as 'deutero-learning' (Argyris and Schön, 1979; 1996). The level refers to 'learning-to-learn' by seeking to improve both single- and double-loop learning. Deutero-learning therefore also refers to improving learning from the incidents process, including improved identification of lessons and improved implementation of remedial actions. The process of continual improvement through a process review, which is explained in the section on safety management, is such a learning-to-learn process. Improving learning from incidents and thus learning-to-learn, is the overall aim of this dissertation. Learning-to-learn is facilitated in this dissertation through better reflection on the learning from incidents process and on the causes of ineffective learning.

2.3 Conditions for learning from incidents

So far this chapter has focussed on theories to define learning from incidents, contributing to Research Question 1: "How do organisations learn from incidents?" The following sections of this chapter address theories on hindrances, and conditions for successful learning from incidents, referring to Research Questions 2, 3 and 4 about why organisations do, or do not, learn

successfully from incidents. The first subsection discusses hindrances and conditions that are known from learning from incidents studies. This section is followed by insights into conditions for learning from organisational learning theories.

Studies on hindrances and conditions when learning from incidents

Some reasons organisations fail to learn effectively from incidents have been considered in earlier studies (e.g. Choularton, 2001; Hovden Størseth and Tinmannsvik, 2011, Le Coze, 2013b) (see also the literature reviewed in Study I, Study III and Study IV). According to these studies, reasons organisations don't learn include: too few incidents are reported (Mancini, 1998; Sanne, 2008; Rasmussen et al. 2013), too little information about the incident is given (Sanne 2008), latent causes for the incident are not identified (Jacobsson et al., 2009; Körvers and Sonnemans, 2008) or the implementation of remedial actions is impeded (Cedergren, 2013). These causes refer to operational factors that occur in specific aspects of learning from incidents (such as analysis, investigation or follow-up), but the conditions that hinder or facilitate learning from incidents as a whole have also been studied (Akselsson, Jacobsson, Börjesson, Ek and Enander, 2012; Chevreau et al., 2006; Pidgeon and O'Leary, 2000; Le Coze, 2013b). Le Coze (2013b) explained in his review of learning from incidents literature that learning depends on different combinations of such conditions. The aspects that influence learning from incidents listed in his review are: the country and the industry in which the learning process occurs, the severity of the event, the scientific discipline from which the process is considered, and the actors in the learning process.

Individual employees are the actors in the learning process, and without them, learning from incidents cannot occur. They are involved in reporting incidents, analysing incidents, determining actions, etc. Limitations in the competences of the people involved (Hovden et al., 2011; Akselsson et al., 2012) or resistance to change (Lundberg et al., 2012) are thus hindrances to learning from incidents. The importance of the people involved is also highlighted in the studies of Boin and Hart (2003) and Carmeli and Gittel (2009). Boin and Hart (2003) even suggested that a lack of recognition for people participating in the learning from incidents process is the main factor that impedes learning.

Fahlbruch and Schöbel (2011), Sanne (2012), Stockholm (2011) and Lundberg, Rollenhagen and Hollnagel (2010) focussed on the importance of beliefs and people's mental models when learning from incidents. Fahlbruch and Schöbel (2011) showed that the analysis of incidents is impeded by premature hypotheses, mono-causal thinking, and ignoring factors that are not written down in the method, meaning that the analysis is impeded by a way of thinking that is formed through earlier analysis and experience. Sanne (2012) also concluded that the investigation and analysis of incidents is influenced by the perspective of the investigator. He analysed the investigation of a nuclear power incident and showed how the industry's learning practices were shaped by so-called risk objects. These risk objects - such as human factors, safety culture or technique - focussed the search for potential causes of an event and the analysis of these causes. Risk objects are shaped through earlier analyses, and by organisational procedures, practices, beliefs and technologies.

Whereas Sanne (2012) and Fahlbruch and Schöbel (2011) focussed only on how beliefs and mental models influence accident investigation, Stockholm (2011) and Lundberg et al. (2010) concluded that improvements after accident investigation are also constrained by these personal issues. Lundberg et al. (2010) showed that choices of recommendations depend mainly on what you know and are able to address, but also on the cost-benefit balance and on previous knowledge: fixes that are known to work and easy to understand are more likely to be

implemented. These findings showed that there are many factors that influence what an investigator finds, and that the identification of lessons does not necessarily mean that those lessons are addressed. The importance of personal understanding and knowledge in decision-making is also underlined by Stockholm (2011). He explains in his practitioners' perspective on learning from incidents how both the identification of lessons (meaning the analysis of incidents) and the choice of remedial actions, are limited by one's own personal beliefs. People tend to hold on to their beliefs, despite evidence to the contrary. Accepting that you were wrong, or that the system failed is uncomfortable and sometimes even difficult to understand, since it requires an alternative viewpoint which limits the possible lessons that can be identified. Lessons can only be addressed in the way that is they are understood, and so follow-up also is limited by one's personal beliefs (ibid.).

The studies of Lundberg et al. (2010) and Stockholm (2011) emphasised the importance of previous knowledge and beliefs for the implementation of identified lessons, which is similar to the findings of Sanne (2012) and Fahlbruch and Schöbel (2011) who emphasised how the analysis of incidents is limited by these same aspects. The studies also give insight into factors that influence the beliefs. Lundberg et al. (2010) explained that the beliefs and knowledge that are used in decision-making, follow from competences, resources, availability of data and the political context in which an investigation and its follow-up occur. Sanne (2012) explained that the perspective for studying incidents is shaped through earlier analyses, and by organisational procedures, practices, beliefs and technologies. In addition, Study I of this dissertation showed that the organisational context in which learning occurs, specifically organisational trust, is an important factor for learning from incidents.

Several researchers investigated the organisational conditions that influence learning from incidents (Akselsson, Jacobsson, Börjesson, Ek and Enander, 2012; Carmeli and Gittel, 2009; Chevreau et al., 2006; Pidgeon and O'Leary, 2000; Reason, 1997). These conditions were: a lack of trust (Pidgeon and O'Leary, 2000; Chevreau et al., 2006; Carmeli and Gittel, 2009; Akselsson et al., 2012), a blame culture (Dekker, 2009; Guldenmund, 2000; Reason, 1997) and that learning from incidents puts weaknesses and errors in the spotlight and challenges competencies and organisational patterns, which is uncomfortable for operators and managers (Wybo, 2012). Carmeli and Gittell (2009) proposed two facilitating contexts for learning in an organisation: the existence of '*high quality relations*' among people – meaning shared goals, shared knowledge and mutual respect – and the existence of a 'psychological safety' – meaning that people feel that they can ask questions or feedback and report errors.

Taken together, the list of studies in this section indicates that many factors can influence the success of learning from incidents. These studies especially emphasise the importance of personal beliefs and the organisational context in which learning from incidents occurs. Unfortunately, despite the large number of theoretical studies, only limited empirical research on hindrances and conditions is available.

Conditions for organisational learning

Organisational learning can provide additional understanding of conditions for learning. Studies of organisational learning mainly emphasise two categories of conditions for successful learning: structures and organisational learning capabilities. *Structures* are the formal arrangements, through tools, IT-systems and procedures, that are created for learning (Senge, 1990; Robey, Boudreau and Rose, 2000). O*rganisational learning capabilities* represent the organisational and managerial environment in which individuals operate (Chiva and Alegre, 2009, Goh and Richards, 1997, Jerez-Gomez, Céspedes-Lorente, and Valle-Cabrera, 2005). These abilities align with the

organisational conditions as per the previous paragraph. According to organisational learning theories, if both structural mechanisms and organisational learning capabilities to promote learning are present, organisational learning, and thus also learning from incidents, is facilitated (Senge, 1990; Dierkes, Berthoin, Child and Nonaka, 2004).

Structures

As explained above, structures such as tools, IT-systems and procedures are considered important conditions for learning. Systems and tools can facilitate learning from incidents and the dissemination of information (on incidents, on identified causation, on planned action, etc.). From his perspective on the learning organisation, Senge (1990) explains that learning organisations typically have excellent knowledge management structures, allowing the creation, acquisition, dissemination, and implementation of this knowledge in the organisation. A review of IT and organisational learning by Robey, Boudreau and Rose (2000) emphasises two main systems as enablers of organisational learning: the organisational 'memory' and communication systems. In the safety field, the facilitation of such a memory is mainly limited to capture and storage of explicit information, including capture of information through incident registration systems and incident investigation, and the storing of information through incident or event-databases. Tools that are used to facilitate communication are, for instance, group support systems or collaborative tools. Despite their benefits for organisational learning; tools and systems are in themselves not sufficient for learning to occur, and may even be limiting. They need to be used and maintained in continual interaction with daily practice. The next section explains how organisational learning capabilities can be used to assess the organisational environment in which the systems are used.

Organisational learning capability

Several authors (Chiva and Alegre, 2009, Goh and Richards, 1997, Jerez-Gomez et al. ,2005) use the concept of organisational learning capability to explain the organisational and managerial characteristics that allow an organisation to learn. The dimensions of this learning capability are: managerial and leadership commitment (Jerez-Gomez et al., 2005), openness and experimentation (Chiva and Alegre, 2009, Goh and Richards, 1997, Jerez-Gomez et al., 2005), knowledge transfer and integration (Jerez-Gomez, 2005; Goh and Richards, 1997), and interaction with external environment (Chiva and Alegre, 2009; Jerez-Gomez et al., 2005). Organisational learning capabilities are known to influence organisational learning and can be measured through a validated questionnaire. 'Organisational learning capability' is, because of these advantages, the main concept that I use to study the organisational context in which learning from incidents occurs.

Jerez-Gomez et al. (2005) developed a questionnaire to measure organisational learning capability, consisting of four dimensions: managerial commitment, systems perspective, openness and experimentation and knowledge transfer and integration. *Management commitment* means that the management recognises and articulates the relevance of learning. They drive the process of change and eliminate old beliefs when necessary. Clear objectives are then stated and effectuated. In an organisation that consists of many individual parts, it is useful to consider the organisation as a system. The dimension *systems perspective* emphasises the importance of a common language, shared mental models and clear objectives to enable collective learning. To learn, an organisation has to be open to new ideas and points of view. This includes ideas from internal processes, but also the use of experience of other organisations as examples. *Openness and experimentation* also relates to the ability to question existing knowledge. Trying out new ideas and options to search for innovations also includes the possibility of making mistakes and

thus learning from failures. The fourth dimension refers to two processes: *internal transfer and integration of knowledge*. Signals, lessons learned, and other information are shared throughout the organisation and should also be integrated so that a collective body of knowledge can be created. Through discussion of information throughout the learning from incidents process, understanding of the information increases, and it is likely to be better used. Sharing and storing knowledge may contribute to a better learning from incidents process, but these processes are also associated with another important aspect of learning: the forming of organisational memory. The idea of organisational memory is that "the knowledge can be subsequently recovered and applied to different situations" (Jerez-Gomez et al. 2005, p.718). Section 2.2.1 explained how sharing information is important for learning from incidents, to create new knowledge and to become organisational. The fourth dimension of the organisational learning capabilities refers to this process of sharing. In this dissertation, sharing information is thus considered a condition for successful organisational improvement, as part of the organisational learning capabilities.

2.4 Model of the learning from incidents process

After having discussed the central conceptual issues relating to learning from incidents, this section shows how insights from safety practice, safety research and of organisational learning tie into the model of the learning from incidents process. The model represents the learning process as a whole, meaning that *learning from incidents* refers to a process from determining lessons, to using the results of these lessons for improvement and the evaluation of the actions taken. *Determining lessons*, through investigation and analysis, is a sub-process of this learning from incidents process. Another learning process in this dissertation is *'learning to learn'*, which relates to the evaluation of the learning process itself. Through studying whether the process as it is currently performed is effective, and why it is or isn't, possible improvements to the learning process can be initiated (Argyris and Schön, 1979; Deming, 1982). Through use of the model, learning from incidents can be systematically studied, meaning that learning-to-learn can be facilitated. Before proceeding to explain the model in further detail, the following sections summarise the development of the model of learning from incidents and the four assumptions underlying the model, which follow from the theories in the previous sections.

Development of the model

The model of the learning from incidents process integrates existing elements from safety practice, safety research and of organisational learning into one model for learning from incidents. Before applying the model in Study II, I presented it in a meeting with stakeholders from 25 companies. This meeting included discussion of whether the model was applicable for studying the learning process within a wide range of organisations, and to verify whether it was easy for the companies to understand. Findings from the first and the second study of this research project led to further specification of the model. Chapter 4 explains the adaptations of the model.

Assumptions underlying the model of learning from incidents

The following assumptions about learning from incidents result from the theory in this chapter.

1: Learning from incidents is a stepwise process from studying incidents to using the results of this study for the effective improvement of safety and the prevention of future incidents.

When learning from incidents, lessons are not only identified, but they are also used for improvements on an organisational level. The model of learning from incidents that is developed and used in this dissertation builds on the PDCA-cycle (Deming, 1982) of continual improvement. In parallel to the development of this model, Lindberg et al. (2010) and Jacobsson et al. (2010;

2011) developed similar models explaining that several follow-up steps for the implementation of lessons are necessary for learning from incidents after the analysis of incidents. The main difference between their models and this model is that in this model, the steps are specified based on experience from practice, and that an evaluation stage is included to facilitate continual improvement.

2: Learning from incidents is not effective if there is a discrepancy between the espoused theory and theory-in-use

Argyris and Schön (1979) emphasised that for successful learning, the theory-in-use should be in line with the espoused theory. A discrepancy between the two theories exists, for instance, when the learning process is organised in formal systems, but is not effective in practice.

3: Improving learning from incidents requires 'learning to learn'.

The aim of this research project is to contribute to improved learning from incidents, meaning that information from incidents can be more effectively used to identify and address weaknesses in the organisation. Improving learning from incidents in an organisation requires some reflection on the process of improvement, so that learning itself can be improved. Throughout the learning from incidents process many options for reflection and adaptation exist. Four moments in the learning process are particularly important for this reflection, resulting in a model of four phases.

4: Learning from incidents is supported or hindered by the organisational environment in which the process is performed.

The theories of learning from incidents and organisational learning illustrate that it is influenced by the organisational context in which it occurs. Specifically the importance of personal beliefs, structures and of organisational learning capabilities is shown. Whereas Assumptions 1, 2 and 3 can become visible through the model of the learning from incidents process, Assumption 4 refers to the environment in which the learning process occurs, which is not visible in the model. One condition is, for instance, that knowledge is shared in order for the LFI process to become organisational (see Section 2.2.1). Theoretically, the steps in the learning from incidents process could be completed by a single person, but for learning from incidents to become organisational other people need to be involved and informed. This model does not include any information on those actors of the learning process and how they share and store information.

Model of the learning from incidents process

Turning now to the model of learning from incidents, the model consists of four phases that are represented in Figure 2.

The first phase describes the acquisition of knowledge through the investigation and analysis of reported incidents. In the second phase this knowledge is translated into action, and in the third phase these actions are performed. The fourth phase aims to evaluate the actions and the learning process. Each of the phases in the model leads to a result (gate) that is considered vital input into the next phase. The result of each phase is necessary, but not sufficient by itself, for an effective learning from incidents process.

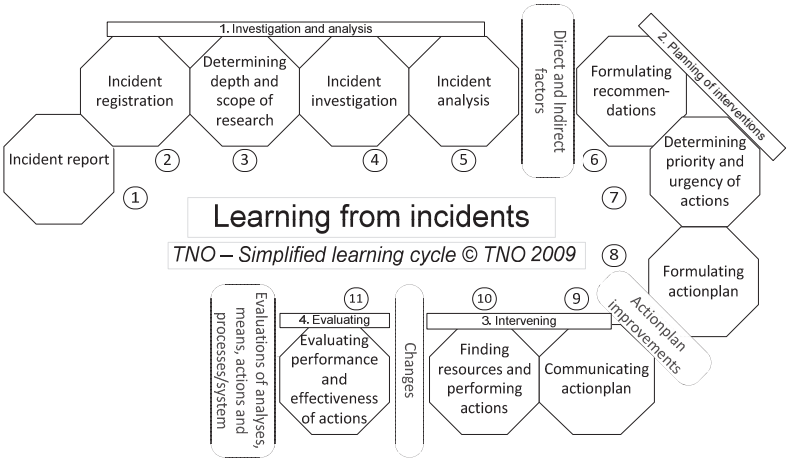

Figure 2. Learning from incidents cycle 2009.

First phase: Incident investigation and analysis

Learning from incidents requires an understanding of incident causation, including underlying causes (Kletz, 1988; Reason, 1990), and of options to prevent future recurrence. This is the vital output that any incident investigation should deliver. If performed well, this first phase leads to the understanding of causality, the lessons from which to learn. The first phase of the learning from incidents process contains five steps. The first step, reporting incidents, is necessary for the whole learning process to occur: if an incident is unknown, no lessons can be identified from it and actions will not follow. Reporting is separated from the step registration. While reporting means that information about the incident is somehow transferred, registration means that the information is also put into a system, so as to be retained. These steps are followed by a step in which the scope of research is determined. Some incidents require an in-depth investigation, with multiple investigators, whereas just noting other incidents could be sufficient. A dilemma in this phase is to determine whether an incident should be investigated and if so: how, and by who? At the end of the first phase, the organisation has insight into direct and indirect causes that exist in the organisation and that may lead to other incidents.

Second phase: Planning interventions

The second phase of the learning from incidents process consists of three steps: formulating recommendations, determining the priority and urgency of actions, and formulating an action plan. An important aspect of this phase is also to prioritise and select those options that are expected to be most effective, and to identify them as recommendations requiring priority (Bhimavarapu and Doerr, 2009). For the causes that need to be addressed, recommendations are generated and a selection of feasible actions is made. When planning the actions, both the identified direct and indirect causes need attention. Addressing indirect (underlying) causes is especially important for double loop learning (Argyris and Schön, 1979). If only direct causes are addressed, learning is in practice limited to single loop learning.

In the model, selecting actions is followed by the integration of the actions in an action plan for improvement. These actions can be integrated with other actions: from risk assessment, earlier incidents, change programmes, etc. The result of this phase, if performed well, is a realistic action plan. Actions that are formulated based on the recommendations and that are included in the

action plan should preferably be specific, measurable, attainable, and relevant, and a specific date to start the intervention should be included.

Third phase: Intervening

The third phase is aimed at the realisation of the action plan through the implementation of the interventions. This phase contains 2 steps: communicate the action plan and 'finding resources and performing actions'. The communication of the action plan refers to the requirement that the people who are responsible for the actions, and those who are supposed to contribute to them, should be informed and given ownership of the actions (Barret, Haslam, Lee, and Ellis, 2005). It is important that the action plan and its objectives are communicated throughout the organisation (Bahn, 2009), especially to demonstrate the willingness to improve safety and to share the 'lessons learned' from the investigation and planning process. Resources, especially time, money and (human and technological) capabilities might be vital to perform the actions as intended. The result of this phase should be the realisation of the actions. This phase of the learning from incidents process is very much dependent on the quality of the second phase. If the action plan is realistic and carefully planned, the actions are more likely to be performed.

Fourth phase: Evaluation

The evaluation phase contains one step, which involves multiple aspects of evaluation: the effectiveness of the actions, the process of implementation, and the learning process itself are evaluated. One can only determine whether an action was effective by reflecting it in retrospect. This phase evaluates whether the actions were performed, whether they were performed well and whether they were the right actions? If an action was not fully realised or not fully effective the reasons can be identified. They form the lessons in the "learning from incidents process" as such, and are the key to improving the learning capability of the organisation (deutero-learning). The results of this phase are an evaluation of actions, processes and impact on the organisation, and if possible of its safety performance. Where relevant, the evaluation can lead to improvements in the other three phases.

3.Methods

This dissertation involves four studies that aimed to contribute to learning from incidents in practice by solving actual practical problems. This chapter covers the study context and the main research strategies used in this dissertation. This project is an applied research project, meaning that the research is performed with the intention to contribute to the solution of a specific problem (Bickman and Rog, 1998): meaning ineffective learning from incidents. Applied research involves combining and developing knowledge to solve a problem (OECD, 2002), instead of developing knowledge for the sake of knowledge-development. Applied research is mainly characterised by its outcome, although outcomes of basic or experimental research could eventually also be applied. Another characteristic of applied research is that it occurs in dynamic real-life situations and strict research protocols may therefore need to be adapted. In this research project, there was, for instance, no random sampling of participants: only the companies that considered the research relevant to their organisation participated, which means that they wanted to improve in learning from incidents.

3.1 Research design

This research uses a multiphase mixed-method design. A multiphase mixed-method design is a design that combines quantitative and qualitative data over multiple phases (either concurrent or sequential) of a research project (Creswell, 2009). This project used an emergent approach, meaning that at the start of the project two studies were planned and the design of the later studies followed from the findings of Study I and Study II. The advantages of emergent design are the flexibility to adapt to new developments and the potential to build on results obtained in an iterative process.

The first two studies used a fixed mixed-method design, where the use of quantitative and qualitative methods was predetermined and planned at the start of the research process (Creswell, 2009). The design as a mixed-method study originated from the twofold nature of the research objective: create an overview of generic problems that occur in multiple organisations (which is best done through a quantitative study) and increase understanding of the actual learning processes in their natural setting, so that the results of the research can be easily applied in practice (which is best done through a qualitative study). This research project combined qualitative and quantitative methods to reach these objectives and use the best aspects of each method type. An additional benefit of the mixed-method approach is that bias is reduced – by varying methods that are each characterised by their own potential biases (Axinn and Pearce, 2006). The methods are discussed later in this chapter.

3.2 Overview of the studies

Before introducing the research methods in detail, this section presents the four studies. The research project started with a literature review to define the processes in learning from incidents (Study I). In parallel, Study II was performed, which presented a model of the stepwise LFI process, and used this model for an analysis of learning from incidents and the bottlenecks in this process (Study II). Study III consisted of focus group interviews and Study IV proposed indicators to assess learning from incidents. The results of Study I and Study II formed the input for Study III, which in turn fed into Study IV, resulting in a multiphase mixed-method design that sequentially connected several studies. Figure 3 presents an overview of the four studies.

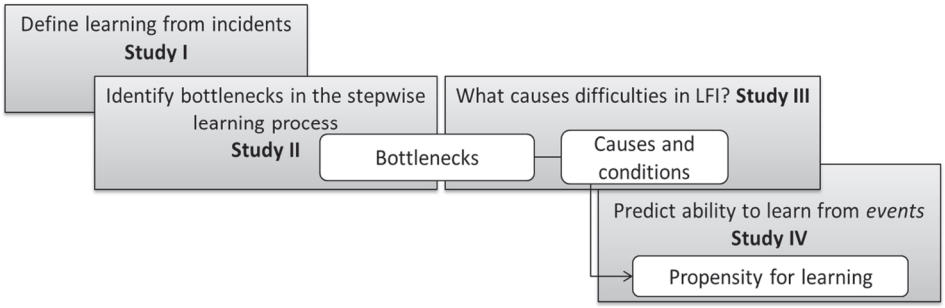

Figure 3. Overview of studies in this dissertation

Study I - What is learning from incidents?

The first study was a theoretical study describing the safety literature on learning from incidents. The aim of this review was threefold: to make a contribution to a more comprehensive knowledge of what learning from incidents is, identifying possible explanations for inefficient learning, and establishing the aspects of learning from incidents that need further attention in research. The papers were categorised according to their main topic and compared with the organisational learning theory of Argyris and Schön (1979). The first study clarified the research questions for the empirical studies. The remainder of this chapter discusses the methodology of the empirical studies (Study II, Study III and Study IV).

Study II – Critical steps in learning from incidents

The aim of the second study was to identify difficulties in learning from incidents. Study II used the initial model of the stepwise LFI process, containing 11 steps. Study II was an embedded mixed-method study, which means that a qualitative method was embedded in the quantitative study. In this study, case study data complemented the data from the survey, to verify and explain the survey results, and so collect more detailed information about actual learning from incidents in practice. The quantitative measures enabled the creation of an overview of problems in learning from incidents in multiple sectors and in different company sizes in a relatively short time. This overview provided insight into generic problems. This was important so that these problems could be used as the subjects of further study. The disadvantage of this approach was that this data gave limited insight into the way in which learning was embedded in organisations and in the specific problems that organisations had in learning. Qualitative measures were therefore added, in the form of explorative case studies.

Study III - What are the causes of bottlenecks in learning?

Whereas the results of the second study indicated *where* in the learning process difficulties arose, Study III aimed to identify *what* the difficulties were and *what caused* these difficulties. The assumption of this study was that to improve learning from incidents, problems should be addressed at their roots, meaning that in-depth knowledge of what caused the difficulties in learning needed to be collected. This study involved seven focus groups.

Study IV - Assessing the propensity to learn from safety-related events

Study IV proposed indicators to determine beforehand whether an organisation could learn well from experience. Here the term 'experience' was used instead of 'incident', because weak signals or operational deviations can also provide information for learning, to prevent occurrences of incidents or accidents. The indicators represent the conditions for effective learning: if these conditions are met, learning is more likely to occur. Study IV validated the indicators through a

questionnaire. The quantitative approach allowed for the validation of the indicators that were based on exploratory findings. Additionally, because the indicators were translated into a questionnaire, the questionnaire can be used as an instrument by organisations, independent of a researcher.

3.3 Methods for data collection

As explained earlier, the research project consisted of a literature review, and three studies to collect qualitative and quantitative empirical data. The data for this research project was collected from nine companies in the Netherlands and from one French company. These companies were partners and clients in the professional network of TNO. Data was collected through a group of 300 safety representatives in the Netherlands. These safety representatives were approached through the Dutch Society for Safety Science (NVVK), which is a network of safety professionals. This section explains the methods used in this dissertation to collect the data, starting with the qualitative methods in the first sections, and continuing with the quantitative methods in the latter sections.

Qualitative

This research project aimed to clarify how the learning from incidents process functions in practice. I mostly used qualitative research methodologies in this research project, since these are especially suitable for determining *how* things work and why. Qualitative methodologies are of great value in the investigation of *how* organisations learn from incidents. Qualitative research is about describing and interpreting phenomena, based on personal views and on experiences (Boeije, 2008) and provides information about the human side of issues, including beliefs, opinions, mental models and emotions. Since organisational learning from incidents cannot occur if individuals are not learning, understanding individual beliefs and motivations for learning is indispensable in understanding learning from incidents. The qualitative methods used in this dissertation are a case study approach (in Study II) and a focus group approach (in Study III).

Despite the advantages, there are certain drawbacks associated with the use of qualitative research. One drawback that is associated with qualitative research is the difficulty of establishing validity. Since qualitative research is often aimed at understanding specific situations, the elimination of threats to validity, such as bias or reactivity, is difficult in advance (Maxwell, 2008; 2012). Whereas bias refers to the effect of the theories and values of the researchers, reactivity refers to the actual influence of a researcher, for instance in interaction with interviewees. The goal in a qualitative study is not to eliminate the effect of the researcher, but to understand it and to use it (Maxwell, 2008). Triangulation of data within the case studies and with other methods enhances the validity of the results (Maxwell, 2012), because it seeks additional evidence for the hypotheses. In this research project the case studies therefore used different methods to study the learning process (interviews and document study). In addition, the results of the cases are integrated with the results of a survey, through which researcher bias is further reduced.

Another aspect of qualitative research that is often questioned is the generalisability of the conclusions. In case studies, for instance, the generalisation of conclusions to other situations is often questioned since data is unique to the studied event or process (see Flyvbjerg, 2006; Maxwell, 2012). Generalisation is not necessarily a drawback, however. For the external generalisability of cases it is important to be aware of the differences between the observed situation and the situations that were not observed (Maxwell, 2012), but, as Flyvbjerg explains in his paper on case-study misunderstandings, formal generalisation is “overrated as the main

source of scientific progress" (Flyvbjerg, 2006, p. 226). Single cases even enhance understanding of a context-dependent phenomena (Flyvbjerg, 2006; Pawson and Tilley, 1997; Maxwell, 2012), which means that they are especially valuable because they lack external generalisability (Maxwell 2012).

Explorative case studies

The case study approach consisted of three cases, in which the learning process and difficulties in this process were explored. The case studies were part of Study II, and focussed on identifying bottlenecks in the learning from incident process. All companies that participated in the case studies were situated in the Netherlands. One of the companies was part of a larger, global organisation. The companies were from three different sectors: the chemical industry, energy and waste, and transport.

I used the case study approach (Yin, 2009) at an early stage in the research project, to gain an initial view of learning as it occurred in practice. Through the use of case studies, detailed information was gathered about the learning process and about the bottlenecks in learning that occurred within each case organisation. This information helped in obtaining a better view of learning and in the identification of issues that required further investigation. Another advantage of the case study approach is that information is acquired in its natural setting (Flyvbjerg, 2006; Yin, 2009). Since specific, context-dependent information was acquired for each organisation, the results are of more use for the participating companies (Flybjerg, 2006).

The case studies consisted of a document study and of semi-structured interviews. The document study provided information about how learning from incidents was formally organised in the organisation. Two researchers of occupational safety (with a background in psychology and in the methodology of research), independently studied an overview of the reports of incidents on the location; a procedure or description of the learning from the incidents process (if this was available); documents related to two incident analyses; and evaluative or follow-up studies related to an incident. Based on the assessment of these documents, we assessed whether a step was formally organised or not. The results from the document study determined the main focus of the interviews. The interviews were semi-structured, based on the phases of the model of the LFI process. The first question of each interview was "In what phase do you think most problems for learning arise?", followed by a question about the most successful phase. The semi-structured interviews provided comparable qualitative data without limiting the interviewees in their answers. In this research project, the use of this format specifically allowed for a comparison of the case study results with the survey results. A semi-structured interview format is still fairly flexible and allows interviewees to express their views in their own words. We used the flexibility to gain more information on specific results of the survey and to elaborate on issues in each company that were specific for their learning from incidents process.

Within a company all interviews took place on a single day, each taking sixty minutes. One senior manager or director, the Health and Safety Manager, a shift supervisor, and a representative of the employees at operational level participated in the interviews. The researchers that were involved in the document study also performed the interviews. There were two interviews at each company where both researchers were present to provide assurance that a consistent structure was being used. In further interviews only one researcher was present.

Focus groups

In seven organisations focus groups were held, in which causes for (in)effective learning from incidents were explored. Study III used the focus group approach to study new questions that arose from the results of the case studies and survey (Study II). The aim was to obtain insight not

only into the difficulties in learning, but also into the causes of these difficulties, so that issues could be addressed at their roots.

Seven organisations participated in the focus groups: four chemical companies, a manufacturing company, a service provider company for a chemical plant, and a construction company. In each organisation approximately 10 people participated in the focus group session, mainly from the operations and maintenance departments. For each focus group, a group that represented an operations or maintenance department was pursued, including one manager. In two organisations this composition was not feasible and a different focus group was chosen. Invitations to the focus group was sent out by the Health and Safety manager, who was also present in the focus group.

I chose the focus group approach because it allows for multiple perspectives to be gathered at the same time, and the group interaction in focus group studies serves as a mechanism to help people generate ideas (Krueger and Casey 2008). In these focus groups, this meant that participants built further on the ideas of their colleagues, resulting in the identification of underlying causes and conditions for (in)effective learning. The focus groups were semi-structured, to allow for comparison between them without limiting group interaction and the openness of this method. In the focus groups, general learning from the incidents process was first discussed by asking: "How well does your organisation learn?"; "Why is that?"; "In which step do main problems arise?"; "What are the main reasons that a phase is well performed or not?"; and "How do you think learning from incidents in this organisation can be improved?" If specific factors or conditions were mentioned it was verified whether these were related to specific phases in the learning process. In three companies, discussion about the difficulties in the general learning from incidents process was followed by a brief presentation of a specific incident. The incidents were selected beforehand by the researchers, together with the Health and Safety manager. The questions to the focus group in each case were semi-structured, the main questions being: "Did the organisation learn from this incident?"; "Could a similar incident happen again?"; "Who or what solved the situation and why?"; and "What can be further improved?" The same topic list was used as for the general learning questions. To make sure that the focus remained on the causes of ineffective learning, and not on the causes of the earlier incident, in-depth discussion of the incident and its investigation was avoided and if necessary was cut-off by the moderator. I was, as the main researcher, involved as a moderator in the focus groups, to ensure that the conversation stayed on track, and to ensure that no individual was dominating the meeting. Another benefit of researcher involvement is that non-verbal information – indicating, for instance, hesitations, fear or personal emotions related to the incident – can be used to steer the discussion. In this research project, such non-verbal information was used either to distract the discussion from the sensible subject, or if deemed relevant, explicit questions were asked to see whether the participant could explain their emotions.

There are also some disadvantages associated with the use of focus groups. It can be difficult for some participants to share their feelings about sensitive topics. In these focus groups, careful selection of the incident that served as the topic of the discussion aimed to reduce the sensitivity of the subject. The moderators were also very important in noting possible reluctance. In these focus groups, two researchers were always involved, so that moderation of the discussion was assured.

The analysis of the qualitative information that resulted from the focus groups followed several steps. These steps combined codes based on deduction (built from theory) and on induction (built from data) (see Russell Bernard and Ryan, 2010, for further explanation on combining

coding strategies). The phases in the LFI process provided the initial set of codes. All information from the focus groups was then categorised in relation to the phases. Open coding of the information for each phase led to the final categories, representing causes of the difficulties in learning from incidents.

Quantitative

In addition to the qualitative methods, this dissertation used two quantitative research methods. The first was a survey, as part of Study II. This survey had a mainly explorative function, in order to create an overview of the learning from incidents process. The second method was a questionnaire, as part of the final study (Study IV) of this research project. The questionnaire served to validate knowledge from qualitative studies and field experience, and enabled the development of indicators. Quantitative research is most often used for questions such as when, where, and how often? The advantages of quantitative measures are that data collection is relatively quick, the research results are relatively independent of the researcher and that it is useful for studying a larger population.

Despite its many advantages, the use of quantitative methods also has some limitations. The main limitation in this research was that the indicators were only assessed through self-reporting, which is susceptible to social desirability bias and therefore represented a threat to the validity of the results of this questionnaire. Quantitative methods are also limited because they cannot answer 'why' questions.

Survey

Study II used a survey to obtain an initial overview of where problems occurred in the learning from incidents process. The eleven steps in the model of the LFI process provided the basis for this survey. Through use of a survey, the learning from incidents process could be studied in multiple types of organisations, in a relatively short time. I chose the survey approach to study a larger population in comparison to the case studies (which were part of the same study), and so as to study the frequency and distribution of the problems in learning from incidents. Additional benefits were that surveys are a cost effective measure of gathering data, and researcher bias was strongly reduced. The survey gave a broad and objective overview that can easily be generalised.

An open invitation to participate was sent by email to all members of the Dutch Society for Safety Science, including a link to the online survey. In the online survey, for each step of the learning from incidents process, two sequential questions were asked: whether the step was formally organised according to the respondent; and how well respondents considered the step was performed in daily practice. The first question (Is this step formally organised in your organisation?) was dichotomous (Yes/No) and the second question (How well does this step work in practice in your organisation?) was in the form of a 4-point scale (Bad/Insufficient/Sufficient/Good). There was also a blank field in which participants were given the opportunity to elaborate on their response for each step. At the end of the survey the participants were asked to indicate in which of the eleven steps, in their view, the most important bottleneck in their organisation was located.

A total of 649 surveys were returned, corresponding to a response rate of about 30%. The survey was sent to a large group, however, including recipients that were not involved as practitioners in organisational safety. The seemingly low response rate can be explained by the composition of the Dutch Society for Safety Science. The society includes not only safety practitioners, but also many other members, including a large group of students. An estimated 50% of the recipients were not part of the target population, the safety practitioners. In addition, there are often many

members of the society from a single organisation, and it is likely that the survey was completed by only one person for each organisation. Although a low response rate can indicate sampling bias, I consider this 30% to be a good sample of Dutch safety practitioners. Of the 649 surveys, 303 fully completed responses were from safety professionals from the seven selected sectors (chemical industry, construction, energy and waste, food, government, metal, transport). The other 346 responses were from other sectors and from independent safety practitioners. For these other sectors, the groups were too small to perform any statistical analysis. The analysis used only the answers from safety professionals of the selected sectors and not of independent safety consultants, because the responses of the safety professionals were considered more representative of the actual learning process in organisations. The safety professionals are in the position to judge both actual and formal learning from incidents process.

The results of the survey provide answers to five questions: At what step of the learning from incidents process is most learning potential lost? (1) Which steps are formally organised in the organisations, and which steps are not? (2) How well are steps performed in daily practice? (3) Is there a difference between the formal organisation of the learning from incidents process and how well this is performed in practice? (4) Are there differences between sectors in the organisation and performance of the learning process? (5) To answer the first, second and third question, I used frequencies about whether the step was performed and organised. Questions four and five ask for differences between steps, between sectors and between actual and formal learning, that are analysed with t-tests. The formal learning process is compared between sectors with non-parametric tests: Kolmogorov-Smirnov and Kruskal-Wallis (Siegel and Castellan, 1988).

Questionnaire

The final study of the research project combined knowledge from theoretical studies, the case studies and field experience into a set of indicators for learning from experience. The indicators are operationalised into a questionnaire with forty-eight questions. These questions were then used to assess the indicators in one pilot study.

There were two versions of the questionnaire: one for managers and one for employees. The questionnaire was developed based on two sets of indicators. The indicators for the propensity to learn were based on the assumptions that:

- An organisation is most likely to learn if people in the organisation have a positive attitude towards reporting, analysing, performing follow-up actions and the evaluation of actions
- An organisation is most likely to learn if people in the organisation have a positive attitude towards sharing information on safety related experiences
- An organisation is most likely to learn if people in the organisation have a positive attitude towards learning in general
- An organisation is most likely to learn if within the organisation, conditions for organisational learning capability exist
- An organisation is most likely to learn if the organisation has systems to facilitate the learning process

The first set were organisational indicators which are related to attitudes, organisational learning capability and facilitating systems. The second set were individual indicators, that are related to performing phases of the learning from experience process and to sharing information. Table 3 represents the overview of indicators.

Table 3
Overview of propensity indicators

Organisational indicator	Individual indicators
Systems to perform steps	Attitude to performing steps
Systems to share information	Attitude to sharing information
Management commitment, openness and experimentation	
Systems perspective and knowledge transfer	

A production plant in France participated in the pilot study. This plant produces consumer products for cooking. 1900 people work on the site. According to the EU Seveso III directive (Seveso III, 2003), this site belongs to a high hazard category. The top management is committed to the safety and health of personnel and to protection of the environment as the top priorities, and accident statistics demonstrate continual progress. In 2013, improvement of the learning process was chosen as one of the key actions for engagement.

The pilot study consisted of the use of a questionnaire in interviews with a selected group of operators (N=50), and a selected group of managers (HSE, maintenance, production and HR departments, N=17). The questionnaire consisted of forty-eight questions. Each of the questions was asked on a 4 point Likert-scale, with 4 (absolutely) being the highest score and 1 (not at all) being the lowest. By using a 4-point scale the midpoint was avoided and so a choice was forced. The analysis of the results consisted of comparisons for each indicator between operators and managers. These comparisons were performed using a series of t-tests. The tests compared the mean value of the questions for each indicator, but also scores on single questions in detail. Correlations were also calculated between the indicators and some separate questions about how people perceived learning. No scale was calculated for the learning questions: the questions were studied separately.

I chose the questionnaire as a method of data collection because it is a highly structured method, in which researcher bias is limited. This means of data collection allows for easy comparisons between the results. In this study, the questionnaire was used in face-to-face interviews because this personal approach was expected to increase the response rate. The approach was appreciated by the employees because they received personal attention, the opportunity to share their opinions and could ask for clarifications if a question was not clear to them.

Summary of the research methods

Overall, the research project included four different methods of data collection in addition to the literature review: case studies (including document study and interviews), focus groups, surveys and questionnaire interviews. Table 4 shows an overview of the data collection methods in the four studies. The surveys and questionnaire interviews had a very high level of structure, whereas the case studies and focus groups were less structured. Researcher involvement was, however, very high in the focus groups and case studies, whereas involvement was lower in the survey and in the questionnaire interviews.

Table 4
Overview of research methods

	Qualitative	Quantitative
Study I	Literature review	
Study II	Case studies (interviews and document study)	Survey
Study III	Focus groups	
Study IV		Questionnaire interviews

4. Findings

This dissertation contributes to the knowledge on learning from incidents by answering the following research questions:

- How do organisations learn from incidents? (Study I and Study II)
- What are the difficulties in learning from incidents in organisations? (Study II and Study III)
- What are the underlying factors that make it difficult to learn from incidents? (Study III)
- Under what conditions is learning likely to be successful? (Study IV)

This chapter discusses the empirical findings from Studies II, III and IV, in four sections that match the research questions. Figure 4 summarises the main findings of this research project.

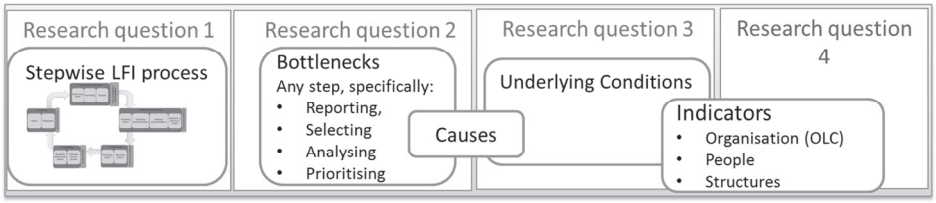

Figure 4. Summary of the main findings.

4.1 A model on learning from incidents

The review of the literature on learning from incidents (Study I) showed that learning from incidents is an organisational learning process that involves multiple sub-processes. Three main processes in learning from incidents are the analysis of events, the use of lessons learned, and sharing and storing information. This chapter focusses on the empirical findings of the research project.

The empirical studies used the model of learning from incidents based on a PDCA cycle, to study difficulties in this learning process. The initial model was developed to study how organisations learn from their own accidents and near-misses. The model started with a phase in which incident information was analysed based on reports, and then the learning process continued. The model was revised based on the findings from Study II. The revised model includes more detailed follow-up steps after incident analysis and also allows for incidents from other organisations or databases to be used as input. The revised version of the model (see Figure 5) consists of five phases: acquiring information, event investigation and analysis, the planning of interventions, performing the interventions and evaluation. In this process, operational steps were sequentially taken, and the knowledge is shared within the organisation. Figure 5 represents the original and the adapted model. The following paragraphs discuss the adaptations for each of the phases. Table 5 at the end of this section summarises the differences between the original and revised model.

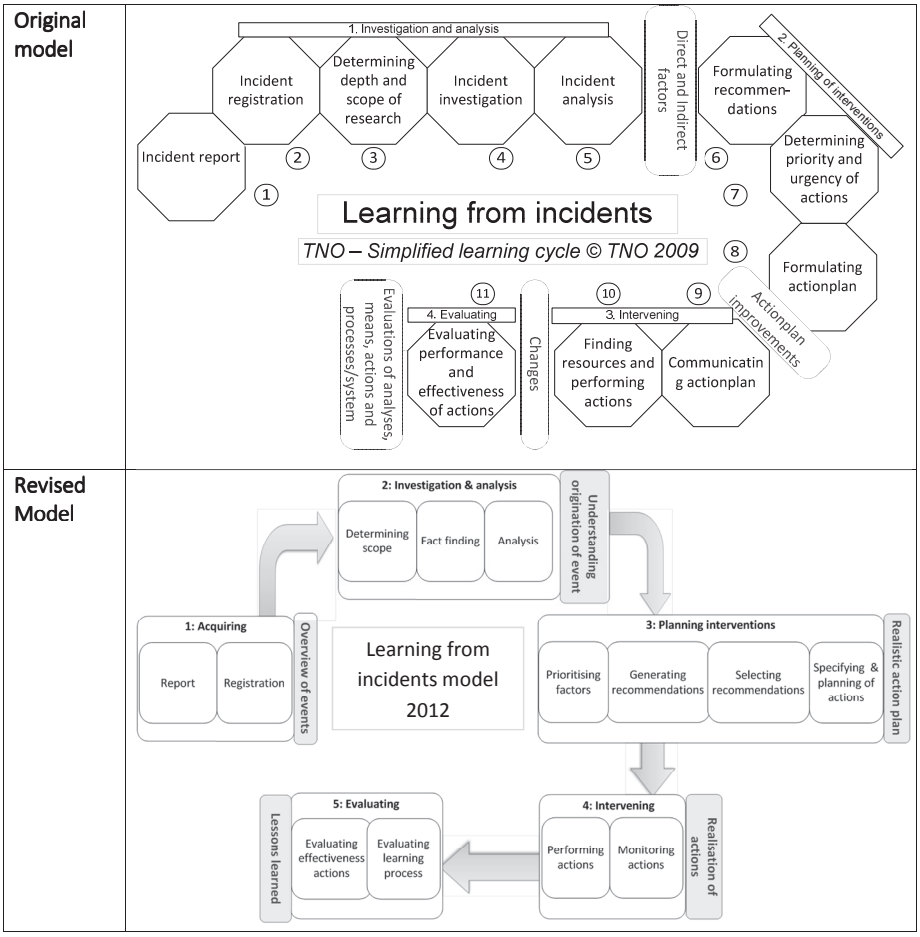

Figure 5. Original and revised model on learning from incidents

Acquiring information and Investigation & analysis (first and second phase)

The first phase of the original model on learning from incidents contained five steps. In the renewed version of the model, these steps were restructured into two phases. The first phase 'acquiring information' is aimed at recognising that a given situation is interesting for learning. This is particularly interesting when learning from positive events (things that went better than expected), when learning from events in other organisations or when performing trend analyses to identify lessons. The first phase identifies situations from which to learn, and forms input for the phase in which lessons are identified through investigation and analysis. When learning within one organisation, this first phase involves getting incidents reported and registered, as in the original model. The adaptation of the model into two phases allows for a wider range of input. Although the input and the way that it is collected differ, the learning process itself remains similar.

Planning and intervening (third and fourth phase)

The main adaptations of the model relate to the planning and intervening phases. The findings show that planning is often not performed well, when it is especially important that actions are carefully planned and that a selection is made of the actions that are required. The planning phase is best explained by the statement "If everything is important, nothing really is". One difference in comparison to the original model is therefore that before recommendations are formulated, a prioritisation of the identified factors is made. In this prioritisation, reports of earlier incidents can be used to identify the recurrence of causes or earlier actions that were proposed.

Another difference between the initial and revised model is that formulating an action plan is replaced by 'specify and plan actions' This step is slightly different, since the planning of actions also refers to the relationship with other actions, and a check of the resources and availability of people.

The phase 'intervening' in the revised model is more specifically aimed at the performance of actions, and at monitoring them, so that they can be adjusted if necessary. The original steps, communicating and finding resources, are removed from the model, since they don't refer to process steps in implementation, but to conditions for this implementation. Resources should be identified before an action starts, and are conditional on the performance of the implementation steps. The step related to the communication of an action plan are removed from the model, because communication is important for all phases of the model and not only for this single step.

Evaluating (fifth phase)

In the original model, the evaluation phase consisted of one step in which multiple different aspects of evaluation were described. The revised model describes two main aspects separately: the evaluation of the action and the evaluation of the learning process itself. Table 5 shows a comparison between the steps of the original model and of the revised model.

Table 5

Comparison between original and revised model of the learning from incidents process

Initial model, 2009	Revised model, 2012
Incident report	Report
Incident registration	Registration
Determining depth and scope of research	Determining depth and scope of research
Incident investigation	Fact finding
Incident analysis	Incident analysis
	Prioritising factors
Formulating recommendations	Generating recommendations
	Selecting recommendations
Determining priority and urgency of actions	Specify and planning of actions
Formulating action plan	
Communicating action plan	
Finding resources and performing actions	
	Performing actions
	Monitoring actions
Evaluating performance and effectiveness of actions	Evaluating effectiveness actions
	Evaluating learning process

4.2 Difficulties in learning from incidents

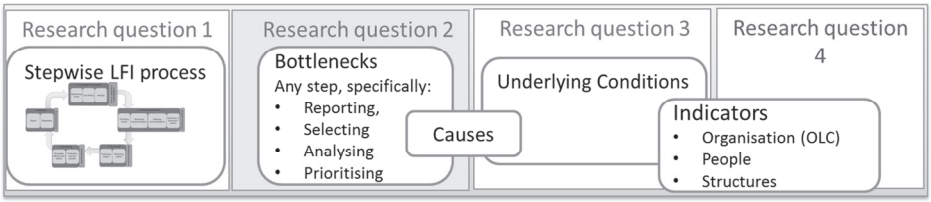

Figure 6. Overview of the findings – Research Question 2.

The second research question in this project is: "What are difficulties in learning from incidents?" This question is mainly investigated in Study II, and verified in Study III. Knowing the difficulties enables organisations to address these difficulties and thus to improve how they learn from incidents. The identification of difficulties means becoming aware of what issues to overcome in order for learning from incidents to become more successful.

Both Study II and Study III showed that each and every step of the learning from incidents process can become a bottleneck. A bottleneck is the step at which the learning process is (partially) impeded because difficulties arise, for instance if the step is not performed, or not performed well. The result of a bottleneck is that not only one step, but also all consequential steps are impeded. The results of Study II show that learning is especially limited in the reporting and the evaluation steps. Reporting was, for instance, considered a weak step because many incidents are not reported at all. According to the safety professionals, this underreporting may be a result of the complexity of reporting systems and a lack of recognition of the importance of reporting. The evaluation step was sometimes performed, but only to check whether an action was performed or not. There was little evaluation of the effect of the actions with respect to preventing recurrence. This finding led to an adaptation of the model, where different aspects of evaluation were separated. In Study III, the evaluation step was not listed by the participants as a main bottleneck. Study III showed that in the third phase of the learning from incidents process - planning actions - many difficulties arise. Planning actions is the phase in which lessons learned from incident investigation are translated into recommendations and the recommendations are prioritised and selected.

Specific difficulties that we identified in Study II and Study III were: problems in deciding which incident to investigate in-depth, problems in the selection of the most appropriate methods for investigating and analysing incidents, and the implementation of lessons learned not being systematically performed. The case studies clarified that although most people are willing to take action, planned actions get lost in the flow of actions that result from incident analyses, audits, and so on. Actual priorities in actions are mainly determined by the availability of resources such as time and money, and this often results in short-term actions. These findings increased our understanding of the steps in learning from incidents, especially the dilemmas that were involved in the follow-up of accident investigations.

Another finding from Study II is that there are significant differences between the formal and the actual learning process, meaning the process as it is planned in procedures and systems, and the process as it occurs in practice. The formally arranged and actual learning process can be compared to the espoused theory (as intended) and theory-in-use (actual), that was presented by Argyris and Schön (1979). The espoused theory may result in different theories-in-use (Argyris and Schön, 1979). All sectors that participated in Study II had formally organised the majority of

phases in the learning process as systems and procedures. If the formal learning from incidents process differs from the actual learning process, however, this may result in a false sense of effective learning, and therefore, when studying the learning from incidents process and the difficulties in this, it is important to distinguish between the formal and actual learning process.

4.3 Direct causes and underlying factors

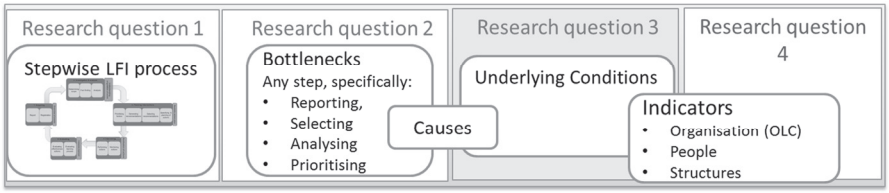

Figure 7. Overview of the findings – Research Question 3

The third question in this research project aimed to identify causes of, and conditions for, the difficulties in learning. Study III investigated this research question and showed a need to distinguish between direct causes and latent or underlying factors. Study III used the adapted version of the stepwise learning process as a framework for the investigation. For each of the phases of the learning from incidents process, direct causes and latent conditions were listed by the participants of the focus groups. The direct causes were directly related to not performing a step or not performing it well, whereas the conditions relate to the situation in which these problems can arise, the 'underlying causes'. The underlying conditions are the weaknesses in the environment, and therefore the factors that need specific attention to improve learning from incidents. Addressing the conditions increases the ability of an organisation to learn, and therefore contributes to 'learning to learn'. Table 6 summarises the factors listed by the participants of the focus groups.

Table 6

Overview of causes and conditions as identified in the focus groups

Phase	Causes for bottlenecks	Conditions
Acquiring information	Not knowing how and what to report	Recognition of situation, successful recovery mechanisms, contradicting signals on incident report vs frequencies, belief that every incident is unique
	Not willing to report	Fear of ruining incident rate, fear of client, fear of colleagues/image, fear of extra work and no sense of urgency, due to lack of feedback
	Limited quality of reports	Time and effort
	No overview of risks	Risk information is distributed over several different systems
Investigation and analysis	Systematic causes not identified	Limitation to direct causes, i.e. human or technical causes, limitation to mitigating actions, time pressure on completion analysis
	No selection of incidents to investigate	No criteria, too many reports as the result of successful campaign and use of reports as action trigger
Planning interventions	No selection of actions	No sense of urgency, due to the belief that incidents are unique, no systematic approach and limited integration with other actions
	Quality of the actions	Limited employee involvement, i.e. top down, focus on quick fix, focus on technical actions (no systemic causes)
Intervening	Not able to perform actions	Time constraints
	Actions are not performed	No sense of ownership to perform actions, large scale organisation and no formal action holder
	Sense of urgency to perform actions	No drivers and fear of extra work, little serious incidents
Evaluating	*Not mentioned by participants*	*Not mentioned by participants*

A specific example of the first phase from Study III, is that acquiring information was not effectively performed due to difficulties in reporting. These difficulties arose because reporting was perceived to be associated with negative consequences or because employees didn't know when and what to report. Possible negative consequences that kept employees from reporting were: blame, image problems or extra workload. If there were no serious consequences, if there was no feedback if an incident *was* reported, or if the signals from the management seemed contradictory (low incident frequency and high number of incident reports) then employees didn't know when and what to report.

Other factors were listed by participants in relation to the second phase: in the selection of incidents to investigate, and in the actual investigation. Difficulties in the selection of incidents to investigate were perceived if there were no selection criteria, if there was no time for a thorough review of all incidents, or if the way incidents were reported made selection difficult, for instance because there was too little detail. Difficulties in investigation and analysis were mainly related to the quality of the investigation and analysis, meaning that systematic causes for the incidents were not identified and addressed (which is closely related to the next phases of the learning from incidents process, planning actions). The main reasons indicated for these difficulties were limitations in competences or in the mental models, resulting in a focus on either technical, human or mitigating actions.

Difficulties in the third phase, planning interventions, were caused by the same factors that limited the investigation, according to the participants. Planning is influenced by the analysis

because only causes that are identified can be addressed, but also, because ideas for improvement were limited by the same mental models: interventions also focused on either technical, human or organisational actions. There was especially a tendency to focus on technical causes and actions for improvement, which meant that structural improvements were not undertaken. Other conditions that hindered the successful planning of actions were: lack of selection or prioritisation, a limited sense of urgency, and limited employee involvement.

Factors listed for difficulties in performing actions (intervening) follow mainly form limitations in the planning phase. The planning phase affects the performance of actions: if there are too many actions and no prioritisation this results in time constraints when the actions need to be performed. In addition, little sense of urgency and little sense of ownership were listed as reasons why intervening was impeded. The lack of a sense of urgency means that the benefit of reducing the risk was not considered to outweigh the costs of implementing changes. The final phase, evaluation, was not explicitly discussed and thus no factors or conditions are listed for this phase.

Taken together, the findings of Study III show five categories of causes and underlying conditions that may influence learning according to the participants of the focus groups: *lack of time, fear of negative consequences, beliefs or mental models, lack of knowledge and competence, and little sense of urgency.* The category *time* relates to causes such as: there was too little time to read all the reports, too little time for a thorough investigation of the incident and too little time to perform the planned actions. It was also often mentioned that there were too many actions, too many causes to address, or too many ideas for improvement, all meaning that there was not enough time to do all the things that one would like to do. Lack of time is often the result of managerial decisions (Schein 1992). Some actions are considered to be more important than others, and therefore more time and resources are available for those actions. Other commonalities were found in relation to: *fear of negative consequences* - such as extra work or a negative image; *beliefs or mental models* - such as the idea that all incidents are unique; *knowledge or competences;* and *sense of urgency.* The absence of sufficient *knowledge or competences* was mainly related to incident investigation and analysis. The investigation often did not address organisational causes, because there was a blind spot for organisational and cultural issues and technical factors were thus more easily identified. As a result, recommendations and actions were often aimed mainly at mitigation of the consequences of an incident, instead of at structural causes. The final commonality was the *sense of urgency,* meaning the importance that people attach to learning from incidents. A lack of feedback on reports, lack of visible actions and contradicting signals on lowering the incident frequency versus increasing the number of reports for improvement, affected this sense of urgency. The lack of a sense of urgency can contribute to difficulties in learning from incidents, and it can be beneficial for learning if a sense of urgency is present.

The categories of conditions are important for improving learning from incidents. Addressing difficulties in the learning process (direct causes) is likely to improve a single step in the learning process, whereas addressing underlying causes has a an effect on the learning process as a whole. This means that for the structural improvement of learning from incidents the categories listed here need to be addressed.

4.4 Conditions for learning

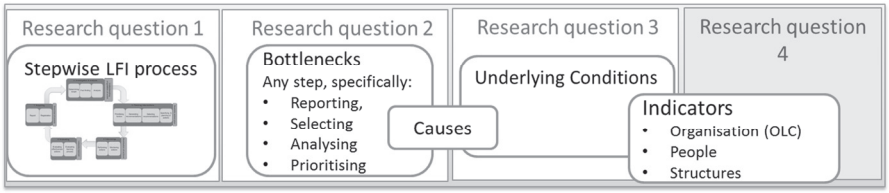

Figure 8. Overview of the findings – Research Question 4

Study IV developed indicators for learning from incidents, representing the conditions for successful learning. For the development of these indicators, the conditions for learning are summarised in three categories: facilitating structures, attitudes and organisational learning capabilities. The learning capabilities of an organisation are management commitment, openness and experimentation, system perspective and knowledge transfer and integration. As explained in Section 2.3, abilities create an environment in which learning from incidents is likely to occur.

The underlying conditions contributing to difficulties, which were identified in Study III, are more specific than the categories of indicators for successful learning, that were developed in Study IV, however, the indicators and the conditions are closely related: if there are many underlying conditions contributing to difficulties, the score for propensity indicators will be low, meaning the propensity of the organisation to successfully learn from incidents is low. The conditions as identified in the focus groups in Study III, relate particularly to factors that hinder or facilitate individuals in the learning from incidents process. The indicator 'attitude' refers to this individual tendency to learn from incidents. The other indicators, facilitating structures and organisational learning capabilities, refer to the environment in which the learning process occurs. Time, knowledge and competences are, for instance, strongly determined by these aspects, they are illustrations of management commitment, and the facilitating structures that are provided by the organisation.

The indicators can be used by organisations to assess the conditions for learning from incidents. Through creating and sustaining the conditions in which successful learning is likely to occur, the ability of an organisation to learn increases. The indicators may help managers to improve the learning process of their organisation, and in addition help to identify training needs, by identifying specific groups or subjects that need attention.

5.Discussion

The aim of the research project was to contribute to organisational safety and accident prevention by increasing knowledge about learning from incidents, specifically on difficulties in the learning process and on conditions for successful learning. The first section of this chapter compares the main findings of this research with other studies, followed by a discussion in Section 5.2 about how the results can contribute to the purpose of the dissertation: better learning from incidents. The third section explains the limitations of the research project, after which the final sections discuss the implications of the findings for research and practice.

5.1 Discussing the findings

This section discusses the findings according to the four research questions: ”How do organisations learn from incidents?”; ”What are the difficulties in learning from incidents in organisations?”; “What are the underlying factors that make it difficult to learn from incidents in organisations?”; and ”Under what conditions is learning likely to be successful?”

The learning from incidents process

This research highlights multiple sub processes that are involved in answering the question “How do organisations learn from incidents?”, such as determining lessons, the implementation and evaluation of these lessons, and sharing and storing information throughout the process. In order to study the difficulties in learning, learning from incidents is simplified into a process model. In this model, learning is presented as a continual stepwise process - from reporting, to investigation and analysis and the effective use of lessons for improvement - and it explicitly includes the evaluation of the learning process itself. One may wrongly assume that this model represents a process that follows from a single unique experience and therefore only has value in preventing experiences that are alike, however, if learning is successful, the lessons identified and the actions for improvement relate to organisational weaknesses and not to the event itself. Therefore, through learning from one specific incident or one specific trend, a wider array of incidents can be prevented (see also Chapter 2).

The process model proved to work well for the analysis of learning from incidents in organisations and for the identification of difficulties in this process. The model clarifies the follow-up steps for improvement and it shows how all steps in the model are tightly coupled, meaning that even minor problems in a single step impede all consequential steps and thus limit the overall effectiveness of the learning process. Limiting the study on learning from incidents to this single process allows organisations to identify specific difficulties and to benchmark with other organisations. Through the use of the learning from incidents process model, I also gained insight into learning conditions. The main advantage of this model is, however, found in its practical value. It is a rational model that is recognisable to safety practitioners and managers. Because it relates to their way of thinking about safety management, managers and safety practitioners can use this model to recognise, accept and implement possible improvements.

Difficulties in learning from incidents

The results show many examples relating to the second research question: “What are the difficulties in learning from incidents in organisations?” Whereas previous research has focussed mainly on difficulties in the earliest phases - the reporting and analysis of incidents - this research illustrates that many difficulties can also arise in the planning, performing and evaluation of actions, and that removing difficulties in these follow-up phases is equally important for effective

learning from incidents. Difficulties particularly arise in the planning phase and the evaluation phase. In the planning phase, identified lessons are translated into actions for improvement; it is the phase that should bridge the gap between investigation and actions for improvement. Difficulties in this phase can result in too limited a focus in the action plan and a lack of structural improvement. In the evaluation phase, the effectiveness of remedial actions and the learning process itself are reflected on. This phase is seldom effectively performed, despite its importance for improving learning from incidents. As in the safety management system, a review of the process provides input for continual improvement. The lack of attention to the effectiveness of the actions taken, and the lack of evaluation of the learning process, imply that learning opportunities are missed.

Not only are planning and evaluating important when learning from incidents: difficulties can also arise in all other steps of the learning process. This finding is mirrored in the wide array of issues that are discussed in the safety literature. Several studies cover the difficulties and potential improvements for specific steps, as discussed in Chapter 2. Cedergren (2013) and Lundberg et al. (2010) focussed, for instance, on the implementation of recommendations, Sanne (2008) investigated how to improve incident reporting , and Kontogiannis et al. (2000) and Sklet (2004) studied methods for the investigation and analysis of incidents. The findings of this dissertation confirm the difficulties as identified in these studies, but, whereas these studies focussed on single steps and phases, this dissertation ties these steps and phases together and shows how difficulties in one step, influence the process as a whole.

Underlying causes for ineffective learning

The third research question in this dissertation, is: "What are the underlying factors that make it difficult to learn from incidents in organisations?" One major finding from this research is the identification of direct and indirect (underlying) causes for ineffective learning from incidents. The difficulties refer to the direct causes of ineffective learning, but the underlying factors that contributed to the difficulties were also assessed. We identified five categories of factors that contribute to difficulties in learning from incidents. These specific categories are: *lack of time, fear of negative consequences, beliefs or mental models, lack of knowledge and competence, and little sense of urgency.* These are the categories that are identified by the employees that participated in the focus groups, however, the categories refer to different types of factors: lack of time, and lack of knowledge and competence may well be a consequence of the beliefs in the organisation, or of the lack of a sense of urgency. The categories of underlying factors are similar to those mentioned in the studies on learning from incidents that are discussed in Chapter 2. Lundberg et al. (2010) and Stockholm (2011), for instance, noted the importance of personal attitudes and beliefs for learning from incidents. Lundberg et al. (2010) explained how the choices for recommendations and the implementation process are impeded by personal viewpoints that are in turn influenced by competences and resources. Although their study focussed specifically on the follow-up process, and this study focusses on the learning from incidents process as a whole, the findings of Lundberg et al. (2010) confirm the importance of these factors for learning. In order to structurally improve learning from incidents, the underlying causes need to be addressed. Removing them makes successful learning more likely, because the impeding factors will be reduced and the potential for double-loop learning increases.

Conditions for success

The fourth research question of this dissertation is: "Under what conditions is learning likely to be successful?" The research project provides a set of indicators that can be used by organisations to assess the conditions for learning from incidents. The indicators assess the facilitation of

structures, individual attitudes towards sharing and towards performing the learning process, management commitment and openness, and systems perspective and knowledge transfer. These indicators tie into the theory of conditions for learning, as described in Chapter 2. The literature on learning from incidents emphasised the importance of people as actors in the learning process, and their beliefs (Akselsson et al., 2012; Boin and Hart, 2003; Carmeli and Gittel, 2009; Fahlbruch and Schöbel, 2011; Hovden et al., 2011; Lundberg, Rollenhagen and Hollnagel, 2010; Sanne, 2012; Stockholm, 2011). The importance of the individual actors is reflected in the indicators on attitudes: the attitude towards sharing and the attitude towards performing the learning process. The other indicators (facilitating systems, management commitment and openness, systems perspective and knowledge transfer) correspond to the findings from organisational learning theories. According to organisational learning theories, if both structural mechanisms and organisational learning capabilities are present, learning from incidents is facilitated (Senge, 1990; Jerez-Gomez et al., 2005).

The indicators are also related to the absence of underlying factors for difficulties, as explained in the previous section. Although removing the underlying factors for difficulties does not necessarily mean that conditions contributing to learning are improved, the underlying factors and the conditions are related. The indicator for the condition 'attitudes towards learning', refers, for instance, to the absence of the factor 'fear of negative consequences' and to the presence of 'sense of urgency' and of 'beliefs or mental models' that enable learning. The indicators for organisational learning capability - 'management commitment and openness' and 'systems perspective and knowledge transfer' – include the importance of knowledge and competence and time. Even though none of the conditions is in itself sufficient for successful learning, the ability of an organisation to learn increases by creating and sustaining the conditions in which successful learning is likely to occur.

5.2 Reflection on the results: towards better learning from incidents

Despite the increased knowledge that I acquired through studying learning from incidents, the question 'How can we improve learning from incidents?' can only be partially answered. The results show that learning is dependent on the organisational context in which it occurs, and therefore a single solution to improve learning in all organisations is not possible. Lack of effective learning within an organisation encompasses many different problems that require different solutions. The results do, however, suggest certain approaches that contribute to improving learning from incidents. This section explains the main contributions from this dissertation for improving learning from incidents, starting with the identification of the actual problems. This is useful because before a start can be made to improve learning from incidents, careful diagnosis of the problems in learning from incidents, is necessary.

Diagnosis: knowing what the problem is

The findings of this dissertation contribute to the diagnosis of problems in learning from incidents by providing a framework of analysis, by providing examples of difficulties, and by providing examples of the underlying causes of these difficulties. The examples of difficulties and underlying causes facilitate the diagnosis because by knowing the common difficulties, they can be more easily recognised by organisations (and therefore also more easily addressed). More specifically, the findings contribute to the diagnosis of problems because they provide two possible approaches to determining if and why the learning from the incidents process is not fully effective. These approaches facilitate learning-to-learn by enabling a systematic study of the learning from incidents process.

The first approach to reflecting on the learning from incidents process is embedded in the model of the process. In the model, five specific moments are indicated in which reflection is necessary, one after each phase of the learning process. Output is obtained after each phase (e.g. an analysis of incident causes or an action plan) and evaluating the outcome of each phase, and the steps that preceded it, allows for early identification of difficulties in the learning process. These difficulties can then be addressed so that the learning process is no longer impeded. This approach implies that results from the evaluation after each phase are fed back into the process. These feedback loops are not visually represented in the model, because the model only represents the main steps to learning from incidents. The use of feedback increases the quality and effectiveness of these steps.

A second approach is to reflect on the learning process in retrospect, bearing in mind one or more incidents from the past. If people in an organisation (usually management or SHE representatives) feel or know that they do not effectively learn from incidents, perhaps because certain types of incidents continue to occur, this ineffective learning can be the subject of study or reflection. This approach allows for the identification of causes and conditions, in a similar way as when investigating an incident or accident. Whereas the first approach focusses mainly on the identification of the problems in the learning process, this approach enables the study of the real targets for improvement: the causes and conditions that contributed to the problems in learning. This second approach to diagnose why learning may not be effective is used in Study III. The benefit of this approach for safety practitioners is that it is similar to an accident investigation approach and therefore relatively easy to understand. Another benefit of the approach is that it can be performed at any given time.

Improving learning from incidents

The main idea behind studying the learning process, and behind the diagnosis of (potential) problems, is that if problems are acknowledged, they can be addressed, and learning from incidents can be improved. The findings suggest that there are two main approaches to improving learning from incidents: addressing the difficulties for specific bottlenecks in the process, and addressing conditions that more generally facilitate or hinder learning. Both approaches are likely to improve the learning process, and so contribute to the prevention of incidents. The first approach - addressing difficulties in the learning process - is likely to improve a single step in the learning process (single loop learning), and so to contribute to the safety level within the organisation.

The second approach - to create the conditions in which learning is most likely to be effective - is likely to improve learning from the incidents process as a whole. The research project provides a set of indicators that can be used by organisations to assess the conditions for learning from incidents. Following this assessment, the conditions can be sustained and improved, which increases an organisations ability to learn, which in turn contributes to better learning from incidents and to better learning about safety in general.

Pitfalls

There are some pitfalls that must be noted when learning to learn, when consciously improving learning. Firstly, knowing the problem is in itself not sufficient to make it disappear. Although this seems obvious, one of the main problems in learning from incidents pointed out in this dissertation is that persistent issues that are identified through incident investigations are often not addressed. In practice, organisations concentrate too much on determining lessons, and they invest much time and many resources in doing so. As a result, often limited time and resources are available for the follow-up. It would be better to distribute time and resources over the whole

learning process. Similarly, when aiming to improve learning from incidents, a similar amount of attention should be spent on improving learning as on identifying problems in learning.

Secondly, as became clear from this research, in most organisations there is a discrepancy between the formal learning process and the actual learning process in practice. It seems self-evident that the aim is to improve the actual learning process and not only the formal learning process, however if the model for the learning from incidents process is (incorrectly) used as a design tool, it can easily lead to the proliferation of formal procedures. It may also be tempting in practice to propose and implement actions that address the systems and procedures, the formal learning process. Such actions are instantly visible, and they are often easier to implement than changes in actual learning and behaviour. The discrepancy between the formal and actual learning process can be compared to the difference in espoused theory and theory-in-use. If those theories align, learning is most likely to be successful.

5.3 Research limitations

Although the strength of this research lies in the simplification of the learning process into a practical and recognisable model, at the same time, the simple model is also problematic, as learning is more complex in reality. The social processes involved in learning, as studied by Lukic et al. (2010) and Weick and Sutcliffe (2001), for example, are not addressed in this model. Both future research and practice can benefit from integrating the research findings on social learning with the findings from this dissertation on the learning from incidents process. The social processes can enhance understanding of lessons (Lukic et al., 2010) and create new suggestions for improvement (Lampel et al., 2009), and thus improve the quality of the steps in the learning from incidents process.

Although specific strengths and weaknesses related to the methods and design have already been discussed in Chapter 3, this section highlights two overall limitations with respect to the research design.

The first limitation of the research design is related to the types of companies that participated in this research project. The companies were not randomly sampled, since participation was on a voluntary basis. This means that only companies that considered learning from incidents to be an important subject to investigate, participated in this project. Companies that have never given learning any thought, or companies that do not consider learning from incidents an important aspect of safety management, were therefore not included in the research. Such companies may run into additional difficulties that are not identified in this research project. This limitation does not, however, weaken the understanding of learning from incidents process. The same model can be used to study learning from incidents in such organisations, and the conditions for successful learning - including a positive attitude towards learning - remain valid.

Secondly, some critique may be directed towards the relationship between the conditions and the effectiveness of the learning from the incident process. The effect of the conditions on the learning process is not systematically tested, meaning that it is not clear what conditions are most influential on learning from incidents. An addition to the current design may be to test the conditions for learning from incidents in a large scale quantitative study. Through such a study, the conditions can be verified on a wider scale, and the relationships and effects between the conditions and the learning process could be modelled. A model of the conditions and their effect on learning from incidents could further improve the propensity indicators, and could facilitate the development of interventions to improve learning from incidents themselves.

5.4 Implications for research

This research has thrown up many questions in need of further investigation. The following paragraphs discuss where more knowledge is needed and in which future directions research should be considered.

What are the (long- term) effects of an improved learning from incidents process?

This dissertation provides a foundation on which to systematically work on learning from incidents, with an aim to improve learning from incidents in practice. Now, 'the proof of the pudding is in the eating', meaning that the findings should be applied in practice to show the value of the research. Based on the current findings, weaknesses in the learning from incidents process and in the conditions can be identified and addressed. The findings allow for the development of interventions to further improve learning from incidents and the conditions for learning. The development of such interventions and an evaluation of these interventions to determine their effectiveness could be subject of a follow-up project. Through the development and testing of new interventions, knowledge on how to improve learning from incidents can be further increased.

How can theories on sharing knowledge contribute to learning from incidents?

The current research project also clarifies that there has been limited application of theories on social learning and knowledge sharing processes in learning from incidents. In knowledge management and organisational studies, models for the sharing and transfer of knowledge are described, for instance, by Nonaka and Takeuchi (1995), Argote and Ingram (2000), and Bontis, Crossan and Hull and (2002). Knowledge management (KM) is the process of capturing, developing, sharing, and effectively using organisational knowledge (Davenport, 1994). Several factors are known from knowledge management theories to influence sharing and using organisational knowledge. These factors are: trust, pride, loyalty reciprocity and rewards (Ghosh, 2004; Gammelgaard, 2005; Panteli and Sockalingam, 2005; Panayides and Lun, 2009). These factors seem to relate to the conditions for learning, where trust, openness, commitment and individual attitudes play important roles. Further research needs to examine more closely the links between knowledge management and the learning from incidents process and the factors that facilitate these processes. Such a research project can clarify the relationships between, and further enhance knowledge of, facilitators for learning from incidents.

How can commitment for learning be triggered?

Throughout the research project, I have noted that there can be many reasons for organisations to become interested in, and committed to, learning from incidents. Some organisations take action towards learning as a result of external pressure – they perform steps of the learning process because they *have* to, whereas others are intrinsically motivated - they learn because they *want* to. After a major accident, there is, for instance, strong external pressure for lessons and for action. This leads to a strong sense of urgency to 'do something'. Learning from near-misses usually lacks the external pressure, and the sense of urgency to 'do something' is lower. To learn from near-misses, other drivers are probably necessary: intrinsic motivation for learning is needed, to be able to use near-misses as input for learning. Based on the experiences throughout the research project, I came to believe that there are at least three types of organisations: organisations that learn from incidents for the sake of general continuous improvement, organisations that learn from incidents with the aim of safety improvement, and organisations that learn from an incident as the result of external pressure.

The findings of this project also showed that commitment, attitudes and a sense of urgency are important for learning from incidents. When an incident is analysed, this will only be followed up

if recommendations are considered feasible and useful. The same applies to the recommendations on improving learning itself. In order to move from the identification of weaknesses to actual improvements in learning, it is necessary that people believe that improvements are useful and that they are willing to take action. All these aspects – commitment, motivation, attitudes and sense of urgency - refer to personal, intangible aspects, that can facilitate learning from incidents. To further improve learning from incidents in practice, a better understanding of how to create or stimulate these aspects, needs to be developed. Future research should therefore concentrate on the investigation of drivers for learning, meaning the drivers of both management and of employees in organisations. Such a research project can investigate the drivers for learning that exist, assess their impact on the effectiveness of the learning process, and so investigate how organisations can be further motivated for continual learning from incidents.

5.5 Recommendations for practitioners

Earlier in this chapter, I explained how many different problems may arise throughout the learning process, and that what works in one organisation does not necessarily work in another organisation. Nonetheless, there are also generic approaches to learning from incidents which can benefit most organisations:

1. Identify the problem
   As explained in the section on diagnosis, knowing what the problems in the learning process are, is a first step towards better learning. The learning from incidents model can facilitate the diagnosis.
2. Prioritise
3. Recommendations from an accident analysis, or recommendations from studying the learning process, pile up with other improvement plans in the organisation, and therefore choices have to be made, even though this means that other important actions are postponed or cancelled: 'if everything is important, nothing really is'. Improve the phases backwards
   If you don't know where to start, I suggest starting at the end of the learning process: the evaluation stage. This statement does, however, need some explanation. Instinctively, if learning from incidents is not successful, most people and organisations start at the beginning of the process by collecting more information. In practice this means, for instance, that a campaign to increase the number of incident reports is implemented. As a result many reports are then collected, which all have to be processed in some way. In practice this may result in an overload of reports, and either more time and resources, or greater prioritisation would be necessary to process the information. To put it very simply: if you spend extra resources in the collection and analysis of incidents, you have more lessons that need to be implemented, and you thus need to spend at least the same amount of resources on the follow-up. You could however also improve learning from incidents by improving the follow-up phases and making more effective use of the information that you already have. If you start with an evaluation of recent actions, it becomes clear whether an action that was performed is successful, and whether adaptation of the action plan is necessary. Through such an evaluation it possibly becomes clear that many actions are not performed at all, or maybe that actions that are planned can be combined with other ideas for improvement. Most importantly, it is possible to check whether weaknesses that were identified through the analysis of incidents are indeed addressed. After all, learning is not a goal in itself, but the aim is to sustain and improve safety through addressing weaknesses in the organisation.

6.Conclusion

This dissertation aims to contribute to better learning from incidents in organisations. Previous studies demonstrated that in the safety field, learning from incidents often refers to determining lessons, and not to the process of improvement that follows from that. Studies that *did* refer to follow-up, focussed on single aspects of learning, and not on the process as a whole. In addition, the literature review showed that despite a growing literature on learning from incidents, limited empirical studies were available on learning from incidents in organisations. This dissertation addresses this gap by providing empirical findings on how organisations learn from incidents. By combining existing theories from safety and organisational learning and applying them to learning from incidents, this dissertation increases the understanding of learning from incidents. Specifically, the findings enhance our understanding of the steps that form a learning from incidents process. This dissertation also provides a systematic approach to study and to improve learning from incidents, which can serve as a basis for future studies.

To allow an organisation to continually improve and become safer, an effective learning from incidents process is needed in which all steps function well in daily practice. The model shows that difficulties in one step reduce the effectiveness of all consequential steps. This means that even minor difficulties can strongly reduce the overall effectiveness of the learning from incidents process.

For the first time, this study demonstrates that both direct and underlying causes of difficulties in learning from incidents can be identified. Direct causes create a starting point for improving learning from incidents, and by addressing them, single steps in the learning process can be improved. In order to structurally improve learning from incidents, the underlying causes also need to be addressed, which has an effect on the learning process as a whole.

Two approaches enable organisations to diagnose why learning from incidents is not effective, identifying direct and underlying causes so that improvements can be better targeted. One way is through the use of 'milestones' throughout the performance of the learning process, so that after each phase an evaluation of the results is performed, if necessary leading to adjustment of previous steps. Another way is to study learning in retrospect, in relation to a specific incident, to see what went well and what could have been improved.

Organisations can also use a set of indicators to assess the conditions for learning from incidents. Through creating and sustaining these conditions, the general ability of an organisation to learn can be increased and therefore learning not only from incidents, but learning in general can be improved.

References

Akselsson, R., Jacobsson, A., Börjesson, M., Ek A., and Enander A. (2012). Efficient and effective learning for safety from incidents. *Work: A Journal of Prevention, Assessment and Rehabilitation, 41,* 3216–3222.

Argote, L. and Ingram, P. (2000). Knowledge transfer: A basis for competitive advantage in firms. *Organizational Behavior and Human Decision Processes*, *82 (1)*, 150–169.

Argyris, C., and Schön, D. A. (1979). *Organizational learning: A theory of action perspective*. Reading, Mass.: Addison Wesley.

Argyris, C., and Schön, D. A. (1996). *Organizational learning II: Theory, method and practice*. Reading, Mass.: Addison Wesley.

Axinn, W.G. and Pearce, L.D. (2006). *Mixed method data collection strategies*. New York, NY: Cambridge University Press.

Bahn, S. (2009). Power and influence: Examining the communication pathways that impact on safety in the workplace. *Journal of Occupational Health and Safety – Australia and New Zealand, 25*, 213–222.

Bateson, G. (1972). *Steps to an ecology of mind: Collected essays in anthropology, psychiatry, evolution, and epistemology*. Chicago: University Of Chicago Press.

Benavides, F.G., Benacha, J., Martínez, J.M., González, S. (2005). Description of fatal occupational injury rates in five selected European Union countries: Austria, Finland, France, Spain and Sweden . S*afety Science*, *43 (8),* 497–502.

Bhimavarapu, K.R. and Doerr, W.W. (2009). A semiquantitative risk assessment methodology to prioritize recommendations. *Process Safety Progress, 28*, 4, 356–361.

Bickman, L. and Rog, D.J. (1998). *Handbook of applied social research methods.* London: Sage Publications.

Boeije, H. (2008). *Analyseren in kwalitatief onderzoek: denken en doen.* Den Haag: Boom/Lemma.

Boin, A., Hart, P. (2003). Public leadership in times of crisis: mission impossible? *Public Administration Review* 63 (5), 544–553.

Bontis, N., Crossan, M. and Hulland, J. (2002). Managing an organizational learning system by aligning stocks and flows. *Journal of Management Studies*, *39 (4)*, 437–469.

Carmeli, A., Gittell, J.H. (2009). High-quality relationships, psychological safety, and learning from failures in work organisations. *Journal of Organisational Behaviour, 30*, 709–729.

Carroll, J.S. and Fahlbruch, B. (2011). The gift of failure: new approaches to analysing and learning from events and near-misses. Honoring the contributions of Bernhard Wilpert. *Safety Science, 49*, 1, 1–4.

Cedergren, A. (2013). Implementing recommendations from accident investigations: A case study of inter-organisational challenges. *Accident Analysis and Prevention*, *53*, 133–141.

Chevreau, F.R., Wybo, J.L. and Cauchois, D. (2006). Organizing learning processes on risks by using the bow-tie representation. *Journal of Hazardous Materials*, *130 (3)*, 276–283.

Chiva, R., Alegre, J. (2009). Organisational learning capability and job satisfaction: an Empirical assessment in the ceramic tile industry. *British Journal of Management*, *20*, 323–340.

Choularton, R. (2001). Complex learning: Organizational learning from disasters. *Safety Science*, *39 (1),* 61–70.

Chung, P.W.H., Broomfield, E. and Yang, S.H. (1998). Safety Related Questions for Computer-Controlled Plants: Derivation, Organisation and Application. *Journal of Loss Prevention in the Process Industries*, *11 (1)*, 397–406.

Creswell, J.W. (2009). *Research design: Qualitative, quantitative and mixed methods approaches*. Thousand Oaks, Ca: Sage Publications.

Cullen, The Hon. Lord. (1990). *The public inquiry into the Piper Alpha disaster.* London, HMSO, .

Davenport, T.H. (1994). Saving IT's Soul:Human-Centered Information Management. *The Harvard Business Review, 72(2),* 119-131.

Dechy, N., Dien, Y., Funnemark, E., Roed-Larsen, S., Stoop, J. and Valvisto, T. (2012). Results and lessons learned from the ESReDA's accident investigation working group: Introducing article to "safety science" special issue on "industrial events investigation". *Safety Science*, *50*, 6, 1380–1391.

De Fretes, L.M. (1986). *The role of human error in 21 fatal S.I.P.M. accidents.* Centre for Safety Research, Leiden: Leiden University.

Dekker, S.W.A. (2009). Just culture: Who gets to draw the line? *Cognition, Technology and Work*, *11* (3), 177–185.

Deming, W. E. (1982). *Out of the crisis: Quality, productivity and competitive position*. Cambridge, MA.: Cambridge University Press.

Dervin, B. (1983). An overview of sense-making research: Concepts, methods and results. Paper presented at the annual meeting of the *International Communication Association*. Dallas, TX. Available at: https://www.ideals.illinois.edu/bitstream/handle/2142/2281/Dervin83a.htm (accessed 20 august 2014)

Dien, Y., Llory, M. and Montmayeul, R. (2004). Organisational accidents investigation methodology and lessons learned. *Journal of Hazardous Materials*, *111* (*1–3*), 147–153.

Dierkes, A., Berthoin, A., Child, J. and Nonaka, I. (Eds.) (2004). *Handbook of organizational learning and knowledge.* New York: Oxford University Press.

EU Directive 89/391 EEC on the introduction of measures to encourage improvements in the safety and health of workers at work [1989] O JL183/ 1- 8.

Eurostat, (2012). Health and safety at work statistics Retrieved June 2014 from http://archive.today/X91A.

Evan, W.M. and Manion, M. (2002). *Minding the machines: Preventing technological disasters.* Upper Saddle River, NJ: Prentice Hall.

Fahlbruch, B. and Schöbel, M. (2011). SOL – Safety through Organizational Learning: A Method for Event Analysis, *Safety Science*, 49 (1), 27–31.

Fiol, C.M. and Lyles, M.A. (1985). Organizational learning. *The Academy of Management Review, 10 (4)*, 803–813.

Flyvbjerg B. (2006) Five Misunderstandings About Case-Study Research. *Qualitative Inquiry, 12 (2)*, 219–245.

Frick, K. (2011). Worker influence on voluntary OHS management systems – A review of its ends and means. *Safety Science, 49* (7), 974–987.

Gammelgaard J., Ritter T. (2005). The knowledge retrieval matrix: codification and personification as separate strategies, *Journal of Knowledge Management, 9 (4)*, 133 – 143.

Ghosh T. (2004). *Creating Incentives for Knowledge Sharing - Draft*, MIT Sloan School of Management, Cambridge, MA. Available at: http://ocw.uj.ac.za/courses/sloan-school-of-management/15-575-research-seminar-in-it-and-organizations-economic-perspectives-spring-2004/projects/tanu_15575.pdf (accessed 20 august 2014)

Goh S., Richards G. (1997). Benchmarking the learning capability of organisations, *European Management Journal, 15* (5), 575–583.

Groeneweg, J. (2002). *Controlling the Controllable: The management of business upsets*. (5th ed.) Leiden, DSWO Press.

Guldenmund, F.W. (2000). The nature of safety culture: a review of theory and research. *Safety Science, 34*, 1–3, 215-257.

Hale, A.R., Heming, B.H.J., Carthey, J. and Kirwan, B. (1997). Modelling of safety management systems. *Safety Science, 26*, (1–2), 121–140.

Hale, A.R., Hovden, J.M. (1998). Management and culture: the third age of safety. A review of approaches to organizational aspects of safety, health and environment. In: A.M. Feyer, A. Williamson (eds.), *Occupational injury: Risk, promotions and interventions*. (pp. 129-165). London, Taylor and Francis.

Hämäläinen, P. Leena Saarela, K., Takala, J. (2009). Global trend according to estimated number of occupational accidents and fatal work-related diseases at region and country level. *Journal of Safety Research*, *40*, 2, 125–139.

Hasle, P., Zwetsloot, G. (2011). Editorial: Occupational health and safety management systems: Issues and challenges, *Safety Science, 49* (7), 961–963.

Heinrich, H.W. (1931). *Industrial accident prevention: a scientific approach*. New York: McGraw-Hill.

Herbert, I. (2010). The UK Buncefield incident – The view from a UK risk assessment engineer. *Journal of Loss Prevention in the Process Industries*, *23* (6), 913–920.

Hollnagel, E. (2004) *Barriers and accident prevention.* Aldershot, UK: Ashgate.

Hopkins, A. (2008). *Failure to learn: the Texas City refinery disaster*. Sydney, Australia: CCH Australia.

Hovden, J., Størseth, F. and Tinmannsvik, R.K. (2011). Multilevel learning from accidents – Case studies in transport, *Safety Science*, *49 (1*), 98–105.

HSE (1993). *The Costs of accidents at work.* London, Health and Safety Executive, HMSO.

HSE (2004). *Investigating accidents and incidents: A workbook for employers, unions, safety representatives and safety professionals*. Sudbury, UK: HSE Books.

ILO (2014). Safety and health at work. Retrieved June 2014 http://www.ilo.org/global/topics/safety-and-health-at-work/lang--de/index.htm

Jacobsson, A., Sales, J. and Mushtaq, F. (2009). A sequential method to identify underlying causes from industrial accidents reported to the MARS database. *Journal of Loss Prevention in the Process Industries*, *22* (2), 197–203.

Jacobsson, A., Sales, J. and Mushtaq, F. (2010). Underlying causes and level of learning from accidents reported to the MARS Database. *Journal of Loss Prevention in the Process Industries*, *23 (1)*, 39–45.

Jacobsson, A., Ek, A. and Akselsson, R. (2011), Method for evaluating learning from incidents using the idea of "level of learning", *Journal of Loss Prevention in the Process Industries*, *24* (4), 333–343.

Jacobsson, A., Ek, A. and Akselsson, R. (2012). Learning from incidents – A method for assessing the effectiveness of the learning cycle. *Journal of Loss Prevention in the Process Industries*, *25* (3), 561–570.

Jerez-Gómez, P., Céspedes-Lorente, J. and Valle-Cabrera, R. (2005). Organisational learning and compensation strategies: evidence from the Spanish chemical industry, *Human Resource Management*, *44(*3), 279–299

Jones, S., Kirchsteiger, C. and Bjerke, W. (1999), The importance of near miss reporting to further improve safety performance, *Journal of Loss Prevention in the Process Industries*, *12* (1), 59–67.

Jørgensen, K. (2008). A systematic use of information from accidents as a basis of prevention activities. *Safety Science, 46 (2),* 164–175.

Kjéllen, U. (2000). *Prevention of accidents through experience feedback*. London and New York, Taylor and Francis.

Kletz 1988 *Learning from Accidents in Industry.* Oxford, Butterworth-Heinemann.

Kletz, T. (2001), *Learning from accidents*. Oxford, Butterworth-Heinemann.

Kletz, T. A. (2008), Searchlights from the past. *Journal of Hazardous Materials, 159 (*1), 130–134.

Kontogiannis, T., Leopoulos, V. and Marmaras, N. (2000), A comparison of accident analysis techniques for safety-critical man-machine systems. *International Journal of Industrial Ergonomics*, *25* (4), 327–347.

Koornneef, F. (2000). *Organised learning from small-scale incidents*, Delft: Delft University Press.

Koornneef, F., Hale, A. R. and Dijk, W. van (2005). Critical assessment of the organisational learning system of the fire service in response to fatal accidents to firemen. In K. K (Ed.), *Advances in safety and reliability* . (pp. 1119-1123). London: Taylor and Francis Group.

Körvers, P.M.W. and Sonnemans, P.J.M. (2008). Accidents: A Discrepancy between Indicators and Facts! *Safety Science*, *46 (*1), 1067–1077.

Krueger, R.A.; Casey, M.A. (2008). *Focus groups: A practical guide for applied research* . Thousand Oaks, CA: Sage Publications.

Lampel, J., Shamsie, J. and Shapira, Z. (2009). Experiencing the improbable: Rare events and organizational learning, *Organization Science, 20 (*5), 835–845.

Le Coze, J. C. (2008), Disasters and organisations: From lessons learnt to theorising. *Safety Science, 46 (*1), 132–149.

Le Coze, J.C. (2013a). New models for new times. An anti-dualist move. *Safety Science, 59,* 200–218.

Le Coze, J.C. (2013b). What have we learned about learning from accidents? Post-disasters reflections. *Safety Science 51 (1)*, 441–543.

Leung, M.Y., Shan Chan, I.Y., Yu, J. (2012) Preventing construction worker injury incidents through the management of personal stress and organizational stressors. *Accident Analysis and Prevention*, *48,* 156–166.

Leveson, N. (2004). A new accident model for engineering safer systems. *Safety Science 42* (4), 237–270.

Liao, S. , Fei, W. , and Liu, C. (2008). Relationships between knowledge inertia, organizational learning and organization innovation. *Technovation, 28 (*1), 183–195.

Lindberg, A. K., Hansson, S. O., and Rollenhagen, C. (2010). Learning from accidents - what more do we need to know? *Safety Science, 48 (* 6), 714–721.

Lukic, D., Margaryan, A., and Littlejohn, A. (2010). How organisations learn from safety incidents: A multifaceted problem. *Journal of Workplace Learning, 22* (7), 428–450.

Lukic, D., Littlejohn, A. and Margaryan, A. (2012). A framework for learning from incidents in the workplace. *Safety Science, 50 (*1), 950–957.

Lundberg, J., Rollenhagen, C., Hollnagel, E., Rankin, A. (2012). Strategies for dealing with resistance to recommendations from accident investigations. *Accident Analysis and prevention 45*, 455–467.

Mancini, P. (1998). Risky information: Social limits to risk management. *Journal of Contingencies and Crisis Management*, *6*, 35–44.

Maxwell, J.A. (2008). The value of a realist understanding of causality for qualitative research. In N.K. Denzin (Ed.), *Qualitative inquiry and social justice* (pp 108-122). Walnut Creek, CA: Left Coast Press.

Maxwell, J.A. (2012*). A realist approach for qualitative research*. Thousand Oaks, CA: Sage.

Nonaka, I. and Takeuchi, H. (1995) *De kenniscreërende onderneming; hoe japanse bedrijven innovatieprocessen in gang zetten [The Knowledge-Creating Company; How Japanese Companies Create the Dynamics of Innovation]*. Scriptum, Schiedam.

OECD (2002). *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development*, 6th edition. Retrieved from http: //dx.doi.org/10.1787/9789264199040-en

OHSAS 18001 (2007) Occupational Health and Safety Management Systems Requirements Standard, 2007, http://www.ohsas-18001-occupational-health-and-safety.com

Oxford Advanced Learner's Dictionary (2010) 8th Revised edition. Oxford University Press.

Panayides, P.M., Lun, Y.H.V. (2009). The impact of trust on innovativeness and supply chain performance. *International Journal of Production Economics, 122 (1)*, 35-46.

Panteli, N., Sockalingam, S. (2005). Trust and conflict within virtual inter-organizational alliances: a framework for facilitating knowledge sharing. *Decision Support Systems, 39 (4)*, 599-617.

Pasman, H.J. (2009). Learning from the past and knowledge management: Are we making progress?, *Journal of Loss Prevention in the Process Industries, 22 (*6), 672–679.

Pawson, R. and Tilley, N. (1997). Realistic evaluation. London: Sage Publishing.

Peuscher, W. and Groeneweg, J. (2012). *A big oil company's approach to significantly reduce fatal incidents*. SPE/APPEA International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production 2012: Protecting People and the Environment - Evolving Challenges, 11 September 2012 through 13 September 2012, Perth, WA, 3, 2173–2190.

Pidgeon, N. and O'Leary, M. (2000). Man-made disasters: Why technology and organizations (sometimes) fail. *Safety Science, 34 (1–3),* 15–30.

Prange, C. (1999). Organizational learning – desperately seeking theory? in M. Easterby-Smith, L. Araujo and J. Burgoyne (eds.) *Organizational Learning and the Learning Organization* (pp 22-43). London: Sage.

Rasmussen, J. (1997). Risk management in a dynamic society: a modelling problem. *Safety Science 27* (2-3), 183–213.

Rasmussen, H.B., Drupsteen, L. Dyreborg, J. (2013) Can we use near-miss reports for accident prevention? A study in the Oil and Gas industry in Denmark. *Safety Science Monitor*, *17 (2*), 1-12.

Reason, J.T. 1990. *Human Error.* New York: Cambridge University Press.

Reason, J.T. 1997. *Managing the risks of organisational accidents*. Ashgate Publishing.

Reason, J., Hollnagel, E., Paries, J. (2006) *Revisiting the "Swiss cheese" model of accidents.* EUROCONTROL Agency, Bruxelles.

Robey D., Boudreau M-C., Rose G.M. (2000). Information technology and organizational learning: a review ad assessment of research, *Accounting, Management and Information Technology*, *10*, 125–155

Robson L.S., Clarke J.A., Cullen K., Bielecky A., Severin C., Bigelow P., Irvin E., Culyer A.J. (2007). The effectiveness of occupational health and safety management system interventions: a systematic review. *Safety Science, 45* (3) 329–353.

Sanne, J. M. (2008). Incident reporting or storytelling? competing schemes in a safety-critical and hazardous work setting. *Safety Science, 46* (8), 1205–1222.

Sanne, J.M. (2012). Learning from adverse events in the nuclear power industry: Organizational learning, policy making and normalization. *Technology in Society, 34*(1), 239–250.

Schein E., 1992. *Organizational Culture and Leadership: A Dynamic View*. San Francisco, CA., Jossey-Bass.

Senge, P. M. (1990), *The fifth discipline; the art and practice of the learning organization*, New York, Doubleday.

Sepeda, A. L. (2006).Lessons learned from process incident databases and the process safety incident database (PSID) approach sponsored by the centre for chemical process safety. *Journal of Hazardous Materials, 130 (*1), 9–14.

Seveso III, (2003). Council Directive 2003/105/EC of the European Parliament amending Council Directive 96/82/EC on the control of major-accident hazards involving dangerous substances. *Official Journal No. L*, *345*.

Siegel S. and Castellan N.J. 1988. *Nonparametric statistic for the behavioral sciences* (2nd edition) Singapore, McGraw-Hill Book Company.

Sklet, S., 2004. Comparison of some selected methods for accident investigation. *Journal of Hazardous Materials 11* (1), 29–37.

Stave, C. and Törner, M. (2007). Exploring the organisational preconditions for occupational accidents in food industry: A qualitative approach. *Safety Science, 45* (3), 355–371.

Stockholm, G. (2011). Insight from hindsight: A practitioner's perspective on a causal approach to performance improvement. *Safety Science, 49 (1* , 39–46.

Swuste, P., van Gulijk, C., Zwaard, W. (2010). Safety metaphors and theories, a review of the occupational safety literature of the US, UK and The Netherlands, till the first part of the 20th century. *Safety Science, 48* (8), 1000–1018.

Swuste, P. Gulijk, C. van, Zwaard, W. Oostendorp, Y. (2014). Occupational safety theories, models and metaphors in the three decades since World War II, in the United States, Britain and the Netherlands: A literature review. *Safety Science, 62*, 16–27.

Van der Schaaf, T. (1992). *Near miss reporting: In the chemical process industry*. Technical University, Eindhoven.

Van Vuuren, W. (1998), *Organisational failure: An exploratory study in the steel industry and the medical domain*, Technische Universiteit, Eindhoven.

Wahlström, B. (2011). Organisational learning- reflections from the nuclear industry. *Safety Science, 49 (*1), 65–74.

Weick, Karl E.; Kathleen M. Sutcliffe (2001). *Managing the unexpected - Assuring high performance in an age of complexity*. San Francisco, CA: Jossey-Bass.

Weick, K. (1979). *The social psychology of organizing*. New York: McGraw-Hill.

Weick, K. (1995). *Sensemaking in organizations.* London: Sage Publications.

Wybo, J.L. (2012). *Maîtrise des risques et prévention des crises*, Cachan Cedex: Lavoisier (in French).

Yin, R. K. (2009). *Case study research: Design and methods* (4th ed.). Thousand Oaks, CA: Sage.

Yukl, G. (2009). Leading organizational learning: Reflections on theory and research. *The Leadership Quarterly, 20*, 49–53.

Papers

I. Drupsteen L. and Guldenmund F.W. (2014). What is Learning? A Review of Safety Literature on Learning from Incidents. *Journal of Contingencies and Crisis Management*, *22 (2),* pp. 81 - 96.

II. Drupsteen L., Groeneweg J., Zwetsloot G. I. J. M. (2013) Critical steps in learning from incidents: Using learning potential in the process from reporting an incident to accident prevention. *International Journal of Occupational Safety and Ergonomics 19 (1)*, 63-77.

III. Drupsteen L. and Hasle, P. (in press) Why do organizations not learn from incidents? Bottlenecks, causes and conditions that create a failure to effectively learn. *Accident Analysis and Prevention*.

IV. Drupsteen L. and Wybo, J-L. (in press). Assessing propensity to learn from safety-related events. *Safety Science*.

What Is Learning? A Review of the Safety Literature to Define Learning from Incidents, Accidents and Disasters

Linda Drupsteen* and Frank W. Guldenmund**

*TNO Work and Employment, PO Box 718, 2130 AS Hoofddorp, The Netherlands. E-mail: linda.drupsteen@tno.nl
**Safety Science Group, Faculty of Technology, Policy and Management, Delft University of Technology, PO Box 5015, NL-2600 GA Delft, The Netherlands. E-mail: F.W.Guldenmund@tudelft.nl

Learning from incidents, accidents and disasters contributes to improvement of safety and the prevention of unwanted events. In this review, literature on learning from safety incidents within organizations is studied and compared with the organizational learning theory of Argyris and Schön. Sub-processes, such as learning lessons, sharing, storing and applying lessons, are described, and factors that influence these processes are listed, such as trust, the severity of the consequences of an incident and the people involved in learning. In comparison with the theory of Argyris and Schön, aspects about the information to learn from, i.e., the incident and analysis, are much more specified in the safety literature. However, the organizational learning theory gives more details about the earlier mentioned sub-processes.

1. Introduction

Many organizations put effort into managing safety to prevent accidents, incidents and disasters. Despite these efforts, incidents keep recurring, resulting in injuries and in damage to the environment (Jones, Kirchsteiger, & Bjerke, 1999; Kjéllen, 2000; Kletz, 1993, 2001; Schöbel & Manzey, 2011). The term 'incident' refers in this paper to unwanted and unexpected events within the organization with an effect on safety, including also accidents and near misses.

One reason for the fact that incidents keep recurring, is a failure to successfully learn from incidents (Kirwan, 2001). By learning from incidents (LFI) that have occurred, organizations expect to further improve the safety levels and prevent future incidents. An organization learns by detecting events, by reflecting on them, by learning lessons from them and by putting these lessons into practice to prevent future incidents.

The safety literature provides some explanations for the failure to successfully learn from incidents, such as underreporting of incidents (Mancini, 1998; Sanne, 2008), inability to identify latent conditions (Jacobsson, Sales, and Mushtaq, 2009), tendency to seek a scapegoat (e.g., Sagan, 1993; Pidgeon & O'Leary, 2000) or political and organizational decision processes (Hovden, Størseth, & Tinmannsvik, 2011).

To improve LFI in organizations such issues have to be addressed, meaning that a clear understanding of the processes involved is needed. LFI therefore is a field that deserves the interest of both scientists and practitioners and the number of papers that is written on the subject is growing rapidly. Both *Safety Science* and the *Journal of Contingencies and Crisis Management*

 DOI: 10.1111/1468-5973.12039

presented special issues about the subject matter (Deverell & Hansén, 2009; Carroll & Fahlbruch, 2011). The papers address a wide range of topics, such as methods for incident analysis, registration databases or learning processes. Moreover, several reviews on the subject of LFI aim to summarize important topics. For instance, Lindberg, Hansson, and Rollenhagen (2010) performed a literature review to identify future research needs on the subject. They used a stepwise model of the learning process to analyze the literature. Lukic, Margaryan, and Littlejohn (2010) also carried out a literature review, aimed at identifying the diversity of approaches for workplace learning from safety incidents and the analysis of these approaches according to four aspects: type of knowledge, nature of the incident causes, process and the actors. Their framework is based on learning theories; therefore, other papers were included in their review compared with Lindberg et al. (2010). In 2013, Le Coze claimed that earlier attempts to create an overview of the learning from accidents literature were limited and that a step back was necessary. In his review, inputs from psychology, sociology and political science are used to produce a bigger picture on learning from accidents (Le Coze, 2013). The three reviews illustrate the multitude of possible perspectives on learning from incidents; however, no clear systematic review of what learning from incidents *is* according to safety research literature and why LFI is often ineffective has not been published yet. Such a literature review is relevant to get a better insight into actual learning processes and into the issues that companies need to address to improve how they learn from incidents. In this paper, safety literature is reviewed to define LFI processes, to describe the contextual factors that influence these processes and to identify possible explanations for inefficient learning. Specifically, LFI is compared with the organizational learning theory from Argyris and Schön (1979, 1996), to establish what aspects of LFI need further attention in research. With this, the aim of this paper is threefold to contribute to a more comprehensive knowledge on learning from incidents, to identify possible explanations for inefficient learning and to establish what aspects of learning from incidents need further attention in research.

Although our main focus is on learning from accidents and near misses, the models for analysis of incidents and for learning may also apply to situations after events, such as the emergency response, as is described by Abrahamsson, Hassel, and Tehler (2010).

The following sections describe the methodology for the review and the results according to three themes that were identified in the literature, i.e., learning lessons from incidents, learning processes and factors that are known to influence the LFI processes. This is followed by the comparison with organizational learning theory.

1.1. Theory for comparison

For the comparison, we use the generic scheme for organizational learning that was presented by Argyris and Schön (1996), including a learner, a learning process and a learning product. We use the organizational learning theory of Argyris and Schön because we regard organizational learning as a key process in improving organizational safety. The theory on organizational learning that Argyris and Schön presented in 1978 already mentioned the importance of learning as a means to detect and respond to errors and unwanted situations. This specific theory on learning is still widely accepted, despite more recent developments in organizational learning (e.g., by Cyert & March, 1992; Flood, 2009; Watson, 2002). Organizational learning is a complex field of research, involving many aspects such as sensemaking (e.g., Weick, Sutcliffe, & Obstfeld, 2005; Klein, Moon, & Hoffman, 2006), workplace learning (e.g., Candy & Matthews, 1998), behavioural change (e.g., Cyert & March, 1992), knowledge flow and transfer (e.g., Nonaka & Takeuchi, 1995; Bontis, Crossan, & Hulland, 2002) and aspects of a learning culture (e.e. O'Keeffe, 2002). The scope of the comparison in this paper is limited to LFI as an organizational learning process of putting lessons learned from incidents into practice to prevent future incidents.

According to the theory of Argyris and Schön (1996), all learning starts with the collection of information, the learning product. This could be new knowledge that is acquired, or existing knowledge that is absorbed. The absorption of existing knowledge concerns for instance experience or lessons learned from others. In this review, we will compare the literature on incidents and the associated lessons learned with the acquisition of information from the learning product.

According to Argyris and Schön (1996), the acquisition of information is followed by processing and storing information. This process can address multiple levels. A well-known distinction is between so-called 'single-loop learning' and 'double-loop learning'. If an organization exhibits single-loop learning, only the specific situation or processes are improved. However, when an organization exhibits double-loop learning, improvements are not limited to the specific situation but the values, assumptions and policies that led to actions in the first place are questioned (Argyris & Schön, 1979). An important kind of double-loop learning is the learning through which the members of an organization may discover and modify the learning system. This learning to learn process (called Deutero learning by Argyris & Schön, 1996) enables an organization to continuously improve (Senge, 1990).

In this review, the LFI processes will be related to the levels of learning, and compared with the steps in the general learning process, i.e., acquisition, processing and storing of information.

2. Methods

To obtain an overview of the available literature, the following databases have been used: Ingenta Connect, Scopus and Science Direct. Searches focussed on abstracts, title and keywords of peer-reviewed articles with no limit on date of publication. The search string used was *(organisational* or *organizational)* and *learning* and *(incidents* or *accidents)* and *safety*, with an exclusion of the domains nursing, health care and medical. No additional search was performed that was specifically aimed at learning lessons, i.e., investigating and analyzing incidents or general learning in safety. The initial search yielded 113 articles. Also three PhD theses are included because they are considered essential for the review. Following a scanning of abstracts, 32 articles were excluded because of their focus on patient safety or because the papers were not in English. The remaining 81 articles were scanned for their use of the word learning. Another 21 were excluded because the papers were about risk management or safety culture, and the search terms were used in those contexts and not in relation to learning itself. Also, 14 papers were excluded because their focus was too specific, for instance, on specific lessons learned or on regulations.

The remaining 46 articles were studied in detail and categorized according to their main subjects. Another two papers were excluded after this because they focussed on individual training and not on LFI at an organizational level. In this paper, the remaining 44 articles and the three PhD theses are analyzed.

An overview of the literature and their main subject category is listed in Table 1. All papers are classified according to the empirical cycle by de Groot (1969), which runs from making empirical observations (observation), stating a theory (induction), to generating hypotheses about this theory (deduction), designing a study in which the hypothesis is confronted with observations (testing) and evaluation of the hypothesis. De Groot's empirical cycle is both descriptive and normative in that it describes how (social) scientists carry out their research but also how they *should* carry it out (e.g., Meerling, 1980; Swanborn, 1987). As a general framework, it orders the papers according to their research focus, i.e., running from observational and conceptual to evaluating. An overview of the classification of the papers into topics is presented in Figure 1. Most articles describe more than one subject.

3. Learning lessons

A first step in LFI is to detect an incident and to reflect on its meaning. Analyzing an event and its origin enables the organization to learn lessons (van Vuuren, 1998) and to address the causes. This section describes the process of learning lessons from incidents by using methods of incident investigation and analysis.

3.1. Incidents as input to learn from

An incident, according to the *Oxford Advanced Learner's Dictionary* (*Oxford Dictionary*) is an instance of something happening, an event or occurrence. Koornneef (2000) calls incidents 'operational surprises', meaning undesirable conditions that have the potential for damage or other losses (ibid.). A similar definition is used by van der Schaaf (1992) who refers with the term incident to a combined set of occurrences of both accidents and near misses, with both severe and less severe outcomes. This definition implies that lessons can be learned from incidents, irrespective of the severity of the consequences.

Similar events can generate very different lessons for organizations and several authors emphasize the importance of distinguishing events from the consequences (Choularton, 2001; Homsma, van Dyck, Gilder, Koopman & Elfring 2009; Lampel, Shamsie, & Shapira, 2009; Uth, 1999). Authors that do emphasize the consequences of events are van der Schaaf (1992) and Homsma, van Dyck, Gilder, Koopman, and Elfring (2009). van der Schaaf (1992) emphasizes the advantages of learning from near misses because near misses are much more numerous than actual accidents and because they provide a continuous reminder to keep safety awareness a top priority. Homsma et al. (2009) conclude on the other hand that more lessons are generated and learned from errors with severe consequences as opposed to similar errors with limited consequences.

As described in the previous subsection, incidents, accidents, errors, surprises and their precursors all provide potential input to learn from. In our opinion, the aim is to learn from unwanted and unexpected events, with severe as well as less severe consequences.

3.2. Identifying incident causes

Incidents have multiple consequences, as described in Section 3.1, and also multiple causes. An analysis of multiple events by Sonnemans, Körvers, and Pasman (2010) for instance showed that accidents are often caused by a combination of technical, human and organizational factors. Analysis of incidents enables the identification of the causes and of barriers that failed to prevent the incident (Chung, Broomfield, & Yang, 1998;

Table 1. Learning from Incidents Literature, Categorized by Topic and the Empirical Cycle (Observation, Induction, Deduction, Test, Evaluation)

Author	Year	Title	Topic category	Evidence
Abrahamsson	2010	Towards a System-Oriented Framework for Analysing and Evaluating Emergency Response	Learning lessons and conditions for learning	Conceptual paper in which a case study is used to illustrate a framework for analysis and evaluation – inductive
Birkland	2009	Disasters, Lessons Learned, and Fantasy Documents	Conditions for learning	Conceptual paper in which learning patterns are presented – observational
Carroll	1998	Organizational Learning Activities in High-Hazard Industries: The Logistics Underlying Self-Analysis	Conditions for learning	Conceptual research in which a model is proposed based on four illustrations of learning practices – inductive
Carroll	2011	'The Gift of Failure: New Approaches to Analyzing and Learning from Events and Near-Misses.' Honoring the Contributions of Bernhard Wilpert	Conditions for learning	Conceptual paper describing themes and views on learning –observation
Catino	2008	A Review of Literature: Individual Blame vs. Organizational Function Logics in Accident Analysis	Learning lessons and conditions for learning	Conceptual paper in which arguments are brought together based on a literature review –inductive
Cedergren	2011	Prerequisites for Learning from Accident Investigations – A Cross-Country Comparison of National Accident Investigation Boards	Learning lessons	Conceptual research in which factors are identified based on investigation reports – inductive
Chevreau	2006	Organizing Learning Processes on Risks by Using Bow-Tie Representation	Conditions for learning	Conceptual research in which method is applied – testing
Choularton	2001	Complex Learning: Organizational Learning from Disasters	Learning lessons and conditions for learning	Conceptual paper in which a theory is presented – deductive
Chung	1998	Safety Related Questions for Computer-Controlled Plants: Derivation, Organisation and Application	Learning lessons	Illustration of a method with examples from application – testing
Coze, Le	2008	Disasters and Organisations: From Lessons Learnt to Theorising	Learning lessons	Conceptual paper in which the organizational dimension in accident methods and models is explored – observational
Coze, Le	2013	What Have We Learned about Learning from Accidents? Post-Disasters Reflections	Learning lessons	Literature review
Dechy	2012	Results and Lessons Learned from the ESReDA's Accident Investigation Working Group: Introducing Article to 'Safety Science' Special Issue on 'Industrial Events Investigation'	Learning lessons	Introducing article to special issue – observational
Dekker	2009	Just Culture: Who Gets to Draw the Line?	Conditions for learning	Conceptual paper in which issues are raised – observation
Deverell	2009	Crises as Learning Triggers: Exploring a Conceptual Framework of Crisis-Induced Learning	Learning lessons	Conceptual paper in which hypotheses are created – deduct
Dien	2004	Organisational Accidents Investigation Methodology and Lessons Learned	Learning lessons	Conceptual paper in which accident cases are described to illustrate a theory – inductive

Table 1. Continued

Author	Year	Title	Topic category	Evidence
Drupsteen	2013	Critical Steps in Learning from Incidents	Learning processes	Survey study of the application a process model in practice – testing
Fahlbruch	2011	SOL – Safety through Organizational Learning: A Method for Event Analysis	Learning lessons	Summarize empirical evidence to discuss practical experience and identify future research challenges – observation
Homsma	2009	Learning from Error: The Influence of Error Incident Characteristics	Learning lessons (and Conditions for learning)	Empirical research in which hypotheses are tested with data from open ended questionnaires – testing
Hovden	2011	Multilevel Learning from Accidents – Case Studies in Transport	Conditions for learning (and Learning lessons)	Validating criteria that are deducted from literature and case studies, in a workshop – testing
Huber	2009	Learning from Organizational Incidents: Resilience Engineering for High-Risk Process Environments	Learning processes	Field study on plant resilience, with interviews and a questionnaire – testing
Jacobsson	2009	A Sequential Method to Identify Underlying Causes from Industrial Accidents Reported to the MARS Database	Learning lessons	Checking applicability and validity of method in an expert group and application of the method for analysis – testing
Jacobsson	2010	Underlying Causes and Level of Learning from Accidents Reported to the MARS Database	Learning lessons	Apply a method to identify more causes – testing
Jacobsson	2011	Method for Evaluating Learning from Incidents Using the Idea of 'Level of Learning'	Learning processes	Apply a method to determine levels of learning – testing
Kletz	2004	Learning from Experience	Conditions for learning	Conceptual paper in which issues are raised – observation
Kletz	2008	Searchlights from the Past	Conditions for learning	Conceptual paper in which issues are raised – observation
Kongsvik	2010	Organisational Safety Indicators: Some Conceptual Considerations and a Supplementary Qualitative Approach	Learning lessons	Conceptual research in which an approach is presented based on literature and practical experience – inductive
Kontogiannis	2000	A comparison of Accident Analysis Techniques for Safety-Critical Man-Machine Systems	Learning lessons	Test a taxonomy of assessment criteria by comparing three accident analysis techniques – testing
Koornneef	2000	Organised Learning from Small-Scale Incidents	Conditions for learning and learning lessons	Case studies, adaptation of framework and comparison with theory – testing
Koornneef	2005	Critical Assessment of the Organisational Learning System of the Fire Service in Response to Fatal Accidents to Firemen	Conditions for learning	Conceptual research in which a learning system was studied to explore its functioning – observational
Körvers	2008	Accidents: A Discrepancy between Indicators and Facts!	Learning lessons	Investigation of recent accidents to test the existence of identified safety indicators and warning signals – testing
Lampel	2009	Experiencing the Improbable: Rare Events and Organisational Learning	Learning lessons (and Conditions for learning)	Conceptual research in which a theory is proposed based on observations and literature – inductive

Table 1. Continued

Author	Year	Title	Topic category	Evidence
Lindberg	2010	Learning from Accidents – What More Do We Need to Know?	Learning processes	Conceptual paper in which a model is presented based on a literature review – inductive
Lukic	2010	How Organisations Learn from Safety Incidents: A Multifaceted Problem	Learning processes and conditions for learning	Conceptual paper in which a framework is presented based on a literature review – inductive
Lukic	2012	A Framework for Learning from Incidents in the Workplace	Learning processes and conditions for learning	Explore factors of the framework in practice – testing
Naevestad	2008	Safety Cultural Preconditions for Organizational Learning in High-Risk Organizations	Conditions for learning	Conceptual paper in which issues are raised and illustrated with literature – observational
Pidgeon	2000	Man-Made Disasters: Why Technology And Systems (Sometimes) Fail	Conditions for learning	Conceptual paper in which issues are raised and illustrated with literature – observational
Sanne	2008	Incident Reporting or Storytelling? Competing Schemes in Safety-Critical and Hazardous Work Setting	Conditions for learning	Ethnographic fieldwork. Comparison of theory and practice – testing
Sanne	2012	Learning from Adverse Events in the Nuclear Power Industry: Organizational Learning, Policy Making and Normalization	Learning processes	Case study, by document study and interviews – observational
Schaaf, van der	1992	Near Miss Reporting: In the Chemical Process Industry	Learning processes and learning lessons	Development of a model and test in a case study – testing
Schaaf, van der	2004	'Biases in Incident Reporting Databases: An Empirical Study in the Chemical Process Industry'		Diary study to test hypotheses, testing
Schöbel	2011	Subjective Theories of Organizing and Learning from Events	Conditions for learning	Conceptual paper in which issues are raised and illustrated with literature – observational
Sklet	2010	Comparison of Some Selected Methods for Accident Investigation	Learning lessons	Comparison of accident analysis techniques by predetermined characteristics – deductive
Sonnemans	2010	Accidents in 'Normal' Operation – Can You See Them Coming?	Learning lessons	Application of approach in three case studies – testing
Stave	2007	Exploring the Organisational Preconditions for Occupational Accidents in Food Industry: A Qualitative Approach	Learning processes	Conceptual paper in which accidents are studied to explore conditions for accidents, resulting in hypotheses – deductive
Uth	1999	Trends In Major Industrial Accidents in Germany	Learning lessons	Conceptual research in which factors are identified based on investigation reports – inductive
Vuuren, van	1998	Organisational Failure: An Exploratory Study in the Steel Industry and The Medical Domain	Learning lessons	Case studies – comparison of theory and practice – testing
Wahlström	2011	Organisational Learning – Reflections from the Nuclear Industry	Learning processes and conditions for learning	Questions are derived from observation and from collected data a model was developed – deductive
Wybo	2004	Mastering Risks of Damage and Risks of Crisis: the Role of Organisational Learning	Learning lessons	Conceptual research in which a theory is proposed and illustrated with a case – inductive

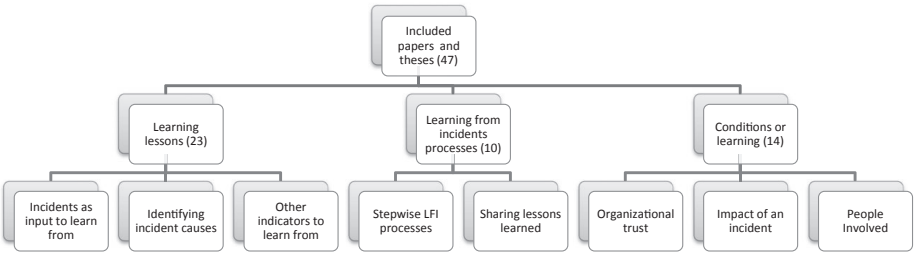

Figure 1. Overview of the topics on learning from incidents in the literature.

Dien, Llory, & Montmayeul, 2004). Abrahamsson et al. (2010) emphasize though that the causes should not be studied in isolation since they are part of a system.

Well-known distinctions in incident analysis are between causes that are directly or indirectly related to the incident (Groeneweg, 1998) and between latent and active failures (Reason, 1990). Active failures are in general errors made at the so-called sharp end of accident causation, e.g., technical and human failure. These failures are directly related to the incident, whereas latent conditions create the circumstances for active failures to occur, e.g., organizational and technical failures or managerial weaknesses (Reason, 1990). Other commonly used terms are indirect causes, root causes or underlying causes. In his review on accident analysis approaches, Catino (2008) labels the approach to identify latent, systemic factors 'organizational function logic'. This approach contrasts with individual blame logic, where guilty individuals are identified. Choularton (2001), Dechy, Dien, Funnemark, Roed-Larsen, Stoop, and Valvisto (2012), Fahlbruch and Schöbel (2011) and Jacobsson et al. (2009) state that the determination of organizational factors or underlying causes is the most important part of learning. Addressing the indirect causes or conditions, independent of the people who are operating, creates a safer environment in which more than just one event will be prevented (Catino, 2008; Jacobsson et al., 2009).

Multiple studies demonstrated however the difficulties in addressing organizational factors. According to Körvers and Sonnemans (2008), the organizational factors often get less attention than the human and technical factors due to the focus of the researchers. Cedergren and Petersen (2011) came to a similar conclusion based on an assessment of incident reports from three Scandinavian accident investigation boards. They noticed that the majority of the attributed causes in the investigation reports were focussed on the sharp end close to the accident scene, such as activities and equipment. However, they expected that these are merely a symptom of issues at the organizational or system level. Similarly, Abrahamsson et al. (2010) state that in a system approach, 'human error should be seen as the consequence of upstream systemic factors'. A review of incidents in the Major Accident Reporting System by Jacobsson et al. (2009) illustrates that the relations between incident causes and managerial weaknesses are often not registered in the database. Sanne (2012) warned in his research that LFI can result in a situation where alternative possibilities are excluded and latent issues remain untouched because the measures and regulations that are used are solely determined based on specific lessons learned.

To facilitate the identification of underlying causes, numerous methods for incident analysis are available. Sklet (2004) described and compared some commonly used methods for the investigation of accidents. He described the different areas of application and different pros and cons for each of the methods and emphasized that for learning, it is important that the methods of choice are well fitted for their purpose and result in an understanding of the incident and its causation. In the investigation of accidents, according to Sklet (2010) and Kontogiannis, Leopoulos, and Marmaras (2000), a combination of techniques should be used. Kontogiannis et al. (2000) state however that current accident analysis techniques do not provide appropriate input for other parts of an investigation. A technical analysis can for instance be an addition to human error analysis, but it is now too difficult to integrate these different techniques. Catino (2008) and Abrahamsson et al. (2010) emphasize that for the identification of latent factors, models of organizational analysis are needed, that are suitable to the complexity of events.

Le Coze (2008) discusses several models that treat the organizational dimension of accidents. The approaches are classified according to depth (micro, meso, macro) and purpose. The results suggest that, although several works and methods are available for addressing the organizational dimension of accidents, they are not always used for this purpose.

The papers described in this subsection show that the underlying causes and preceding factors, including organizational and managerial factors are often not

addressed. Addressing these underlying causes is nevertheless important for so-called double-loop learning. If only direct causes are addressed, learning is in practice limited to single-loop learning. As Deverell (2009) states, both single- and double-loop learning are equally important, and although it is important to aim for double-loop learning, single-loop lessons are just as important. A wide variety of methods for investigating and analyzing incidents, so that causes can be identified and addressed, is available.

3.3. Other indicators to learn from

Some papers mention that it is also possible to learn from other indicators. Kongsvik, Almklov, and Fenstad (2010), conclude for example that organizational safety indicators, such as safety climate measures or risk indicators also carry a potential for learning since they offer ideas for changing and modifying work practices. Körvers and Sonnemans (2008) identified a list of warning signals based on an analysis of 70 accidents. These pre-warning signals or so-called precursors are not necessarily related to safety events, but they are indicators that enable an organization to prevent accidents if countermeasures are successfully taken. Examples of precursors are operator complaints, maintenance problems and quality problems. Wybo (2004) explains however that different risk management approaches apply to anticipated risks, such as those based on risk indicators or precursors, and to the risk associated with unexpected events. Lampel et al. (2009) distinguish between deliberate learning and emergent learning. When learning from other indicators, as described in this subsection, an organization is deliberately learning. A systematic attempt to analyze past experience is made, for instance, by learning from other organizations, from quality management systems, or from trends in accidents. When learning from situations that are not known from experience yet, such as incidents, learning is emergent.

In conclusion, safety indicators, experiences of other organizations and analyses of past experiences can also provide input to learn from. Although this paper focusses on LFI and not as much on learning from other indicators, organizations that are able to improve their capability to learn from incidents, may also be able to improve their capability to learn from other indicators and so to create opportunities for continuous improvement.

3.4. Conclusion on learning lessons from incidents

In Section 3, we described how lessons can be learned from events, which is a specification of the acquisition process as described by Argyris and Schön (1996). All events such as accidents, disasters or near misses provide valuable learning products, meaning information to learn from, regardless of the severity of their outcome. In order to determine options for improvement, it is important to gain an understanding of the origin of an event. Opportunities for double-loop learning are now often missed due to difficulties in the identification of organizational factors and managerial weaknesses that created the conditions for the event to occur. If only direct causes are addressed, learning is limited to single-loop learning.

4. Learning from incidents processes

The previous section described aspects in the analysis of incidents, to enable people and organizations to learn lessons from events. A traditional approach to LFI is that when the analysis is performed with care and lessons are formulated, it will lead to the prevention of incidents (Blanco, Lewko and Gillingham, 1994; van Vuuren, 1998; Kontogiannis et al., 2000). However, to successfully learn, it is important to go from identification of lessons learned, to the implementation of these lessons. Some follow-up steps are necessary, such as practical recommendations and actions that lead to effective interventions (Carroll & Fahlbruch, 2011; Lindberg et al., 2010; Le Coze, 2008; Wahlström, 2011), meaning the lessons learned need to be applied. This section describes the learning processes as described in literature.

4.1. Stepwise learning from incidents processes

Several models are described that represent LFI as a stepwise process (Drupsteen, Groeneweg, & Zwetsloot, 2013; Jacobsson, Ek, & Akselsson, 2011; Lindberg et al., 2010; van der Schaaf, 1992). These models follow similar steps and phases, the first steps of which are aimed at the process of learning lessons, as described in the previous section.

The near-miss management system as described by van der Schaaf (1992) includes seven steps. The first step is the detection of the near miss, which is followed by a selection of the most relevant near misses (step 2) and a description of these (step 3). In the fourth step, basic causes of the selected near misses are classified, meaning that lessons are identified. In the near-miss management system, the classification of the causes is followed by an interpretation step (step 5). The final steps are implementation (step 6) and evaluation (step 7) by means of an explicit feedback loop to measure the effectiveness of a measure. Steps have also been presented by Lindberg et al. (2010) in the Chain of Accident Investigation (CHAIN) model of experience feedback. This chain process as a whole fails if one of its links fails. The first step is the reporting of incidents, and at the second step, a selection of incidents for

further investigation is made, based on the reports. These steps are similar to the earliest steps in the near-miss management system (van der Schaaf, 1992). The third step is the investigation and thereafter, at the fourth step, the results are disseminated, meaning that lessons are communicated. The fifth and final step is the actual prevention of accidents (Lindberg et al., 2010). This process should also be self-reflective and include evaluation activities that lead to improvement of the process itself.

The learning from events process as described by Drupsteen et al. (2013) is more detailed and contains 13 steps, divided over five stages. The stages are similar to the steps by Lindberg et al. (2010): collecting information (1), investigation and analysis (2), planning actions (3), implementation (4) and evaluation of the actions and the learning process itself (5). In their study, they used the model to identify the differences between how steps are formally organized in organizations and how well people believe they function in daily practice.

Jacobsson et al. 2010, 2011) describe a formal incident learning system with a procedure, consisting of step-by-step instructions that handles information at all steps. The typical learning cycle, according to Jacobsson et al. (2011) includes data collection and reporting, analysis and evaluation, decisions, implementations and follow-up. This cycle is derived from the safety, health and environment information system of Kjéllen (2000). The model is used in a study to determine the effectiveness of LFI, based on the level of learning. The level of learning is expressed in terms of how broadly lessons are applied within the organization, how much organizational learning is involved and how long-lasting the effect of learning is. The results showed that the potential level of learning was considerably higher than the actual level of learning (Jacobsson et al., 2011), meaning that more use could be made out of the lessons learned.

The learning from incident models described in this section are similar stepwise processes that demonstrate two main sub-processes in LFI: determining the lessons learned, as described in the previous section, and a follow-up to these lessons. The models are summarized in Table 2.

Kletz (2008) states that improvements are possible in the follow-up steps after learning lessons. Some researchers and some organizations can apply changes too hastily, leading to wrong or superfluous interventions, such as a change in instructions instead of design. As Jacobsson et al. (2010) state, the steps in these models should be completed sequentially for learning to take place. For successful learning, the information that is handled at all steps of the learning process needs to be detailed enough and of high quality. Another issue is raised by Carroll (1998) and by Deverell (2009) who state that organizations can also over-invest in learning processes. Deverell (2009) for instance states that 'if organisations that experience a crisis engage in learning, then lessons will pertain to specific crisis procedures and structures rather than to general norms and policies'.

In contrast with the process that is known from organizational learning theory, the stepwise LFI models only focus on one type of processing and they do not address the levels of learning identified by Argyris and Schön (1979, 1996). In the theory of Argyris and Schön (1996), two main categories for the processing stage can be distinguished. On the one hand, knowledge can be used to improve work processes, conditions or behaviour. This is part of the follow-up process as described in this section. On the other hand, knowledge can be shared or diffused within the organization and help in creating new ideas for improvement (Lampel et al., 2009; Liao, Fei, & Liu, 2008; Yukl, 2009). The latter aspects are only limitedly addressed in the models describing the learning from incident processes. Some literature on sharing and storing knowledge is described in the next subsection.

4.2. Sharing lessons learned

In the CHAIN model (Lindberg et al., 2010), there is explicit attention to dissemination of lessons from an incident investigation. This dissemination can be seen as another learning process that exists next to the process of improvement. Lessons that are learned by a person or a group can be interesting or even significant for the whole organization. The lessons learned might also apply to other situations and it is important to share the information so that people know how an incident is followed up. This need is underlined by Koornneef, Hale, and van Dijk (2005). Koornneef et al. (2005) describe the importance of disseminating lessons in the

Table 2. Process Steps in Models on Learning from Incidents (Organized By Main Author)

Author	Learning lessons process				Follow-up process		
van der Schaaf (1992)	Detect	Select	Describe	Identify lessons	Interpret	Implement	Evaluate
Lindberg et al. (2010)	Report	Select	Investigate		Disseminate	Prevent	
Jacobsson et al. (2010, 2011)	Collect and report		Analyze and evaluate		Decision	Implement	Follow-up
Drupsteen et al. (2013)	Collect information		Investigate and analyze		Plan	Implement	Evaluate

specific context in which an incident occurs in order for lessons to be implemented. Lukic et al. (2010) describe a more participative approach, in which learning is embedded in social relations and knowledge is created by getting new ideas from working with others.

Communication between members in an organization and sharing information can be facilitated by formal systems, such as IT systems (Wahlström, 2011). Another possible facilitator is described by Sanne (2008), who used storytelling in his research as a way to facilitate local sharing of lessons. Telling stories about incidents and accidents enables sharing knowledge about the events and possible lessons to learn. This occurs when people are asked about their experiences and when they feel comfortable about talking with each other. Huber, Wijgerden, Witt, and Dekker (2009) conclude in their research that 'person to person safety meetings are needed to learn from other people within the organization and intranet/computer communication regarding safety should be discouraged or solely used as a complementary source of information'. Lukic, Littlejohn, and Margaryan (2012) underline this statement, and also conclude that in the organizations that they studied, employees were often not involved in the meetings in which incidents where discussed.

In some literature on learning, the overall importance of communication, meaning the general exchange of information, is mentioned. Stave and Törner (2007) emphasize that communication, including the sharing of lessons, is the foundation of everyday learning. Their research showed that poor communication of safety information affected risk awareness, and that risks that could have been detected and reflected upon were not shared (ibid.). This aligns with the statement of Pidgeon and O'Leary (2000), who in an overview of learning barriers show that communication is often poor, possibly because handling information in a constantly changing situation is very difficult.

The process in which knowledge is shared and diffused within the organization to help creating new ideas is named by Lampel et al. (2009) 'learning about events' instead of learning from events. An example is when organizations share good practices or negative experiences, to learn from each other to increase their knowledge.

To learn at an organizational level, experiences of groups and individuals need to be shared and knowledge needs to be transferred within the organization. Models for sharing and transfer of knowledge are described in organizational studies, for instance by Nonaka and Takeuchi (1995), Argote and Ingram (2000) and Bontis et al. (2002); however, in the analyzed safety literature, these knowledge transfer processes and the use of implicit knowledge for learning are overlooked.

The lessons learned also need to be stored in a collective memory or knowledge base for continuous learning (García-Morales, Lloréns-Montes, & Verdú-Jover, 2007) and for future use. Creating, combining, increasing and creating knowledge is based on earlier learning; therefore, these lessons need to be stored. In the literature on LFI, the storing of incident information and lessons learned is not addressed specifically. However, incident registration databases are one example of storing lessons, as is described for instance in papers of van der Schaaf and Kanse (2004) and by Sepeda (2006). Another example is the storing of lessons in regulations and procedures.

4.3. Conclusion on learning from incidents processes

Models from both the LFI literature and organizational learning theory support the idea that experience should lead both to lessons learned and to actions for improvement. There is, however, less attention in the LFI models for the need to share and store the lessons learned. Moreover, it is indicated that current approaches for communication between members in the organization are ineffective and that more face-to-face communication is needed.

5. Conditions for learning

In the previous sections, steps have been described that need to be taken to learn lessons from incidents and to use the outcome of these lessons for prevention. This section describes factors that are described in the literature on LFI, that create the conditions for successful completion of the learning processes.

5.1. Organizational trust

A well-known condition that influences learning is a culture in which openness and trust are valued. These are necessary values for an organization to strive for (Carroll, 1998; Naevestad, 2008; Schöbel & Manzey, 2011; Wahlström, 2011). If the aim is to learn from an event, there should be no blame for the actors involved and people need to feel comfortable to report what happened (Catino, 2008; Dekker, 2009). As Edmondson (1996) states in her research, a climate of openness can make people more willing to report and discuss errors, and learn more about the system in the process.

In a so-called 'just culture', trust and openness are key aspects. In a just culture, 'people are encouraged, even rewarded for providing essential safety-related information' (Reason, 1990). According to Eurocontrol (2006, in Catino and Patriotta, 2013): 'Within a just culture, frontline operators or others are not punished for actions, omissions or decisions taken by them that are commensurate with their experience and training. However, gross negligence, wilful violations and destructive acts are not tolerated'.

An absence of trust (and of a just culture) may lead to faulty reporting, lack of reporting, secrecy and less transparency (Hovden et al., 2011; Pidgeon & O'Leary, 2000). As Sanne (2008) encountered when undertaking ethnographic fieldwork, a sense of shame for a situation or fear of blame or social sanctions can create reluctance to report and therefore limits the information available to be learned from.

Situations in which trust is absent can be created due to political processes, power conflicts, anxiety and blame (Hovden et al., 2011; Carroll, 1998; Naevestad, 2008). Increasing trust, according to Chevreau, Wybo, and Cauchois (2006) implies several factors: that sanctions need to be separated from reporting, people need to be respected and feel that their knowledge is useful and that there is also a need for open communication through common language and shared tools. Hovden et al. (2011) mention that it is necessary that incident investigations are independent and excluded from liability and blame questions. For the follow-up, a culture valuing openness and trust is also necessary and therefore reports following an investigation should be public (ibid.).

5.2. Impact of an incident

Another factor that influences the learning process is the incident itself and the importance that is attributed to this incident by the organization or its stakeholder. Pidgeon and O'Leary (2000) state that 'the potential impact on the organization and its environment and the potential relevance of the event for an organization drives the processes and influences the magnitude and scope of subsequent learning'. Incidents with severe consequences easily gain interest from media and create external pressure (Hovden et al., 2011). Lampel et al. (2009) indicate in their research that events with a major impact clearly motivate individuals to draw lessons and make operational and cognitive adjustments. Organizations are more willing to invest in identifying the causes of events that are seen as being likely to occur (ibid.). Homsma et al. (2009) researched how organizations learn from error and concluded that only if errors result in relatively severe consequences, a more profound need for learning is perceived. In their study, there was a higher generation of new ideas and insights and a higher implementation of improvements in the week following the occurrence of the error. Findings suggest also that severe error consequences are likely to induce communication, i.e., the sharing of knowledge about errors (ibid.). Birkland (2009) states however, that especially for major events, some reports are generated too quickly and causes are not investigated in depth, but only observed. Lukic et al. (2012) present the possibility of different learning approaches, depending on how complex the identification of causes for an incident or a near miss is.

Although learning is possible from many events, there is more attention for incidents with a major impact, meaning that only a limited number of possibilities to learn from is used. Due to incorrect assumptions about the significance of events, relevant learning opportunities can also be missed, and therefore, preventive actions will be delayed or absent (Pidgeon & O'Leary, 2000).

5.3. People involved

People within organizations influence the learning processes in several ways. They notice unwanted events and therefore are the eyes and ears of an organization. If people do not believe that a specific event needs reporting because they do not know how it can be used, this event will not be learned from (Sanne, 2008). Also, in the investigation of events, interviews with people are the main source of information. Two problems arising from this are identified by Abrahamsson et al. (2010). Firstly, human memory is fallible and interviews are biased by hindsight. Secondly, as already described in 5.1, people may feel reluctant in sharing what happened. Members of an organization are also involved in performing the incident investigations and follow-up, which are essential steps in the learning process.

Recent literature on accident investigation and analysis for instance emphasizes the performance of analysis and the role of the investigators (Hovden et al., 2011; Dechy et al., 2012; Kontogiannis et al., 2000). Hovden et al. (2011) described the results of a workshop on multilevel learning, in which it was concluded that the expertise of investigators and their independence are considered the most important conditions for learning. Knowledge about the work process or the sector that is being investigated and about safety in general is preferred and one needs to be familiar with a range of investigation methods. Different experiences can be represented by different members if an investigation team is formed. Since different problems require different methods of investigation, Sklet (2004) emphasizes that in an investigation team, at least one member should have sufficient knowledge to make a choice for the proper method. Dechy et al. (2012) state that to be part of an investigation team, one needs to possess expertise either on the technique, the particular sector of industry or human reliability.

Some studies focus on who those persons are that should be involved and address the importance of involving people throughout the whole organization in the steps of the learning process (Choularton, 2001; Schöbel & Manzey, 2011; Wahlström, 2011). Examples from learning in practice by Lukic et al. (2012) do

however also conclude that involving and informing people more creates a risk for information overload.

Hovden et al. (2011) emphasized the importance of involving people affected by an incident in the follow-up when measures are developed. According to Kletz (2008), especially senior management is influential on learning since in his opinion, they often determine what actions are taken and sometimes also what incidents are investigated. He states that senior management should encourage investigations instead of just tolerating them. Carroll (1998) also concludes from his study that learning initiatives require significant management support because the managers are typically the persons that create opportunities for learning. At least to some degree, managers' attitudes and values favourable to learning support deeper levels of learning, such as double-loop learning. If the people that are informed about the lessons learned, such as managers or regulators are not capable of handling the feedback, then nothing will change. Possible reasons are for instance that they are too busy, overconfident, have fixed ways of thinking or a fear of being wrong (Carroll & Fahlbruch, 2011).

A review by Lukic et al. (2010) illustrates that not only people as individuals are relevant for learning, but that interactions and social relations between members of the organization and their environment also impacts on the organizational learning processes. Koornneef (2000) describes in his research the concept of a learning agency, containing those people who are motivated to learn, that can learn on behalf of an organization and who ensure that learning experiences become embedded in the organization. A learning agency collects lessons learned and shares these within the organization. To facilitate the learning agency in constituting an organizational memory, an organization can use bow tie models because they encompass a formalization of the knowledge on safety (Chevreau et al., 2006).

This subsection described that people within an organization play an important role in learning. To learn from incidents, both individual and collective experiences should be used, retained and shared and people at all levels of an organization need to be able and motivated to learn. People are not only involved in experiencing the situation to learn from, but also in the follow-up and embedding of lessons learned. Both the theory of Argyris and Schön and the safety literature (especially by Koornneef, 2000) use the concept of a learning agency. Argyris and Schön (1996) stated that 'a learning agent can be a dedicated person or group inside or outside the organization'(Argyris & Schön, 1996). Several years before that, Kolb (1984) described that people that act as part of a learning agency must be willing to be actively involved in the experience in order to gain genuine knowledge from it, which could mean being actively involved in the analysis and investigation of incidents. For learning from incidents, this means that the learner must be able to reflect on and analyze the experience, and must possess decision making and problem-solving skills in order to use the new insights gained from the experience.

5.4. Conclusions on conditions for learning

It is a prerequisite that incidents need to be reported for learning from them to occur. Therefore, trust and openness are necessary values within the organization. Without these values, incidents will be kept secret, investigations will focus only on a selection of factors and learning opportunities will remain unused. However, if incidents are reported, they are not necessarily used as opportunities to learn from since a selection is often made based on the consequences of the events. Although people are considered a key factor in the learning processes, only limited attention is given to their role in LFI.

6. Discussion

By reviewing the literature on learning from incidents processes and factors that influence these processes, we aimed to contribute to a more comprehensive knowledge on learning from incidents, to identify possible explanations for inefficient learning and to establish what aspects of learning from incidents need further attention in research.

The analysis of the literature showed that when learning from incidents, multiple processes are involved. The three main processes are the analysis of events, the use of lessons learned and sharing and storing information. To improve learning from incidents in companies, the activities involved in these three processes should be optimized. The results for the review also showed that there are many factors that may hinder or facilitate the learning processes and that should be taken into account when actions to improve learning are determined. Without trust, openness, and capable and motivated people, successful learning from incidents is for instance unlikely to occur.

The results also demonstrated that despite the number of papers written on the subject of learning from incidents, only limited empirical research is available on how incidents are used to learn from. Some applied studies on learning in companies are performed, but most research is theoretical. Moreover, in most studies, there does not seem to be a clear understanding of what LFI processes are. The use of knowledge from organizational learning theory might improve this understanding.

Our comparison between organizational learning and LFI studies (see also Table 3) demonstrated that aspects directly related to the learning product were much

Table 3. Summary on the Comparison of the Key Aspects in the Learning Processes

Organizational learning	Learning from incidents
Learning product	
The learning product can be any informational content, learned by either an individual or a group.	Incident and incident causes are the learning product, they are thoroughly described in the literature, see 3.1; 3.2. Section 5.2 also describes the importance of the incident impact for learning.
New knowledge	Incident analysis enables the acquisition of new knowledge – lessons learned – from incidents, see also 3.2.
Existing knowledge	An organization can learn from existing knowledge, such as safety indicators or by deliberately learning from other organizations. This is briefly addressed in 3.3.
Learning processes	
Acquiring knowledge	Incident investigation The knowledge acquisition process is described in much more detail for LFI, in comparison to organizational learning theory. New knowledge can be acquired through study of incidents: Investigation and analysis, see also 3.2
Processing: sharing or using knowledge	
Sharing knowledge	Communication and knowledge sharing are crucial for learning. In the literature sharing is mainly described as a condition for LFI, although it is also part of some of the learning processes as described in 4.1. Sharing as a separate learning process is underexposed.
Using knowledge (for improvement)	The follow-up process, where knowledge is used to improve or change is thoroughly described in Section 4.1. The literature on LFI does however not distinguish between use of knowledge in similar situations and in new situations.
Storing information	Storing information gets limited attention. It is however briefly described in Section 4.2 as part of the collective memory created through a learning agency.
Learner	Section 5.3 described the role of people involved in learning. They detect events, perform follow-up steps such as investigations and as part of a learning agency they also facilitate sharing, storing and embedding of knowledge. However, in the organizational learning theory, specific qualifications of people as part of a learning agency are described, such as active involvement, ability to reflect, decision making and problem-solving skills. Transfer from individual to group learners and vice versa is an important aspect to learn from incidents on an organizational level.

more specified in the LFI studies, i.e., the incident itself, incident causes, incident impact and incident analysis.

The results showed that follow-up processes are similar in some aspects, but the organizational learning theories give more details about the sub-processes. The reviewed literature on LFI did not distinguish between the implementation of lessons learned in similar and new situations. Applying lessons only in similar situations could prevent similar incidents (or incidents with a similar set of causes). Applying lessons in a wider setting could however address safety at a more generic level and allows for prevention of multiple incident types. Moreover, the levels of learning, single- and double-loop learning, were only marginally described in LFI literature. Double-loop learning was briefly mentioned in the section on identification of underlying causes (3.2), but the 'learning to learn' process that enables an organization to continuously improve was not discussed in the safety literature, despite its relevance for safety improvement. In the theory of Argyris and Schön, also more attention is given to the learners and to sharing and storing knowledge than in LFI studies. Storing information was not explicitly addressed in the review, but it was mentioned that it can be facilitated by the learning agency.

This comparison highlights three main issues that need further attention in research. These main issues for attention are the use and implementation of lessons learned, sharing and processing of knowledge, and the conditions for learning – specifically the role of people.

Several limitations in this study need to be acknowledged. Firstly, the review in this paper is limited by the selection of only peer-reviewed papers, whereas there are also books and other publications that cover aspects of learning from incidents. These books also cover aspects such as learning in the absence of incidents, proactive learning, preparing for incidents and so on. In our opinion, it is also possible to learn without having incidents, by using other indicators, signals and by continuous adaptation of the organization. However, if an organization is not able to learn from an incident in retrospect, it may also have difficulty with learning in general and with continuous improvement. To put it more positively, if an organization can improve LFI, it can also improve general learning, learning from risk assessments and so on.

Secondly, this analysis is limited by the frame of reference of the authors. This study focusses only on the operational processes and the cognitive dimension of learning from incidents. Other dimensions to learning are equally relevant, such as the emotional and cultural dimension that are described by Catino and Patriotta (2013). The comparison is limited to the theory of Argyris and Schön (1996), whereas also many other theories on learning and on organizational change are available.

Notwithstanding these limitations, the results of this study give a clear indication of the strengths and weaknesses in safety research on learning from incidents. Limited empirical research and limited applied research into learning from incidents is available, which can be explained by the complexity of the subject. The learning processes need to be optimized so that more incidents can be prevented. By focussing on specific aspects of the learning processes or learning conditions that impact these processes, more detailed knowledge can be obtained on how to achieve this. Specifically, the role of people in the steps of the learning processes and in sharing and processing of knowledge needs considerably more attention in safety research.

7. Conclusion

By reviewing and comparing the literature about learning at an organizational level from incidents, this paper aimed to describe the learning processes, to identify possible explanations for insufficient learning and to establish research needs.

This paper clarifies the multiple processes that are involved in LFI, and it gives possible explanations for inefficient learning from incidents. These explanations may need further attention in both research and practice.

Firstly, more use could be made of the lessons learned. Opportunities for double-loop learning are now often missed due to difficulties in the identification of organizational factors and managerial weaknesses that created the conditions for the event to occur. Also, when lessons are learned, follow-up steps to use the lessons for prevention are necessary, which are often neglected.

Secondly, there is limited attention in research for sharing and storing lessons learned in the follow-up processes after an event. Lessons are, in practice, often shared through one-way communication, for instance through email and IT systems, whereas multiple authors identify the need to discuss incidents and lessons learned in face-to-face meetings for successful learning.

Thirdly, despite their strong influence on the success (or failure) of learning, the conditions for learning get limited attention in the literature. Due to a lack of trust, people can be reluctant to report and learning opportunities can be missed. However, if incidents are reported, they are not necessarily used as opportunities to learn from since a selection is often made based on the consequences of the events. Because mainly, incidents with high impact are used to learn from, this means that a limited number of opportunities is used and also that most learning efforts take place when the pressure to identify lessons is highest. This could result in hastily written reports and overlooking of causes.

References

Abrahamsson, M., Hassel, H. and Tehler, H. (2010), 'Towards a System-Oriented Framework for Analysing and Evaluating Emergency Response', *Journal of Contingencies and Crisis Management*, Volume 18, Number 1, pp. 14–25.

Argote, L. and Ingram, P. (2000), 'Knowledge Transfer: A Basis for Competitive Advantage in Firms', *Organizational Behavior and Human Decision Processes*, Volume 82, Number 1, pp. 150–169.

Argyris, C. and Schön, D.A. (1979), *Organizational Learning: A Theory of Action Perspective*, Addison Wesley, Reading, MA.

Argyris, C. and Schön, D.A. (1996), *Organizational Learning II; Theory, Method and Practice*, Addison Wesley, Reading, MA.

Birkland, T.A. (2009), 'Disasters, Lessons Learned, and Fantasy Documents', *Journal of Contingencies and Crisis Management*, Volume 17, Number 3, pp. 146–156.

Blanco, J., Lewko, J.H. and Gillingham, D. (1994), 'Fallible Decisions in Management: Learning from Errors', *Disaster Prevention and Management*, Volume 5, pp. 5–11.

Bontis, N., Crossan, M. and Hulland, J. (2002), 'Managing an Organizational Learning System by Aligning Stocks and Flows', *Journal of Management Studies*, Volume 39, Number 4, pp. 437–469.

Candy, P. and Matthews, J. (1998), 'Fusing Learning and Work: Changing Conceptions of Workplace Learning', in Boud, D. (ed.), *Current Issues and New Agendas in Workplace Learning*, National Centre for Vocational Education Research, Adelaide, pp. 9–30.

Carroll, J.S. (1998), 'Organizational Learning Activities in High-Hazard Industries: The Logics Underlying Self-Analysis', *Journal of Management Studies*, Volume 35, Number 6, pp. 699–717.

Carroll, J.S. and Fahlbruch, B. (2011), 'The Gift of Failure: New Approaches to Analysing and Learning from Events and Near-Misses. Honoring the Contributions of Bernhard Wilpert', *Safety Science*, Volume 49, Number 1, pp. 1–4.

Catino, M. (2008), 'A Review of Literature: Individual Blame vs. Organizational Function Logics in Accident Analysis', *Journal of Contingencies and Crisis Management*, Volume 16, Number 1, pp. 53–62.

Catino, M. and Patriotta, G. (2013), 'Learning from Errors: Cognition, Emotions and Safety Culture in the Italian Air Force', *Organization Studies*, Volume 34, Number 4, pp. 437–467.

Cedergren, A. and Petersen, K. (2011), 'Prerequisites for Learning from Accident Investigations – A Cross-Country Comparison of National Accident Investigation Boards', *Safety Science*, Volume 49, Number 8–9, pp. 1238–1245.

Chevreau, F.R., Wybo, J.L. and Cauchois, D. (2006), 'Organizing Learning Processes on Risks by Using the Bow-Tie Representation', *Journal of Hazardous Materials*, Volume 130, Number 3, pp. 276–283.

Choularton, R. (2001), 'Complex Learning: Organizational Learning from Disasters', *Safety Science*, Volume 39, Number 1, pp. 61–70.

Chung, P.W.H., Broomfield, E. and Yang, S.H. (1998), 'Safety Related Questions for Computer-Controlled Plants: Derivation, Organisation and Application', *Journal of Loss Prevention in the Process Industries*, Volume 11, Number 1, pp. 397–406.

Cyert, R. and March, J.G. (1992), *A Behavioral Theory of the Firm* (2nd edn), Blackwell, Oxford.

Dechy, N., Dien, Y., Funnemark, E., Roed-Larsen, S., Stoop, J. and Valvisto, T. (2012), 'Results and Lessons Learned from the Esreda's Accident Investigation Working Group: Introducing Article to "Safety Science" Special Issue on "Industrial Events Investigation" ', *Safety Science*, Volume 50, Number 6, pp. 1380–1391.

Dekker, S.W.A. (2009), 'Just Culture: Who Gets to Draw the Line?', *Cognition, Technology and Work*, Volume 11, Number 3, pp. 177–185.

Deverell, E. (2009), 'Crises as Learning Triggers: Exploring a Conceptual Framework of Crisis-Induced Learning', *Journal of Contingencies and Crisis Management*, Volume 17, Number 3, pp. 179–188.

Deverell, E. and Hansén, D. (2009), 'Learning from Crises and Major Accidents: From Post-Crisis Fantasy Documents to Actual Learning in the Heat of Crisis', *Journal of Contingencies and Crisis Management*, Volume 17, Number 3, pp. 143–145.

Dien, Y., Llory, M. and Montmayeul, R. (2004), 'Organisational Accidents Investigation Methodology and Lessons Learned', *Journal of Hazardous Materials*, Volume 111, Number 1–3, pp. 147–153.

Drupsteen, L., Groeneweg, J. and Zwetsloot, G.I.J. (2013), 'Critical Steps in Learning from Incidents: Using Learning Potential in the Process from Reporting an Incident to Accident Prevention', *International Journal of Occupational Safety and Ergonomics*, Volume 19, Number 1, pp. 63–77.

Edmondson, A. (1996), 'Learning from Mistakes Is Easier Said Than Done: Group and Organization Influences on the Detection and Correction of Human Error', *Journal of Applied Behavioral Science*, Volume 32, Number 1, pp. 5–28.

Fahlbruch, B. and Schöbel, M. (2011), 'SOL – Safety through Organizational Learning: A Method for Event Analysis', *Safety Science*, Volume 49, Number 1, pp. 27–31.

Flood, R.L. (2009), *Rethinking the Fifth Discipline: Learning within the Unknowable*, Routledge, London.

García-Morales, V.J., Lloréns-Montes, F.J. and Verdú-Jover, A.J. (2007), 'Influence of Personal Mastery on Organizational Performance through Organizational Learning and Innovation in Large Firms and SMEs', *Technovation*, Volume 27, Number 9, pp. 547–568.

Groeneweg, J. (1998), *Controlling the Controllable: The Management of Safety*, DSWO Press, Leiden.

de Groot, A. (1969), *Methodology: Foundations of Inference and Research in the Behavioral Sciences*, Mouton & Co, Belgium.

Homsma, G.J., van Dyck, C., Gilder, D., Koopman, P.L. and Elfring, T. (2009), 'Learning from Error: The Influence of Error Incident Characteristics', *Journal of Business Research*, Volume 62, Number 1, pp. 115–122.

Hovden, J., Størseth, F. and Tinmannsvik, R.K. (2011), 'Multilevel Learning from Accidents – Case Studies in Transport', *Safety Science*, Volume 49, Number 1, pp. 98–105.

Huber, S., Wijgerden, I., Witt, A. and Dekker, S.W.A. (2009), 'Learning From Organizational Incidents: Resilience Engineering for High-Risk Process Environments', *Process Safety Progress*, Volume 28, Number 1, pp. 90–95.

Jacobsson, A., Ek, A. and Akselsson, R. (2011), 'Method for Evaluating Learning from Incidents Using the Idea of "Level of Learning" ', *Journal of Loss Prevention in the Process Industries*, Volume 24, Number 4, pp. 333–343.

Jacobsson, A., Sales, J. and Mushtaq, F. (2009), 'A Sequential Method to Identify Underlying Causes from Industrial Accidents Reported to the MARS Database', *Journal of Loss Prevention in the Process Industries*, Volume 22, Number 2, pp. 197–203.

Jacobsson, A., Sales, J. and Mushtaq, F. (2010), 'Underlying Causes and Level of Learning from Accidents Reported to the MARS Database', *Journal of Loss Prevention in the Process Industries*, Volume 23, Number 1, pp. 39–45.

Jones, S., Kirchsteiger, C. and Bjerke, W. (1999), 'The Importance of Near Miss Reporting to Further Improve Safety Performance', *Journal of Loss Prevention in the Process Industries*, Volume 12, Number 1, pp. 59–67.

Kirwan, B. (2001), 'Coping with Accelerating Socio-Technical Systems', *Safety Science*, Volume 37, Number 1, pp. 77–107.

Kjéllen, U. (2000), *Prevention of Accidents through Experience Feedback*, Taylor & Francis, London and New York.

Klein, G., Moon, B. and Hoffman, R.F. (2006), 'Making Sense of Sensemaking: A Macrocognitive Model', *IEEE Intelligent Systems*, Volume 21, Number 5, pp. 88–92.

Kletz, T. (1993), *Lessons from Disaster – How Organisations Have No Memory and Accidents Recur*, IChemE, Rugby, United Kingdom.

Kletz, T. (2001), *Learning from Accidents*, Butterworth-Heinemann, Oxford, United Kingdom.

Kletz, T.A. (2008), 'Searchlights from the Past', *Journal of Hazardous Materials*, Volume 159, Number 1, pp. 130–134.

Kolb, D.A. (1984), *Experiential Learning*, Prentice Hall, Englewood Cliffs, NJ.

Kongsvik, T., Almklov, P. and Fenstad, J. (2010), 'Organisational Safety Indicators: Some Conceptual Considerations and a Supplementary Qualitative Approach', *Safety Science*, Volume 48, Number 10, pp. 1402–1411.

Kontogiannis, T., Leopoulos, V. and Marmaras, N. (2000), 'A Comparison of Accident Analysis Techniques for Safety-Critical Man-Machine Systems', *International Journal of Industrial Ergonomics*, Volume 25, Number 4, pp. 327–347.

Koornneef, F. (2000), *Organised Learning from Small-Scale Incidents*, Delft University press, Delft.

Koornneef, F., Hale, A.R. and van Dijk, W. (2005), 'Critical Assessment of the Organisational Learning System of the Fire Service in Response to Fatal Accidents to Firemen', in K, K. (ed.), *Advances in Safety and Reliability*, Taylor & Francis Group, London, pp. 1119–1123.

Körvers, P.M.W. and Sonnemans, P.J.M. (2008), 'Accidents: A Discrepancy between Indicators and Facts!', *Safety Science*, Volume 46, Number 1, pp. 1067–1077.

Lampel, J., Shamsie, J. and Shapira, Z. (2009), 'Experiencing the Improbable: Rare Events and Organizational Learning', *Organization Science*, Volume 20, Number 5, pp. 835–845.

Le Coze, J.C. (2008), 'Disasters and Organisations: From Lessons Learnt to Theorising', *Safety Science*, Volume 46, Number 1, pp. 132–149.

Le Coze, J.C. (2013), 'What Have We Learned about Learning from Accidents? Post-Disasters Reflections', *Safety Science*, Volume 51, Number 1, pp. 441–543.

Liao, S., Fei, W. and Liu, C. (2008), 'Relationships between Knowledge Inertia, Organizational Learning and Organization Innovation', *Technovation*, Volume 28, Number 1, pp. 183–195.

Lindberg, A.K., Hansson, S.O. and Rollenhagen, C. (2010), 'Learning from Accidents – What More Do We Need to Know?', *Safety Science*, Volume 48, Number 6, pp. 714–721.

Lukic, D., Littlejohn, A. and Margaryan, A. (2012), 'A Framework for Learning from Incidents in the Workplace', *Safety Science*, Volume 50, Number 1, pp. 950–957.

Lukic, D., Margaryan, A. and Littlejohn, A. (2010), 'How Organisations Learn from Safety Incidents: A Multifaceted Problem', *Journal of Workplace Learning*, Volume 22, Number 7, pp. 428–450.

Mancini, P. (1998), 'Risky Information: Social Limits to Risk Management', *Journal of Contingencies and Crisis Management*, Volume 6, pp. 35–44.

Meerling (1980), *Methods and Techniques of Psychological Research. Part 1: Model, Observation and Decision* (in Dutch), Meppel, Boom.

Naevestad, T.O. (2008), 'Safety Cultural Preconditions for Organizational Learning in High-Risk Organizations', *Journal of Contingencies and Crisis Management*, Volume 16, Number 3, pp. 154–163.

Nonaka, I. and Takeuchi, H. (1995), *De Kenniscreërende Onderneming; Hoe Japanse Bedrijven Innovatieprocessen in Gang Zetten [The Knowledge-Creating Company; How Japanese Companies Create the Dynamics of Innovation]*, Scriptum, Schiedam.

O'Keeffe, T. (2002), 'Organizational Learning: A New Perspective', *Journal of European Industrial Training*, Volume 26, Number 2, pp. 130–141.

Pidgeon, N. and O'Leary, M. (2000), 'Man-Made Disasters: Why Technology and Organizations (Sometimes) Fail', *Safety Science*, Volume 34, Number 1–3, pp. 15–30.

Reason, J.T. (1990), *Human Error*, Cambridge University Press, Cambridge.

Sagan, S.D. (1993), *The Limits of Safety: Organizations, Accidents and Nuclear Weapons*, Princeton University Press, Princeton.

Sanne, J.M. (2008), 'Incident Reporting or Storytelling? Competing Schemes in a Safety-Critical and Hazardous Work Setting', *Safety Science*, Volume 46, Number 8, pp. 1205–1222.

Sanne, J.M. (2012), 'Learning from Adverse Events in the Nuclear Power Industry: Organizational Learning, Policy Making and Normalization', *Technology in Society*, Volume 34, Number 1, pp. 239–250.

van der Schaaf, T. (1992), *Near Miss Reporting: In the Chemical Process Industry*, Technical University, Eindhoven.

van der Schaaf, T. and Kanse, L. (2004), 'Biases in Incident Reporting Databases: An Empirical Study in the Chemical Process Industry', *Safety Science*, Volume 42, Number 1, pp. 57–67.

Schöbel, M. and Manzey, D. (2011), 'Subjective Theories of Organizing and Learning from Events', *Safety Science*, Volume 49, Number 1, pp. 47–54.

Senge, P.M. (1990), *The Fifth Discipline; the Art and Practice of the Learning Organization*, Doubleday, New York.

Sepeda, A.L. (2006), 'Lessons Learned from Process Incident Databases and the Process Safety Incident Database (PSID) Approach Sponsored by the Centre for Chemical Process Safety', *Journal of Hazardous Materials*, Volume 130, Number 1, pp. 9–14.

Sklet, S. (2004), 'Comparison of Some Selected Methods for Accident Investigation', *Journal of Hazardous Materials*, Volume 11, Number 1, pp. 29–37.

Sonnemans, P.J.M., Körvers, P.M.W. and Pasman, H.J. (2010), 'Accidents in "Normal" Operation – Can You See Them Coming?', *Journal of Loss Prevention in the Process Industries*, Volume 23, Number 2, pp. 351–366.

Stave, C. and Törner, M. (2007), 'Exploring the Organisational Preconditions for Occupational Accidents in Food Industry: A Qualitative Approach', *Safety Science*, Volume 45, Number 3, pp. 355–371.

Swanborn, P.G. (1987), *Methods of Social-Scientific Research* (in Dutch), Boom, Meppel.

Uth, H.J. (1999), 'Trends in Major Industrial Accidents in Germany', *Journal of Loss Prevention in the Process Industries*, Volume 12, Number 1, pp. 69–73.

van Vuuren, W. (1998), *Organisational Failure: An Exploratory Study in the Steel Industry and the Medical Domain*, Technische Universiteit, Eindhoven.

Wahlström, B. (2011), 'Organisational Learning – Reflections from the Nuclear Industry', *Safety Science*, Volume 49, Number 1, pp. 65–74.

Watson, B. (2002), *Rethinking Organisational Learning*. Doctorate, Faculty of Education, Education, The University of Melbourne, Melbourne.

Weick, K., Sutcliffe, K.M. and Obstfeld, D. (2005), 'Organizing and the Process of Sensemaking', *Organization Science*, Volume 16, Number 4, pp. 409–421.

Wybo, J. (2004), 'Mastering Risks of Damage and Risks of Crisis: The Role of Organisational Learning', *International Journal of Emergency Management*, Volume 2, Number 1, pp. 22–34.

Yukl, G. (2009), 'Leading Organizational Learning: Reflections on Theory and Research', *The Leadership Quarterly*, Volume 20, pp. 49–53.

International Journal of Occupational Safety and Ergonomics (*JOSE*) 2013, Vol. 19, No. 1, 63–77

Critical Steps in Learning From Incidents: Using Learning Potential in the Process From Reporting an Incident to Accident Prevention

Linda Drupsteen

TNO Work and Employment, The Netherlands

Jop Groeneweg

Leiden University, Leiden, The Netherlands
TNO Work and Employment, The Netherlands

Gerard I.J.M. Zwetsloot

TNO Work and Employment, The Netherlands
Institute of Work, Health and Organisations, Nottingham University, Nottingham, UK

Many incidents have occurred because organisations have failed to learn from lessons of the past. This means that there is room for improvement in the way organisations analyse incidents, generate measures to remedy identified weaknesses and prevent reoccurrence: the learning from incidents process. To improve that process, it is necessary to gain insight into the steps of this process and to identify factors that hinder learning (bottlenecks). This paper presents a model that enables organisations to analyse the steps in a learning from incidents process and to identify the bottlenecks. The study describes how this model is used in a survey and in 3 exploratory case studies in The Netherlands. The results show that there is limited use of learning potential, especially in the evaluation stage. To improve learning, an approach that considers all steps is necessary.

organisational learning incident survey learning potential case studies

1. INTRODUCTION

Despite all efforts, many organisations have problems in reducing the number of safety incidents. This can be partly attributed to the failure to learn from accidents [1, 2, 3, 4]. The term "incident" refers to the combined set of occurrences of both accidents and near misses [5]. It can refer to any unwanted event, including occupational or process safety incidents, or events with environmental impact. Both accidents and near misses are preceded by similar sets of failure causes and only the presence or absence of defence and recovery mechanisms determines the actual outcome (e.g., normal situation, near miss or accident) [6]. Incidents are an outcome of organisational failure causes that should have been addressed [7]. Therefore, incidents include many types of

This work was in part financed and supported by the Ministry of Social Affairs and Employment (SZW). The authors wish to thank the department of Health and Safety at Work of the Ministry for many stimulating discussions. The authors wish to acknowledge also their colleagues at TNO Work and Employment, in particular Niek Steijger, Jakko van Kampen and Ellen Bos for adding their knowledge, and for their assistance in performing this study. The authors also would like to thank the Dutch Association of Safety Professionals (NVVK) for spreading the call for participation in the survey, and they wish to thank the companies which participated in the survey and in the case studies. This paper does not necessarily reflect any position or policy of SZW.

Correspondence should be sent to Linda Drupsteen, Polarisavenue 151, 2132 JJ Hoofddorp, The Netherlands. E-mail: linda.drupsteen@tno.nl.

unwanted events, but by analysing them to identify organisational failures in preventing those incidents, valuable lessons to learn from are determined [8, 9]. Identifying the unwanted deviations and learning from them leads to safer and more reliable processes, which will result in fewer incidents [10, 11].

A traditional approach to learning from incidents is that when an analysis is performed with care and lessons are formulated, this will lead to the prevention of incidents [6, 12, 13, 14]. However, learning from incidents should not only focus on preventing recurrence, but also on making an organisation inherently safer and on improving the learning from incidents process itself. Effective learning from incidents entails follow-up steps and actions that lead to effective interventions [15, 16]. Moreover, the learning process itself should be evaluated. To improve the learning from incidents process, it is necessary to gain insight into the steps of this process and to locate any steps where learning potential is lost. This paper presents a model for the steps in the learning from incidents process and the operationalisation of these steps into a survey used to identify bottlenecks that need to be addressed to improve this process. The survey was used to analyse the learning from incident processes in Dutch organisations from a range of sectors, with the aim of answering the following research questions:

- At what step of the learning from incidents process is most learning potential lost?
- Which steps are formally organised in the organisations and which steps are not?
- How well are steps performed in daily practice?
- Are there differences in the formal organisation of the learning from incidents process and how well is the process performed in practice?
- Are there differences between sectors in the organisation and performance of the learning process?

Section 2 of this paper presents the model of the learning from incidents process and its background. The model is used to gain insight into the perception of the actual performance of the learning process (qualitative) and for the development of a survey in which the process steps are systematically analysed. Sections 3 and 4 discuss the methods and findings of the survey and the exploratory cases in which the model was applied. Sections 5 and 6 summarise the strengths and limitations, and discuss some issues for the direction of future research.

2. THE LEARNING FROM INCIDENTS PROCESS

A model of the learning from incidents process was developed; this was based on expert opinion, an overview of existing systems used by large, mainly petrochemical and petroleum companies, and a literature review. The review focused on learning from safety incidents and accidents. The model was a schematic representation of the learning process. It was translated into a survey to obtain quantitative information and enable comparisons. The model was also used to obtain qualitative information in the case studies that added in-depth information to the quantitative results. The main purpose of the model was to enable the systematic analysis of steps in the learning from incidents process and to identify bottlenecks in this learning process. A bottleneck is the step at which the process is hindered or impeded. This section introduces the model and its background. It describes the steps in the learning from incidents model and their theoretical background.

2.1. The Learning From Incidents Model

The learning from incidents process consists of 11 steps, divided into four stages: investigating and analysing incidents, planning interventions, intervening and evaluating (see Figure 1). The quality of each step depends on the drivers, methods, resources and outputs [17].

Each of the four stages leads to a result (gate) that is considered to be a vital input into the next stage in the learning process. The result is necessary, but not sufficient by itself, for an effective learning from incidents process. When the results are suboptimal or missing, the next stage is expected to be less effective. If a step is not

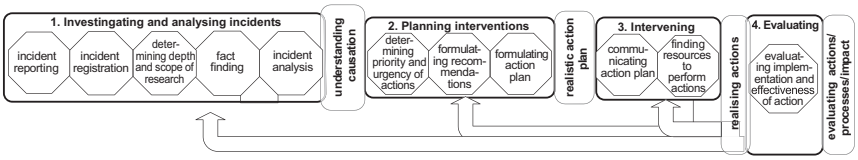

Figure 1. Model of the learning from incidents process.

performed, not performed well or relevant information is not used, this is a bottleneck in the learning process, leading to a loss of learning potential (which is the measure of what the organisation is capable of learning and doing when all relevant information is taken into account). For example, it is possible that management will still formulate recommendations even in the absence of a proper investigation. However, this will reduce the effectiveness of the overall learning process. Moreover, communication through the stages and steps is necessary. This includes feedback to earlier stages if there is a mismatch between the intended and the actual outcome for that stage.

The learning from incidents process can be compared with the plan–do–check–act (PDCA) cycle [18], in which the outcomes are part of an iterative process: a plan of action is drawn up, the actions are performed, the actions are then evaluated and, based on this evaluation, new lessons are formulated. In his last years, Deming changed the C in his cycle to S (study) [19], because, in his view, the results should be studied and causes of failure should be investigated rather than just checked. The Deming cycle is also the basis of many management system approaches (e.g., Standards No. ISO 9001:1997 [20]), ISO 14001:2004 [21] and OHSAS 18001:2007 [22] and is seen as the core of a process of continual improvement. Similar loop models for experiential learning can also be used to describe and analyse collective or organisational learning processes (e.g., Kolb [23], Senge [24], Swieringa and Wierdsma [25] and Zwetsloot and Allegro [26]).

The next sections describe stages of the learning from incidents process and their operationalisation into steps to enable a systematic analysis.

2.1.1. Stage 1: investigating and analysing incidents

Stage 1 in the learning from incidents process consists of the following steps: incident reporting, incident registration, determining the depth and scope of research, fact finding and incident analysis. The learning from incidents process requires an understanding of the causation of incidents, including underlying causes [6], and of options to prevent future recurrence. This is the vital output that any incident investigation should deliver.

Before an incident can be analysed, it is necessary for it to be reported. To enable reporting to take place, some form of reporting system is required [27, 28] and a no-blame culture should be present [29, 30]. It is also an option to learn from the incident investigations of other organisations; that is, however, beyond the scope of the research presented here.

2.1.2. Stage 2: planning interventions

The nature and quality of recommendations for the prevention of future incidents are based on the output of the incident investigation. Part of the planning process involves prioritising and selecting those options that are expected to be most effective, and identifying them as the recommendations requiring priority [31].

In stage 2, a realistic action plan is formulated. The steps in stage 2 are determining the priority and urgency of actions, formulating recommendations and formulating the action plan. Actions that are formulated based on the recommendations, and that are included in the action plan, should preferably be specific, measurable, attainable and relevant, and a specific date for commencing the intervention should be included. The

result of the planning stage is a realistic action plan, which is based on a good understanding of (underlying) causes and their remediation.

2.1.3. Stage 3: intervening

Stage 3 aims at realising the action plan, through the implementation of interventions. The steps in this stage are communicating the action plan and finding resources to perform the actions. A first requirement is that the people responsible for the actions, and those supposed to contribute to them, should be informed and have ownership of the actions [32]. Resources, especially time, money and human and technological capabilities, may be vital for performing the actions as intended. It is important that the action plan and its objectives are communicated throughout the organisation [33], especially to demonstrate a willingness to improve safety and to share the lessons learned from the investigation and planning process. The outcome of this stage should be the realisation of the actions.

2.1.4. Stage 4: evaluating

A well-known distinction in organisational learning processes is between single- and double-loop learning [34]. In single-loop learning, the basic characteristics of the situation remain constant, but the existing situation or processes are improved. In double-loop learning, the values of the theory in use are evaluated and changed [34, 35]. The evaluation stage involves both levels; that is, whether the actions are performed or not (first-order learning) should be evaluated as well as whether the actions taken were effective or not (second-order learning).

If an action is not fully realised or not fully effective, the reasons for this should be identified. These constitute the lessons from the learning from incidents process, and as such are the key to improving the learning capability of the organisation. This so-called learning to learn process (called deutero-learning by Argyris and Schön [34, 35]) is an important kind of double-loop learning. It enables an organisation to continuously improve and, in this context, system thinking and the mental models of the key actors are crucial to success [24]. The outcome of this stage is an evaluation of actions and processes, and of the impact on the organisation and, if possible, on its safety performance. Where relevant, the evaluation should lead to improvements in the other three stages.

2.2. Background

We regard the process of learning from incidents as a variation of learning by doing, or experiential learning [23]. According to Kolb, learning by experience should lead to the adaptation of "doing", and to changes in behaviour. Cognitive progress alone is thereby regarded as incomplete learning, as long as the lessons learned do not lead to changes in actual practice [23]. Piaget, who focused on learning in schools, distinguished several levels of learning, ranging from being able to reproduce certain knowledge, via being able to apply the knowledge in a similar setting to that in which it was offered, to being able to apply the knowledge adequately in other (new) settings [36]. Whether knowledge is applied and actual changes are established can only be determined if all stages of the learning from incidents process, including the evaluation stage, are performed. In this study, the survey and the cases are both used to determine whether the steps are performed. The case studies are specifically used to give meaning to the survey results. The levels of learning are used in the interpretation of these case studies.

Organisational learning theories emphasise the importance of the potential differences between what has been said or written and what is actually done. The actual performance, but also the learning, of organisations is determined with the practical activities in organisations, referred to by Argyris and Schön as theory-in-use [34]. When steps of the learning from incidents process are actually performed and put into practice, this is an illustration of the theory in use. However, managers are all too often only learning "talking and thinking", in which case they learn according to what Argyris and Schön call espoused theory [34]. For example, audits of safety management systems that focus too much on the documentation of procedures, and do not carefully

investigate the actual practice, are less effective because they address mainly the espoused theories of the organisation. The espoused theory of learning is illustrated with the formal organisation of the steps in the process, e.g., with systems and procedures. In this study, the difference between how learning is formally organised and how it is performed is analysed with the survey.

3. METHOD

This section describes the two data collection strategies that were used to gather information to help answer the research questions; these were a survey amongst safety professionals and exploratory case studies in three organisations in The Netherlands.

3.1. Survey

The analytical framework was used to develop a survey in which each of the 11 steps was made explicit (Figure 1). The survey was used to ask Dutch safety professionals which steps of the learning cycle were organised in their organisation (e.g., with procedures, rules or division of tasks), which steps of the learning cycle were, in their view, performed effectively in daily practice and which step was the most important bottleneck in the learning cycle.

Two questions in the same format were asked for all steps. There was also a blank field in which the participants could elaborate on their response. The (here translated) questions were asked in Dutch:

- Is this step formally organised in your organisation?
- How does this step work in practice in your organisation?

The first question was dichotomous (*yes*/*no*); the answers to the second one were on a 4-point scale (*bad*, *insufficient*, *sufficient*, *good*). At the end of the survey, the participants were asked to indicate in which of the 11 steps, in their view, the most important bottleneck was located in their organisation.

The results were used to analyse differences in the scores (for the different steps and stages), in the distributions, and in the espoused theory and theory in use. Sector differences and differences between large and smaller organisations were also calculated.

Based upon the scores on performance in daily practice, the learning potential curve was calculated. If all stages were 100% correctly performed, learning potential was 100%. The stages in the model were conditional (e.g., it was not possible to formulate recommendations based on an accident that had not been analysed), so learning potential could be calculated by multiplying the proportion of successive correctly performed stages.

The participants in this study were all safety professionals. They were in the position to judge both the espoused theory and the theory in use of the learning from incidents process. All members of the Dutch Society for Safety Science (NVVK), a network of safety professionals, were approached by e-mail (N = 2200). Seven sectors were selected and, in addition to the e-mail, participants from the authors' personal network for each sector were approached and asked to distribute the hyperlink of the survey within their sector and ask others to participate. A total of 649 surveys were returned, corresponding to a response rate of ~30%. Of these, 303 fully completed responses, including the final question on the main bottleneck, came from safety professionals from the seven selected sectors; and 173 of those used the blank field to elaborate on their responses. The other 346 responses, e.g., from consultants and researchers, were excluded from this analysis, because they were not linked to a specific sector.

For the analysis, the variable describing the size of the company was classified into two groups: companies with 250 or more employees, and those with 100–249 employees.

3.2. Case Studies

In three exploratory case studies, more information was gathered on the steps where learning potential was lost (the bottlenecks) and on the origins of these bottlenecks.

TABLE 1. Respondents (*N*) for Each Sector and the Size of the Company

		Employees			
Company	***N***	**<50**	**50–100**	**100–249**	**≥250**
Chemical industry	76	4	14	12	46
Construction	56	12	8	8	28
Energy and waste	42	7	4	11	20
Food industry	14	1	0	3	10
Government	23	1	3	3	16
Metal industry	68	6	6	15	41
Transportation	24	1	2	3	18
total	303	32	37	55	179

An invitation to participate was disseminated across the authors' professional network. Five companies responded and three were selected on the basis of their size and availability during the timeframe of the study. The three participating companies were organisations with 250 or more employees; each one was from a different sector (chemical industry, energy and waste, and transport).

The case studies consisted of a document study and interviews with representatives of operational employees, supervisors and top-level management.

The document study focused mainly on whether the steps were formally organised (the espoused theory). Two researchers in occupational safety (with a background in psychology and in the methodology of research), independently studied an overview or report of incidents on the location; a procedure or description of the learning from incidents process, if this was available within the organisation; documents related to two incident analyses; and evaluative or follow-up studies related to an incident. Based on their assessment of these documents, the researchers rated whether a step was formally organised or not. If the document gave no clear indication of this, this was further checked during the interviews.

The main objective of the interviews was to gather qualitative data about the organisation and how it performed the steps in daily practice. A semistructured interview format was used, based on the analytical framework. The interviews focused on how steps were organised in daily practice and on finding bottlenecks in learning. Within a company, all interviews took place on a single day, each taking 60 min. One senior manager/director, the health and safety manager, a shift supervisor and a representative of the employees at operational level were invited. A researcher who was also involved in the document study performed the interviews. There were two interviews at each company where both researchers were present; this was to provide assurance that the structure was consistent. Each interview started with a question about the most critical step from the interviewee's perspective. After this, each step was discussed briefly and one stage of the learning from incidents process was discussed in depth, based on questions from the document study and the interview itself.

After the description and analyses were complete, the cases studies were interpreted with the theories in section 2.2.

4. RESULTS

This section deals with the survey results for each research question. The results for each question will be discussed separately. Section 4.6 describes the results of the case studies. For each stage and step in the model, two variables will be presented: the quality of how it is formally organised and the quality of performance in daily practice.

4.1 Internal Consistency of the Survey

The internal consistency of the survey was tested separately for each stage with item total correlation and with Cronbach's α [37] on the items that

measured whether the stage was organised and on the items that measured whether the stage was well performed. The item-total correlation ranged from .21 to .79 for the scale on how steps were arranged, and from .61 to .76 for the scale on how steps were performed, indicating that there was no item redundancy. Cronbach's α ranged from .65 to .89. Overall, α for all items (N = 22) was .93. Cronbach's $\alpha > .70$ was indicative for a high level of internal consistency of the items; in other words, they all measured the same construct [38, 39]. Cronbach's $\alpha < .70$ might have resulted from the limited number of items in the stage (N = 2). In addition to computing α, the dimensionality of the scales was investigated with factor analysis. The eigenvalue for the first factor was quite a bit larger than the eigenvalue for the next factor for the aspects that measured whether the stage was organised (4.74 versus 1.69) as well as for those that measured whether the stage was performed (6.67 and 1.02). Additionally, the first factor explained 43% of the variance for the measures on whether stages were organised and the first factor for the measures on how well the stages were performed explained 70% of the variance, suggesting that the items are unidimensional.

4.2. In Which Step Are Main Bottlenecks Located?

The participants were asked to indicate the step with the main bottleneck for their organisation. The last step, the evaluation, was most often identified as the step with the main bottlenecks (20%) (Figure 2). In the comment field of the survey, it was indicated that if there was an evaluation, it often aimed only at establishing whether the remedy was performed or not, rather than at preventing recurrence or evaluating the quality of a remedy. The reporting of incidents was indicated in 19% of the responses as the next main bottleneck.

4.3. Which Stages Are Formally Organised?

For each stage, frequencies on whether or not the step was formally organised were collected and the mean value of how much of the stage was indicated as formally organised was calculated. Table 2 shows the proportions. Most stages were formally organised and earlier stages were more often formally organised than later ones, but the overall proportion decreased after stage 1; t tests were performed for the differences between steps.

4.3.1. Are the separate steps in the stages formally organised?

When the steps were studied separately, it turned out there was an overall decrease in the number of occasions when they were formally organised from the first to the later steps (Table 2). There were significant differences between all steps in stage 1, i.e., between incident reporting, incident registration, determining the depth and scope of research, fact finding and incident analysis.

In stage 2, there were differences between formulating recommendations and determining the priority and urgency of actions, and between formulating the action plan and communicating the action plan. There were slight, but not significant, increases in the proportions from steps 5 to 6, from incident analysis to formulating recommendations, and from steps 7 to 8, from determining the priority and urgency of actions to action.

4.3.2. Differences in the formal organisation of the learning process

Overall, there were small differences between the sectors. The decrease from stage 1 to 2 was significant for all sectors. There was also a significant decrease from stage 2 to 3 in the construction, chemical, metal and government sectors. From stage 3 to 4, there was no significant decrease in how often the stage was organised, except for the transport sector.

The scores for the separate stages also differed between the sectors. The chemical industry formally organised more stages than the other sectors, and the intervention stage in the metal industry was more often organised than that in the food industry and the government sector.

The overall distribution of frequencies in the chemical industry differed from the distribution in the energy and waste sector, the construction industry and the food industry (Kolmogorov-Smirnov, $p < .05$). There was no difference in the

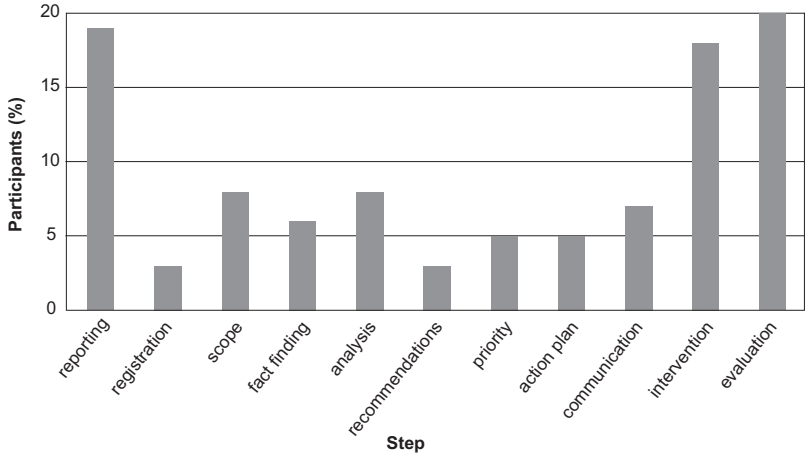

Figure 2. Step in which main bottleneck is located according to participants.

distributions between the other sectors or between the overall distribution of large and smaller organisations**.** There was also no difference in the proportion of stages that were organised between companies with under and over 250 employees. In addition to the comparison of overall distributions, a Kruskal-Wallis test was performed to compare the distribution between industries of the mean ranks over the steps. We discuss the significant differences ($p < .05$) only. The mean rank in the chemical industry for the final step evaluation was higher than in the transport industry. It was higher than in the metal industry for the incident analysis step. The chemical industry also had a higher mean rank for determining the depth and scope of research, incident analysis, formulating action plan, communicating the action plan, intervening and evaluating than the food industry. The test also illustrated that the mean rank score in the energy and waste sector was lower than in all other sectors in the formulating the action plan and communicating the action plan steps. It was lower for evaluating in the metal, chemical and construction sectors. It was also low for determining the depth and scope of research and incident analysis in comparison to transport, chemical and metal sectors. There were no significant differences between the construction, metal and transport sectors.

4.4. Are the Stages Performed Well in Daily Practice?

Scores for how well a step of the learning from incidents process was performed in daily practice were collected. The mean value of each stage was calculated and *t* tests were performed for differences between sectors and between large and small organisations. The highest possible score was 4, indicating that the safety professionals believed the performance of the step was *good* in daily practice. There was a significant decrease at all stages.

4.4.1. Are the separate steps in the stages performed in daily practice?

Results for the individual steps showed that there was a decrease from the first to the last steps in how often they were carried out. Follow-up steps (from stage 2 on) were more often neglected than the earliest steps, such as incident analysis.

4.4.2. Differences in the daily performance of the learning process

The mean value for how well stage 1 was performed was significantly higher for the chemical industry than for the other six sectors. The value for how well stage 1 was performed was significantly

TABLE 2. Formal Organisation of Steps and Stages per Sector (Proportions of Respondents)

Steps and Stages	Chemical Industry	Construc-tion	Energy and Waste	Food	Govern-ment	Metal	Trans-port	Total	*N*
1. Incident reporting	.99	1.00	.95	1.00	1.00	.97	.96	.98	294
2. Incident registration	.99	.96	.95	1.00	.96	.94	.91	.96	284
3. Determining scope	.81	.59	.49	.54	.64	.70	.76	.67	193
4. Fact finding	.90	.82	.85	.85	.91	.87	.90	.87	245
5. Analysis	.86	.70	.64	.46	.91	.68	.84	.74	209
Investigating and analysing	.91	.82	.77	.77	.89	.83	.85	.85	
6. Recommendations	.87	.69	.69	.69	.77	.77	.79	.77	215
7. Priority	.77	.61	.64	.54	.55	.65	.58	.65	182
8. Action plan	.84	.63	.46	.39	.55	.73	.74	.67	187
Planning interventions	.82	.64	.60	.54	.62	.72	.70	.70	
9. Communication	.76	.57	.49	.23	.50	.66	.68	.61	171
10. Intervention	.70	.50	.59	.39	.32	.61	.53	.57	159
Intervening	.73	.54	.54	.31	.41	.64	.61	.59	
11. Evaluation	.67	.56	.41	.31	.41	.57	.37	.53	148
Evaluating	.67	.56	.41	.31	.41	.57	.37	.53	148

Notes. Stages in italic type, steps in roman type; *N* for stages is not given, because the number of respondents per step differed.

lower in the energy and waste sectors than in the metal sector. The chemical industry had a higher mean value for stage 2 than the construction, metal, energy and waste, and government sectors. The values for stage 3 were higher for the chemical industry than for the energy and waste, government and construction sectors. There was no difference for the stages between the large and small organisations.

The results showed that most steps were performed better in the chemical industry than in the other sectors. The construction industry and the energy and waste sectors seemed to perform less well than the other sectors on some steps. There were no significant differences for the last step, evaluating.

The mean value of step 1 was significantly higher for the chemical industry than for the other sectors, except food. These differences applied to step 2, too, where the chemical industry scored higher than all other sectors. At step 3, there was no significant difference between the chemical industry and transport, but the score of the chemical industry was still higher than that of the other sectors.

4.5. Differences Between the Formally Organised Process and the Performance in Daily Practice

To compare the theory in use and the espoused values, the results for which steps were formally organised were compared with those for whether the steps were performed well in daily practice. Table 3 presents the results. Overall, there were significant differences between how well stages 1 and 4 were organised and performed. Both stages 1 and 4 were more often organised than performed well. Stages 2 and 3 appeared to work well in daily practice, even though they were not always formally organised. Figure 3 presents an overall comparison.

In stage 1 (investigating and analysing incidents), the difference between what was arranged and performed was significant for the construction, metal and government sectors. The stage was organised better than it was performed. There were no differences for stage 2 (planning interventions). And in stage 3 (intervening), the food industry's score for how well the stage was performed in daily practice was significantly higher than the score for how it was organised. Stage 4

TABLE 3. Performance of the Steps and Stages (Mean Values)

Steps and Stages	Chemical Industry	Construc-tion	Energy and Waste	Food	Govern-ment	Metal	Transport	Total
1. Incident reporting	3.4	2.7	2.8	3.0	2.7	2.9	2.8	3.0
2. Incident registration	3.5	3.0	2.9	3.2	3.1	3.3	3.1	3.2
3. Determining scope	3.2	2.6	2.6	2.7	2.8	2.8	3.0	2.8
4. Fact finding	3.2	2.7	2.7	2.8	2.8	2.8	3.1	2.9
5. Analysis	3.1	2.6	2.5	2.5	2.9	2.8	3.0	2.8
Investigating and analysing	3.3	2.7	2.6	2.8	2.9	2.9	2.9	2.9
6. Recommendations	3.2	2.6	2.6	3.0	2.8	2.7	3.0	2.8
7. Priority	3.0	2.5	2.7	3.1	2.6	2.6	2.7	2.7
8. Action plan	3.0	2.5	2.4	2.5	2.5	2.8	2.7	2.7
Planning interventions	3.1	2.5	2.6	2.9	2.6	2.7	2.8	2.8
9. Communication	2.9	2.4	2.4	2.5	2.5	2.6	2.7	2.6
10. Intervention	2.8	2.7	2.6	2.9	2.4	2.7	2.5	2.7
Intervening	2.9	2.5	2.5	2.7	2.4	2.7	2.6	2.6
11.Evaluation	2.4	2.2	2.2	2.4	2.4	2.3	2.4	2.3
Evaluating	2.4	2.2	2.2	2.4	2.4	2.3	2.4	2.3

Notes. Stages in italic type, steps in roman type.

(evaluating) was better organised than performed in the construction, metal and chemical sectors. For the energy and waste, and the transport sectors, there were no significant differences.

The learning potential curve was calculated on the basis of these findings. If all steps were 100% correctly performed, the use of learning potential was 100%. The stages in the model were conditional and learning potential was calculated by multiplying the proportion of successive stages. For example, 65% of the respondents thought the investigating stage was performed and 60% thought the planning stage was performed. The actual use of learning potential after stage 2 was,

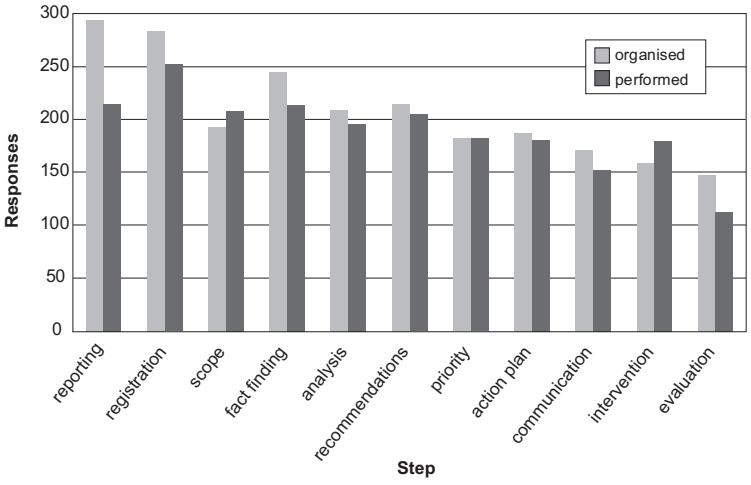

Figure 3. Overall comparison in responses per step on what is organised and what is performed well. *Notes.* $n = 303$.

therefore, 60% of 65%, i.e., 39%. Figure 4 presents the learning potential curve. It illustrates how learning potential decreased over the different stages of the model. The overall use of learning potential was under 10%.

4.6. Case Studies

In the case studies, additional information was gathered on the origins and the types of problems causing the bottlenecks identified in the survey. The case studies supported the aforementioned differences between the formal organisation of the learning from incidents process and the performance of this process. In the interviews, questions about the quality of the steps that were performed were also asked. The results indicated that learning potential was lost and improvements were possible at all stages.

The main bottlenecks in stage 1 (investigating and analysing incidents) were no incident registration, due to barriers in reporting and to the complexity of registration systems, and the quality of incident analysis. The problems that were identified were difficulties in deciding which incident to investigate in depth, and selecting the most appropriate method of investigating and analysing these incidents. Many of these problems were caused by a lack of resources such as time, finance and knowledge.

The steps in stage 2 (planning interventions), from analysis to action planning, were hardly ever separately organised or separately performed. It is assumed that the proposed actions in the participating organisations followed directly from the results of the analysis. Priorities were not usually determined for the issues that needed to be addressed.

In stage 3 (intervening), bottlenecks were identified in implementing and communicating the actions. The case studies confirmed that the implementation of lessons learned was seldom performed systematically. Although most people were willing to take action, planned actions were lost in the enormous flow of actions that resulted from incident analyses, audits and so on. Usually, there was no overview of all actions and they were not often prioritised as they were all seen as necessary. As a result, actual priorities were mainly determined by the availability of resources, such as time and money, and this often resulted in short-term actions. Actions aimed at the more complex underlying causes were often left unattended.

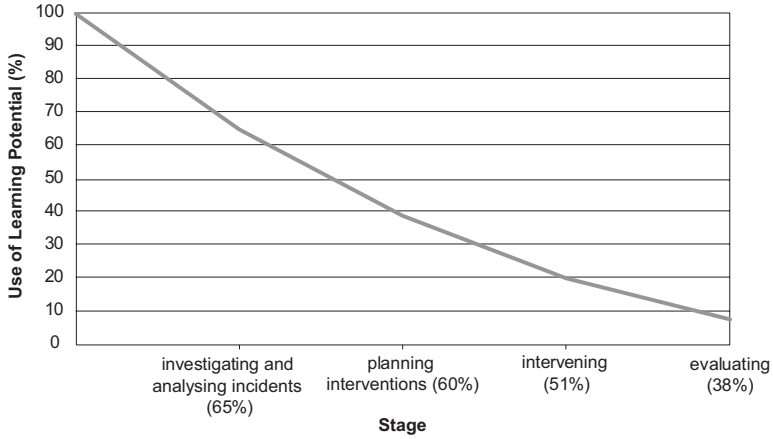

Figure 4. Use of learning potential. *Notes.* The percentages on the horizontal axis indicate the percentage of respondents that indicated that the stage was performed well in daily practice. Learning potential is calculated by multiplying the proportions of successive stages.

Other important bottlenecks in stage 3, and also in the other stages of the learning process, originated from inadequate communication. Actions were often locally performed and the actions and their reasons were hardly ever communicated throughout the organisation. Lessons learned were not implemented in similar situations in the organisation or in situations that were different but where similar (underlying) causes were relevant.

Stage 4 (evaluating) confirmed a lack of systematic evaluation. When evaluations were carried out, they often referred only to whether actions were taken or not. In the case studies, we did not identify examples where the effectiveness of the actions in preventing future incidents was evaluated. The learning process itself was also not evaluated in these organisations.

5. DISCUSSION

A model has been developed to analyse how companies with a safety management system are supposed to learn from incidents. This is used in a survey for analysing the learning from incidents process and for identifying which steps of the learning process require improvement because learning potential is being lost. It is important to note that the model is intended to be a tool for analysing the learning from incidents process only, and not a tool for designing that learning process. Used as a design tool, the model could easily lead to the proliferation of formal procedures.

The results shown in the previous sections demonstrate that there is ample room for improvement in the learning from incidents process, at all steps and stages. Context and method limit the generalisability of these results. The model has been shown to work well in identifying the main bottlenecks for Dutch organisations. It would be interesting if the results could be replicated in other countries and other sectors. Another application might be to ask employees and managers to participate in the survey to get a broader representation from the organisations. The survey results reflect the perception of safety professionals. They often play an important role in the learning from incidents process, e.g., in investigating incidents. Those results might, therefore, be somewhat biased, although the case studies confirmed them.

When this model is used in combination with qualitative data collection strategies, it indicates the types of bottlenecks and their origins. The results from these case studies illustrate that actions aimed at the more complex underlying causes are often left unattended. We assume that addressing these underlying issues requires double-loop learning. We, therefore, conclude that in our case studies, not only was learning potential for single-loop learning lost throughout the learning from incidents process, but that the more fundamental double-loop learning processes were even more scarce. The actions are also mainly locally performed and lessons are not applied in similar and other situations. When we analyse this by using the different levels of learning distinguished by Piaget [36], it can be understood as the lowest level of learning: reproducing the knowledge. To achieve a higher level of learning, it is necessary to share lessons learned more broadly and to transform the knowledge of specific situations into more general lessons.

Finally, the lack of attention to the effectiveness of the actions taken and the lack of evaluation of the learning process imply that learning opportunities are missed. Good evaluations are indispensable for improving the learning from incidents process as such and are an essential input for learning to learn processes.

The current model is aimed at learning from incidents within an organisation. To learn from other incidents, in other departments, organisations or sectors, the steps might differ, especially in stage 1. The formulation of the lessons and the ways in which they are shared will also differ. This can be considered as part of the further development of the model. To improve learning from incidents, it is essential to better understand the factors that drive the learning process or form its bottlenecks. Some factors may be rooted in the organisational culture, which is, in our model and for this research, regarded as the context wherein the learning process takes place.

6. CONCLUSION

This paper presents a model for analysing the learning from incidents process and applies it to identify critical steps and to compare how the process is formally organised with the actual performance in daily practice. The results show that learning from incidents in organisations is limited and that the proposed model enables organisations to identify bottlenecks in their learning process.

The survey showed that learning potential was especially lost at the reporting and the evaluating steps, and the latter was a critical step for the learning to learn process. When actions are evaluated, the evaluation is often aimed at the performance and not at its effectiveness. However, an approach to improve the learning from incidents process should consider the process as a whole and not only separate steps or stages. Organisations often focus mainly on improving one or two steps, such as investigating and analysing incidents. This can only marginally increase learning potential for the overall learning process, as the learning potential curve illustrates.

In all sectors, most stages are formally organised with systems and procedures. The chemical industry has arranged this more often than other industries. In all industries, there is a progressive decrease in what is formally organised through the successive stages of the learning process. This trend is also shown for the daily performance of the learning from incidents process. However, the learning from incidents process (as it is formally organised), might differ from the actual learning process (as it is performed in practice), resulting in a false sense of effective learning.

The case studies confirmed the loss of learning potential that was identified though the survey and also led to a better understanding of why companies had so many problems in learning effectively from incidents. The higher levels of learning, i.e., learning about addressing underlying causes, applying lessons learned more broadly throughout the company and managing the learning to learn process to continuously improve the learning from incidents process, were often either problematic or absent.

To allow an organisation to continuously improve and become safer, an effective learning from incidents process in which all steps function well is necessary. This process should be embedded in an organisation. This requires insight into the organisational requirements that influence the effectiveness of the process, such as organisational knowledge management and the organisational culture. Future research will, therefore, be aimed at better use of learning potential, considering the organisational context and organisational learning theories.

REFERENCES

1. Jones S, Kirchsteiger C, Bjerke W. The importance of near miss reporting to further improve safety performance. Journal of Loss Prevention in the Process Industries. 1999;12(1):59–67.
2. Kjellén U. Prevention of accidents through experience feedback. London, UK: Taylor & Francis; 2000.
3. Kletz T. Lessons from disaster—how organisations have no memory and accidents recur. Rugby, Warwickshire, UK: Institution of Chemical Engineers; 1993.
4. Kletz T. Learning from accidents. 3rd ed. Oxford, UK: Butterworth-Heinemann; 2001.
5. van der Schaaf TW. Near miss reporting in the chemical process industry [doctoral dissertation]. Eindhoven, The Netherlands: Eindhoven University of Technology; 1992. Retrieved December 14, 2012, from: http://alexandria.tue.nl/extra3/proefschrift/PRF8B/9205360.pdf.
6. van Vuuren W. Organisational failure: an exploratory study in the steel industry and the medical domain [doctoral dissertation]. Eindhoven, The Netherlands: Eindhoven University of Technology; 1998. Retrieved December 14, 2012, from: http://alexandria.tue.nl/extra3/proefschrift/boeken/9800441.pdf.
7. Reason J. Managing the risks of organizational accidents. Aldershot, UK: Ashgate; 1997.

8. Carpenter JK, Hendershot DC, Watts SJ. Learning from reactive chemistry incidents. Chem Health Saf. 2004;11(4):10–6.
9. Carroll JS. Organisational learning activities in high-hazard industries: the logics underlying self-analysis. Journal of Management Studies. 1998;35(6):797–822.
10. Groeneweg J. Controlling the controllable: the management of business upsets. 5th ed. Leiden, The Netherlands: DSWO Press; 2002.
11. Reason JT. Human error. Cambridge, UK: Cambridge University Press; 1990.
12. Blanco J, Lewko JH, Gillingham D. Fallible decisions in management: learning from errors. Disaster Prev Manag. 1994; 5(2):5–11.
13. Kontogiannis T, Leopoulos V, Marmaras N. A comparison of accident analysis techniques for safety-critical man-machine systems. Int J Ind Ergon. 2000;25(4): 327–47.
14. Lawton R, Parker D. Barriers to incident reporting in a healthcare system. Qua Saf health care. 2002;11(1):15–8. Retrieved December 14, 2012, from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1743585/.
15. Le Coze JC. Organisations and disasters: from lessons learnt to theorising. Saf Sci. 2008;46(1):132–49.
16. Lindberg AK. Hansson SO, Rollenhagen C. Learning from accidents—what more do we need to know? Saf Sci. 2010;48(6): 714–21.
17. Baguley P. Improving organizational performance: a handbook for managers. London, UK: McGraw-Hill; 1994.
18. Deming WE. Out of the crisis; quality, productivity and competitive position. Cambridge, MA, USA: Cambridge University Press; 1982.
19. Deming WE. The new economics for industry, government, education. Cambridge, MA, USA: MIT Center for Advanced Engineering Study; 1993.
20. International Organization for Standardization (ISO). Quality systems—model for quality assurance in design, development, production, installation and servicing (Standard No. ISO 9001:1997). Geneva, Switzerland: ISO; 1997.
21. International Organization for Standardization (ISO). Environmental management systems—requirements with guidance for use (Standard No. ISO 14001:2004). Geneva, Switzerland: ISO; 2004.
22. OHSAS Project Group. Occupational health and safety management systems—requirements (Standard No. OHSAS 18001:2007). London, UK: OHSAS Project Group; 2007.
23. Kolb DA. Experiential learning. Upper Saddle River, NJ, USA: Prentice Hall; 1984.
24. Senge PM. The fifth discipline; the art and practice of the learning organization. New York, NY, USA: Doubleday; 1990.
25. Swieringa J, Wierdsma A. Becoming a learning organization. Harlow, UK: Longman; 1992.
26. Zwetsloot GIJM, Allegro JT. Organisatieverandering door managementsystemen voor voortdurende verbetering [Organisational change through management systems for continuous improvement]. Gedrag en organisatie. 1994;7(6):352–365.
27. Armitage G, Newell R, Wright J. Reporting drug errors in a British acute hospital trust. Clinical Governance. 2007;12(2):102–14.
28. Thornton PD, D'Souza DC, Ng K, Koller LJ. Reporting, review and application of near-miss prescribing medication incident data. Journal of Pharmacy Practice and Research. 2004;34(3):190–3.
29. Firth-Cozens J. Organisational trust: the keystone to patient safety. Qual Saf Health Care. 2004;13(1):56–61. Retrieved December 14, 2012, from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1758064/pdf/v013p00056.pdf
30. Hopkins A. A corporate dilemma: to be a learning organisation or to minimise liability. Journal of Occupational Health and Safety: Australia and New Zealand. 2006;22(3):251–9.
31. Bhimavarapu KR, Doerr WW. A semi-quantitative risk assessment methodology to prioritize recommendations. Process Safety Progress. 2009;28(4):356–61.

32. Barret JH, Haslam RA, Lee KG, Ellis MJ. Assessing attitudes and beliefs using the stage of change paradigm—case study of health and safety appraisal within a manufacturing company. Int J Ind Ergon. 2005;35(10):871–87.
33. Bahn S. Power and influence: examining the communication pathways that impact on safety in the workplace. Journal of Occupational Health and Safety: Australia and New Zealand. 2009;25(3):213–22.
34. Argyris C, Schön DA. Organizational learning: a theory of action perspective. Reading, MA, USA: Addison-Wesley; 1978.
35. Argyris C, Schön DA. Organizational learning II: theory, method and practice. Reading, MA, USA: Addison-Wesley; 1996.
36. Piaget J. The mechanisms of perception. London, UK: Rutledge & Kegan Paul; 1969.
37. Cronbach LJ. Coefficient alpha and the internal structure of tests. Psychometrika. 1951;16(3):297–334.
38. DeVellis RF. Scale development. 2nd ed. Thousand Oaks, CA, USA: Sage; 2003.
39. Nunnally JC, Bernstein IH. Psychometric theory. 3rd ed. New York, NY, USA: McGraw-Hill; 1994.

Accident Analysis and Prevention 72 (2014) 351–358

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Why do organizations not learn from incidents? Bottlenecks, causes and conditions for a failure to effectively learn

Linda Drupsteen[a,b,*], Peter Hasle[b]

[a] TNO, Schipholweg 77-89, Leiden, The Netherlands
[b] Centre for Industrial Production, Department of Business and Management, Aalborg University Copenhagen, A.C. Meyers Vænge 15, 2450 Copenhagen SV, Denmark

ARTICLE INFO

Article history:
Received 14 January 2014
Received in revised form 12 June 2014
Accepted 23 July 2014

Keywords:
Organization
Safety
'Failure to learn'
Causes
Cases
Accident

ABSTRACT

If organizations would be able to learn more effectively from incidents that occurred in the past, future incidents and consequential injury or damage can be prevented. To improve learning from incidents, this study aimed to identify limiting factors, i.e. the causes of the failure to effectively learn. In seven organizations focus groups were held to discuss factors that according to employees contributed to the failure to learn. By use of a model of the learning from incidents process, the steps, where difficulties for learning arose, became visible, and the causes for these difficulties could be studied.

Difficulties were identified in multiple steps of the learning process, but most difficulties became visible when *planning actions*, which is the phase that bridges the gap from incident investigation to actions for improvement. The main causes for learning difficulties, which were identified by the participants in this study, were tightly related to the learning process, but some indirect causes – or conditions – such as lack of ownership and limitations in expertise were also mentioned.

The results illustrate that there are two types of causes for the failure to effectively learn: *direct causes* and *indirect causes*, here called *conditions*. By actively and systematically studying learning, more conditions might be identified and indicators for a successful learning process may be determined. Studying the learning process does, however, require a shift from learning from incidents to learning to learn.

1. Introduction

"Every day, 6300 people die as a result of occupational accidents or work-related diseases" states the International Labour Organization ILO on their website (ILO, 2013). They also state that this means that "every 15 seconds, somewhere around the world a worker dies from a work-related accident or disease" (ILO, 2013). Employers have a legislative responsibility to look after the health of workers and many employers also want to prevent injury or loss. Therefore employers put effort into the prevention of accidents and incidents (such as near-misses). Besides the prevention of personal injury, employers also aim to prevent material damage and process disturbances. In recent years, both researchers and practitioners have become increasingly interested in "learning from incidents" as a strategy to prevent incidents and accidents. Learning from incidents involves both the analysis of incidents and a follow-up on this analysis (Drupsteen and Guldenmund, 2014).

In the analysis of incidents, causes that led to the incident are identified. A well-known distinction in the causes of incidents is the distinction between active failures–or direct causes- and latent conditions (Reason, 1990; Groeneweg, 2002). Active failures are the activities that directly contribute to the emergence of an incident, such as human errors. Latent conditions are the weaknesses in the organization that contribute to the situation in which an accident could occur. For the prevention of accidents, both active failures and latent conditions in the organization need to be addressed. Many ways to identify these failures and conditions are described in the safety literature (e.g. by Kontogiannis et al., 2000; Reinach and Viale, 2006; Sklet, 2004; Le Coze, 2008).

For successful learning, the analysis of an incident should be followed by remedial actions that address the identified causes. This follow-up is necessary for the prevention of future incidents (Lindberg et al., 2010; Jacobsson et al., 2011), because if the causes are addressed effectively, they cannot lead to repetition of similar incidents. Effective learning from incidents is therefore also part of the safety management system. Despite the attention for

* Corresponding author at: TNO, Safe and Healthy Business, Schipholweg 77-89, 2316 ZL Leiden, The Netherlands. Tel.: +31 888665182.
E-mail address: linda.drupsteen@tno.nl (L. Drupsteen).

http://dx.doi.org/10.1016/j.aap.2014.07.027
0001-4575/

learning from incidents as a strategy to prevent incidents and accidents, many organizations fail to effectively learn from incidents (Drupsteen et al., 2013).

Some reasons why organizations fail to learn effectively from incidents are considered in earlier studies (e.g. Pidgeon and O'Leary, 2000; Choularton, 2001; Lampel et al., 2009; Hovden et al., 2011). According to these studies, causes why organizations don't learn are for instance: too little incidents are reported (Mancini, 1998; Sanne, 2008; Rasmussen et al., 2013), too little information about the incident is given (Sanne, 2008), latent conditions are not identified (Jacobsson et al., 2009; Körvers and Sonnemans, 2008) or the implementation of remedial actions was impeded (Cedergren, 2013). These causes directly contribute to a failure to effectively learn, just like active failures directly contribute to the emergence of an incident. Conditions that hinder learning from incidents have also been studied, such as a lack of trust (Pidgeon and O'Leary, 2000; Chevreau et al., 2006), a blame culture (Dekker, 2009), a limitation in the competences of the people involved (Hovden et al., 2011) or resistance to change (Lundberg et al., 2012). Especially trust and openness are considered to be necessary values within an organization. Without these values, incidents will be kept secret, investigations will focus only on a selection of factors, and learning opportunities will remain unused.

Although these studies highlighted several causes for a failure to effectively learn from incidents from a theoretical perspective, there are not many studies that systematically investigated why organizations fail to learn in practice. In this study we aim to identify causes for the 'failure to learn' in seven organizations. The objective of this paper is to determine what causes and conditions need to be addressed to improve learning from incidents and so to contribute to the prevention of incidents.

2. Theory

The aim of this study is to identify causes and conditions that contribute to problems in the learning from incidents process. An incident is in this study defined as any unwanted event, irrespective of its consequences. This definition encompasses accidents, near-misses, operational disturbances, errors etc. The main difference between these events is whether they led to damage or injury, or not. In our opinion, all those events are preceded by similar causes and conditions. Therefore, although these events require different responses after they occur, they all provide similar lessons to learn from.

Before explaining how we studied the learning from incidents process, we will briefly discuss the theories that are used in the development of this study. As was pointed out in the introduction to this paper we use the concepts of direct factors and indirect factors to study the failure to effectively learn. This concept is known from accident causation theory where Reason (1990, 1997) introduced the active failures and latent failures as factors that contribute to an accident. Latent failures create sub-optimal conditions in an organization and are the real target for improvement in order to control the environment (Groeneweg, 2002). Other commonly used terms that describe the causes that are not directly linked to the accident, are indirect causes, root causes or underlying causes. The systemic latent failures may lie dormant for years before they align with the active failures, meaning the operational 'direct' failures, and contribute to an incident (Reason, 1997). In this study we use the term causes to describe the factors that directly contribute to negative events, and the term conditions to describe the factors and issues that indirectly contribute to negative events.

Some theorists argue that traditional models of accident causation, such as that of Reason, are not able to capture the dynamics of the real world (Hollnagel et al., 2006; Leveson, 2004; Rasmussen, 1997). They have presented systemic models that focus on the complexity and interactions that may lead to accidents. Two well-known systemic modeling approaches are Rasmussen's hierarchical sociotechnical framework (1997) and Leveson's (2004) Systems-Theoretic Accident Model and Processes model: STAMP. Despite the differences, these models also emphasize that the weaknesses in the organization or system allow actions (causes) on an operational level to result in an accident. These weaknesses (conditions) are the issues that we aim to identify through studying incidents, and in this case through studying learning from incidents.

The distinction between causes and conditions relates to the concept of single and double loop learning as developed by Argyris and Schön (1979). Addressing the conditions that contributed to an incident, is important for so-called double loop learning. If an organization exhibits single loop learning, only the specific situation or processes are improved. However, when an organization exhibits double loop learning, improvements are not limited to the specific situation but the values, assumptions and policies that led to actions in the first place, are questioned (Argyris and Schön, 1979). If only the direct cause of an incident is addressed, this relates to single loop learning. In practice, this would mean that recurrence of a specific situation is prevented, whereas if the conditions that contributed to an incident are addressed, this is likely to increase safety in general, and so to prevent multiple future incidents.

In this study, we applied the distinction between direct and indirect factors to explain difficulties in the learning from incidents process itself. This means that instead of identifying causes and conditions that contributed to an incident, this study focuses on the learning process itself. By identifying and addressing conditions for learning from incidents, the learning capability of the organization can be improved. This learning to learn process (called Deutero learning by Argyris and Schön, 1996) enables an organization to continually improve (Senge, 1990). Building on Argyris and Schön (1979), learning from incidents therefore encompasses both the study of incidents to identify weaknesses, and addressing those weaknesses (single loop learning), and in a similar way, learning to learn from incidents encompasses both studying the learning process to identify weaknesses, and addressing these weaknesses. Addressing weaknesses that are identified through studying incidents is likely to prevent future incidents and so contribute to safety, and addressing weaknesses that are identified through studying the learning process, is likely to prevent failure to learn, i.e. it will contribute to safety, through increased learning capability.

To study the causes and conditions that contribute to a failure to learn from incidents, we used a simplified model of a learning from incidents process, that is described in an earlier study (Drupsteen et al., 2012). In the model of the learning from incidents process, learning is represented as a process with five phases (Drupsteen et al., 2012): acquiring information, investigation and analysis, planning interventions, intervening and evaluating. The first phase, *acquiring information*, consists of reporting and registration of incidents. In some organizations this includes only the registration of accidents, in others also near-misses, dangerous situations or process deviations are registered to learn from. In the second phase of the learning process, *investigation and analysis*, lessons are identified. In this phase, a first prioritization of incidents is made, because some are investigated and others are not. This phase also includes choices on the method of investigation and the people to involve in the investigation process. In the third phase, *planning*, identified lessons are translated into actions. In this phase choices are made on what causes to address, how to address them, which resources to allocate and when to perform actions. The fourth phase, *intervening*, consists of performing and monitoring actions, to see if they are performed as planned. In the fifth phase, *evaluating*, both the effect of the actions, and the learning process itself are evaluated. In each phase, the learning

from incidents process can be affected, if an activity is not performed or not performed well. This activity or step in the process is called a bottleneck, meaning "a step at which the learning process is hindered or impeded" (Drupsteen et al., 2013). If the step is hindered or impeded this does not necessarily mean that there is a full stop to learning, the learning process can continue despite limitations in a certain step. The quality and success of the learning process will however be limited through the bottleneck (Drupsteen et al., 2013). In this study, the effectiveness of learning is determined according to the learning from incidents process. If one or more of the phases are not effectively performed, learning will be ineffective, meaning that there was a 'failure to learn'.

3. Methods

In focus groups in seven organizations we studied learning from incidents and causes and conditions for ineffective (or effective) learning. We used the model of the learning from incidents process in the analysis of the focus group results to answer the following questions:

- In what steps are difficulties to learning identified (bottlenecks)?
- What are the causes and conditions for the difficulties in learning from incidents?

The use of focus groups allows for multiple perspectives in one session and the group interaction serves as a mechanism to help people generate ideas and discuss more causes for ineffective learning. Therefore focus groups were held in seven organizations to get a shared understanding of the causes for ineffective learning from incidents. In addition, in three of these organizations the focus group also discussed how they had learned from specific incidents (Company E, F, G).

The participating companies were: four chemical companies (one with more than 1000 employees, one with approximately 350 employees, two with approximately 250 employees), a manufacturing company (approximately 800 employees), a service provider company on a chemical plant, and a construction company. The service provider and construction company had varying numbers of people working for them, since they work with many subcontractors.

In each organization a focus group session was held with about 10 participants. The Health and Safety manager invited the participants for each focus group. The composition of the focus groups was agreed between the Health and Safety manager and the researchers. The point of departure was to invite operators from a single department and a first line manager. Having both a first line manager and the operators in the same group may have influenced the willingness to be critical. However, it was the clear impression that all participants quite openly expressed their view, and as seen in the results later, none of the participants tried to paint a particularly favorable picture of learning from incidents in the organization. The exception was Company E where the Health and Safety managers considered it necessary to split the focus group in two with operators and managers, respectively.

Before the focus group a list of incidents of the past year was retrieved to gain an overview of the type and number of incidents and the amount of background information for each incident. In the focus groups, first the general learning from incidents process was discussed by asking: how well does your organization learn? And why? In which step do main problems arise? What are the main reasons that a phase is well performed or not? How do you think learning from incidents in this organization can be improved? A topic list was used by the researchers to check whether human, technical and organizational aspects were all addressed. If specific factors or conditions were mentioned, it was verified whether these were related to specific phases in the learning process or not. In three companies (E, F and G), this discussion was followed by a brief presentation of a specific incident. The incidents were selected beforehand by the researchers, together with the Health and Safety manager. Three criteria were used for the selection: the incident should be recent, non-threatening, and recognizable. The questions to the focus group for each case were semi-structured, with as main questions: "Did the organization learn from this incident?" "Could a similar incident happen again?" "Who or what solved the situation and why?" "What can be improved even more?" The same topic list was used as for the general learning questions.

The notes from each focus group were summarized in a report that was checked by the Health and Safety manager. The reports are used for the analysis in this study. These reports were analyzed to assess for each company what the bottlenecks were, i.e. the step in which difficulties arose, and what the causes and conditions where for ineffective learning, according to the participants in the focus groups.

4. Results

4.1. Company A

This company is a production company in the chemical industry, which employs about 1500 people. In the focus group, thirteen participants were present: eleven employees from two teams, the HSE manager and the site manager. According to the participants, the organization learned well from incidents, because employees received many newsletters and reports about incidents and lessons learned. They indicated, however, also that improvements were possible in the third phase of the learning process, specifically in 'planning *good* actions', meaning the translation from identified causes to recommendations. Although the participants only mentioned the third phase of the learning process as a bottleneck, difficulties that were related to other phases (phases two and four) were also mentioned. Factors that contributed to the difficulties in learning according to the participants were: time limitations, a technical focus, a lack of ownership and perceived control over actions to be taken.

The participants indicated that the motivation and the time to take up actions were limited in this organization. When generating actions, the employees felt that some good solutions were not thought of, because there was too limited time to think it through and there was no systematic approach for the decision on what actions to take or not. There were not many serious incidents, therefore the sense of urgency to learn from incidents had decreased over the past years and so did the motivation to perform actions. Another condition that became clear from the discussion was that most employees in the organization had a technical background, which resulted in a focus on technical issues in the incident analysis and in a focus on technical actions for improvement. Human and organizational issues were rarely addressed.

Many of the recommendations formulated after incidents were seen as uncontrollable, because action should be taken on a site level or even on a global company level. This is related to a similar finding: it was not clear for the focus group who should take the actions that resulted from the recommendations. Employees considered the management to be responsible for taking actions. At the same time they considered the managers as outsiders with too limited involvement and knowledge on the core processes, and therefore too limited knowledge to determine the right actions. At the same time, the employees did not feel inclined to raise ideas for improvement, because they felt they would be made

responsible for such actions and the responsibility for the actions would involve much extra work.

4.2. Company B

This company is an industrial service provider that works as a contractor in the oil and gas industry. Ten people were present in the focus group: the HSE manager, a safety representative, two foreman, five workers and one (sub)contractor. According to the participants, the organization insufficiently learned from incidents. The main bottleneck was located in the first phase of the learning process, because there was a limitation in the number of incident reports. There were very few reports, and the participants agreed that the incidents that were reported, did not give a good overview of the risks on site.

There were practical and cultural reasons for the limited number of reports. Reporting cost a lot of time and the employees did not know how to justify that time to their client. They felt that every minute counted, and any delay would be used against them. For a similar reason they didn't want to ruin the current low accident rate, because it was part of their image as good contractor. Other reasons not to report were related to the group culture. The employees felt that only losers reported and that there was no need to report: you could just fix most situations yourself and they didn't feel that anything else was done with the reports.

4.3. Company C

This chemical manufacturing company has approximately 800 employees. Five employees from the HSE department participated in the focus group. The HSE department was considered to be the key stakeholder with respect to learning from incidents. According to the participants, the main difficulties in learning from incidents in their organization were located in the first and in the third phase of the learning process: in 'reporting incidents' and in 'planning actions', specifically in the generation of recommendations.

Difficulties in reporting were for instance caused by the fact that is wasn't always clear whether a situation was dangerous or not and that this interpretation differed between function groups such as engineers or operators. Another reason for the limited number of incident reports, was the fact that there were many successful 'recovery mechanisms', meaning that operators were often able to correct errors or dangerous situations, so that negative consequences were prevented. These successful mechanisms could provide valuable lessons to learn from, if they would have been reported.

There were also difficulties identified when planning actions for improvement, after an incident occurred. There was often not time for a thorough analysis and for a structural follow-up of the recommendations, because already a couple of days after the event, a report for the management should be ready, including recommendations and possible actions. When the HSE formulated actions, they often focused on technical and mitigating actions because they had a blind spot for human and cultural issues. In combination with the time pressure this meant that although actions were often performed fast, structural measures for prevention were not taken.

4.4. Company D

This construction company was hired as the contractor for a long-term utility building project. Since the amount of work activities and the needed number of people, it is difficult to estimate the number of employees, which could range from 75 to 500. The holding company employs more than 1500 people. This focus group was performed with a group of nine people as a representation of the specific project: one HSE manager and the project HSE expert, a site manager a, project planner, the project director and four contractors. According to the participants, the main difficulties for learning in their organization were found in the second and third phase of the learning from incident process: 'incident investigation' and in 'planning actions'. Some difficulties related to the first phase were also mentioned. An important factor in creating these difficulties was the fact that every incident was considered to be unique and unpreventable and therefore many incidents were not recognized as incidents to learn from. There were no objective selection criteria to distinguish between accidents that should be or should not be investigated in depth, and all incidents were perceived similarly: as consequences of human error. In the incident investigation there was a strong focus on direct causes and on the human error, and not on the context in which an error occurred and on the reasons for certain behavior. As a result, structural measures for improvement were not taken and follow-up actions mainly consisted of reminders of existing rules and procedures. If a new action was planned, there was limited integration with other actions and the actions were not performed, because employees didn't feel it would have changed the situation: 'it was stupid behavior'.

4.5. Company E

Organization E is an oil and gas company with about 350 employees in The Netherlands. The Health and Safety manager explained that due to recent incidents, the organization realized the need to learn. There was a recurrence of incidents that could potentially have had large consequences. Because openness was considered to be an issue in this organization, two separate sequential focus groups were held: one group with the operators (five participants) and one group with nine representatives of the management departments: quality, health, safety and environment (5), site management (2) and engineering (2). Both groups agreed that the organization insufficiently learned from incidents. According to the participants in both groups, the main issues in learning were related to the third phase in the learning process: 'planning actions', specifically in determining what were the right actions for improvement. The group with managers and engineers indicated that there was also a bottleneck in the first phase, because 'getting an overview of incidents' was an issue that hindered learning. Issues related to the fourth phase were also mentioned in both focus groups.

There were multiple factors mentioned that created the difficulties in the learning process. The difficulty in gaining an overview was for instance caused by the multitude of systems from which information could be retrieved. Environmental safety, personal safety and process safety were each registered separately and this caused a lot of work when aiming to get an overview of safety incidents. To get this overview, and to read the reports, more time was needed than was available. Another cause was that, according to the group of managers and engineers, the operators were reluctant to report. The reports that were received were of limited quality, because insufficient time and effort was put into writing the report.

Difficulties in generating the right actions for improvement were partly caused by the lack of overview of incidents. Both groups mentioned the difficulties in the follow-up of incidents as the main cause for insufficient learning. The difficulties were for instance caused by: too many causes to address, too many recommendations, and there was not enough time to perform the actions. After an incident there was often an immediate solution, the 'quick fix'. After the quick fix, people got back to normal day to day work, and as one participant stated 'the quick fix often turns out to be the permanent solution'. Issues were therefore not systematically and structurally addressed.

Another issue for the follow-up was that people in this organization often transferred – or pushed off – tasks to colleagues. One

task that was often transferred to the next shift, was the reporting of incidents. Reporting incidents takes time and did not get any priority, because employees did not receive feedback after reporting. Employees felt that they didn't have time to register reports, take up extra work, or to read new procedures. Solutions that were proposed by the management after incidents were by employees considered as a burden, that even further limited their effective working time. In their view, actions were often implemented top down, without taking into account consequences for the work processes.

The incident case that was discussed in this focus group illustrated difficulties in planning actions. The incident was the result of a well-known risk, because similar incidents (with limited consequences) were reported weekly. The risk was inherent to the current work process (it had to do with pressure in the conduits), and the risk could only be avoided with a different technical design or with a different work approach. However, the trade-off between operations and safety and maintenance was a topic of ongoing discussion. In this case, the costs for change of work processes were considered too high by the management and therefore actions were limited to mitigation of the consequences with a quick fix. The employees had little understanding for this fix; they considered it to be a decision of a manager without knowledge of the work process, since they felt many other possible solutions were available.

4.6. Company F

Organization F is a chemical company with a production site in the Netherlands with approximately 250 employees and about 50 contractors a day. The focus group consisted of seven persons: an environmental engineer, a process operator, a coordinator process safety management, a shift leader, a senior operator, a team leader operations and a coordinator QHSE. This organization learned quite well according to the participants in the focus groups, but there was also room for improvement. The main bottlenecks pointed out to be located in phases two and three, due to difficulties in 'selecting what incidents to investigate' and in 'determining what actions to take'.

There were many reports in this organization, because accidents, incidents, near misses and dangerous situations were often reported. Reporting was sometimes used by employees if they wanted things changed or to get attention for a specific issue. Because there were large numbers of reports, difficulties arose in the selection of events that should be investigated. There was not sufficient time to read and investigate all reports and a systematic investigation of incidents was seldom performed. The focus group stated that steps from analysis to planning of actions were neglected, meaning that the investigation was often stopped too early to have identified all causes, and the selection of recommendations was done based on 'expert opinion' of the investigator. This resulted in a strong focus on technical actions. Moreover, resulting actions were not always performed, due to time pressure and difficulties in prioritization of tasks.

The first incident case that was discussed in this organization illustrated the difficulties that arose due to the large number of reports. The incident report was not recognized as relevant to investigate in further detail. As a result of a successful campaign to increase the number of reports there were so many reports that the QHSE manager was not able to read all reports on a short notice. Moreover, there were no criteria to select relevant reports, so he made a quick scan of the reports based on the title of the report, which was given by the employee who reported the incident. Since this specific incident had a very common title, it was not recognized as an event that required further attention, meaning that it was not investigated and there were no lessons learned.

The second case illustrated difficulties that were not discussed in the general part of the focus group. The incident was reported, analyzed and actions for improvement were determined, but the actions were not performed in time. A similar incident happened, that could have been prevented if the planned actions would have been performed in time. However, the causes for the delay were similar to those that were mentioned in the general part of the focus group: there were too many actions and too little budget, and there was no prioritization in actions. Another cause that was mentioned was that there was no ownership, meaning that nobody felt responsible for performing the actions.

4.7. Company G

Company G is an organization with approximately 350 employees that produces chemicals. Six persons participated in the focus group: two operational managers of different departments, a maintenance coordinator, a team coach, an assistant team coach and a HSE engineer. According to the participants in the focus group, bottlenecks for learning in this organization were located in phases one, two, three *and* four. The main reasons for a failure to learn effectively were 'insufficient reports', 'quality of the accident investigation' and 'performance of actions'.

Multiple factors that created these difficulties in the learning process were mentioned. Employees were for instance reluctant to report incidents, because they felt that by reporting they were saddling themselves up with extra tasks. The reporting employee was often asked to follow-up on the report. The employees carefully considered the doubts and benefits related to reporting: what can it do for me and for the team, what does the organization want me to report and what are the consequences of reporting? Some employees found it confusing that the organization wanted as much reports as possible, but at the same time, the incident frequency was supposed to be zero. The reluctance to report was strengthened because there was no feedback on given reports.

The quality of accident investigation was considered to be insufficient, because the investigators did not have the knowledge and experience to carry out root cause analyses. The quality was also limited because the investigators were afraid to include human factors, for a fear to blame colleagues. The lack of knowledge and fear to include all factors resulted in investigations in which underlying issues were not addressed.

In the focus group also multiple causes were discussed that hindered a successful performance of follow up actions. Most actions were focused on the short term, to cover liability and mitigate consequences. These actions were not evaluated for their effect and no additional actions to address underlying issues were performed. The employees indicated that they were not motivated to perform additional actions, because there were no clear drivers to perform them, as it was not clear what their added value was. Most workers already had a lot on their plate and there was in general no time to perform actions, let alone to monitor or evaluate them. The actions would increase the workload, but there was no additional time or funding available to perform them. According to this focus group, the workload was a result of limited attention by senior managers for the consequence of implementation of actions and policy in practice.

The two incident cases that were discussed in this focus group, both illustrated difficulties in performing actions. The first incident was analyzed and lessons were learned, but due to financial and technical objections, the actions were not pursued. According to the employees, actions were seldom implemented, which meant that the risks remained. After the second incident, risks also remained, however some actions were taken that aimed to reduce the consequences. Although the risks were identified and could be addressed,

Table 1
overview of bottlenecks per company.

Phase	Company							Bottleneck
	A	B	C	D	E	F	G	
Acquiring information		x	x	x	x		x	Reporting (B, C, D, E, G)
Investigation and analysis	x			x		x	x	Selection (D,F); Investigation (A, D, F, G)
Planning interventions	x		x	x	x	x	x	Plan actions (A, C, D, E, F, G)
Intervening	x				x		x	Perform action (A, F, G)
Evaluating								

the organization chose to focus on remedial measures for financial reasons, and to let the risks exist.

4.8. Causes and conditions for failure to effectively learn

For each of the organizations one – or more – bottleneck is identified, meaning the step in which the learning process is hindered. The overview of the results in Table 1 shows bottlenecks in reporting, selection, investigation, planning actions and performing actions. Table 2 summarizes for each phase the causes and conditions, which were identified in relation to the bottlenecks.

Table 1 shows that five organizations identified difficulties with acquiring information (i.e. reporting incidents). In Table 2, it is shown that this was either because reporting was associated with negative consequences – such as blame, image problems or an extra workload – and people were unwilling to report, or because employees didn't know when and what to report, because there were no serious consequences, there was no feedback if an incident *was* reported and the signals from the management seemed contradictory (a low incident frequency rate versus a high number of incident reports).

There were four out of seven organizations where the investigation and analysis formed a bottleneck for learning from incidents, including choices on what incidents to investigate and how to carry out the investigation itself. Two organizations perceived difficulties in the selection of incidents to investigate, because there were no selection criteria, there was no time for a thorough review, and the way incidents were reported made selection difficult. In four organizations systematic causes for the incidents were not identified and addressed (which is tightly related to the next phases of the learning from incidents process, planning actions). The main reasons were limitations in competences or in the mental models, resulting in a focus on either technical, human or mitigating actions.

In six organizations difficulties became visible when planning actions. There was a tendency to focus on technical causes and actions for improvement, which meant that structural improvements were not performed. Other conditions that hindered a successful planning of actions were: a lack of overview of causes to address, lack of time, limited sense of urgency and a lack of ownership.

In three organizations, the performance of actions (intervening) was considered a bottleneck to learning from incidents. In one case this was the result of planning difficulties; there were too many actions, no prioritization and no ownership to perform the actions. In other companies the actions were not performed, because there was no sense of urgency: the benefit of reducing the risk was not considered to outweigh the costs of implementing changes.

The evaluation phase was not discussed in any of the focus groups. Since this is the last phase of the learning process, and many bottlenecks have been identified in earlier steps, difficulties in evaluation are, however, likely to exist.

Some commonalities were be identified in the conditions for difficulties in learning. For instance, aspects related to *time* were often mentioned by the participants as an important factor to hinder learning from incidents. There was too little time to read all the reports, too little time for a thorough investigation of the incident and too little time to perform the planned actions. It was also often mentioned that there were too many actions, too many causes to address or too many ideas for improvement, all meaning that there was not enough time to do all the things that one would like to do.

Other commonalities were found in relation to: *fear of negative consequences* – such as extra work or a negative image – *beliefs or mental models* – such as the idea that all incidents are unique – *knowledge or competences* and *sense of urgency*. *Knowledge or competences* were mainly related to incident investigation and analysis. The investigation did often not address organizational causes, because there was a blind spot for organizational and cultural

Table 2
Causes and conditions for the bottlenecks.

Phase	Causes for bottlenecks	Conditions
Acquiring information	Not knowing how and what to report (C, D, G)	Recognition of situation, successful recovery mechanisms, contradicting signals on incident report vs frequencies, belief that every incident is unique
	Not willing to report (B, E, G)	Fear of ruining incident rate, fear of client, fear of colleagues/image, fear of extra work and no sense of urgency, due to lack of feedback
	Limited quality of reports (E)	Time and effort
	No overview of risks (E)	Multitude of systems
Investigation and analysis	Systematic causes not identified (A, D, F, G)	Limitation to direct causes i.e. human or technical causes, limitation to mitigating actions, time pressure on completion analysis
	No selection of incidents to investigate (D, F)	No criteria, too many reports as result of successful campaign and use of reports as action trigger
Planning interventions	No selection of actions (A, D)	No sense of urgency, due to the belief that incidents are unique, no systematic approach and limited integration with other actions
	Quality of the actions (A, C, E, F, G)	Limited employee involvement, i.e. top down, focus on quick fix, focus on technical actions (no systemic causes)
Intervening	Not able to perform actions (A, E)	Time limitations
	Actions are not performed (A)	No sense of ownership to perform actions, large scale organization and no formal action holder
	Sense of urgency to perform actions (A, G)	No drivers and fear of extra work, little serious incidents

issues and technical factors were more easily identified. As a result, recommendations and actions were often mainly aimed at mitigation of the consequences of an incident, instead of at structural causes. The final commonality was the *sense of urgency*. This sense of urgency was low in two organizations as a result of earlier successes, meaning the low incident frequency in organization A and the successful recovery mechanisms in organization C. However, a lack of feedback on reports, lack of visible actions and contradicting signals on lowering the incident frequency versus increasing the number of reports for improvement, also affect the sense of urgency.

5. Discussion

Most of the case companies indicated that immediate actions were taken to remedy incidents. The consequence is that even though the risk of repetition of the specific incidents is mitigated, a similar incident may occur if the conditions are slightly different. Therefore learning from incidents should secure a more generic prevention of repetition.

The findings clearly illustrate that bottlenecks appear in all steps of the learning process. The steps *reporting, selection, investigation, planning actions* and *performing actions* all formed bottlenecks for learning, but most difficulties became visible when *planning actions*. *Planning actions* is the phase in which lessons learned from incident investigation are translated into recommendations and the recommendations are prioritized and selected. It is the phase that should bridge the gap between investigation and actions for improvement. In this phase, choices for follow-up have to be made, even though this often excludes or postpones other important actions. If these choices are not made, this could result in too limited focus in the action plan and a lack of structural improvement. The consequence is that the learning process in most cases is severely hampered and that neither single loop nor double loop learning takes place.

The participants in the case companies reported a number of causes for learning difficulties, the most important ones are: employees were reluctant to report incidents, the quality of incident reports was limited, systematic causes were not addressed in the investigation and planned actions were not performed. A number of latent conditions was also mentioned. Examples are fear for extra workload, limited eye for organizational incident causes, no sense of urgency to change, or little ownership for actions, created the latent conditions in which learning was impeded. Whereas, these conditions have a negative effect on learning from incidents, they can easily be reversed to conditions for successful learning form incidents. These results illustrate that in causes for the difficulties in the learning process, direct causes and latent conditions could be distinguished. This implies that to improve learning itself, a similar approach could be used as when learning lessons from incidents or accidents, in which latent conditions are identified to address them. Here it is important to note that identification of problems, causes and conditions is in itself not sufficient, but a follow-up in which these issues are successfully addressed is necessary.

Most of the identified causes in this field study are similar to those that were described in previous theoretical studies (Pidgeon and O'Leary, 2000; Choularton, 2001; Lampel et al., 2009; Hovden et al., 2011). A lack of competence or a limitation of the expertise (technical or human behavior focus) was often mentioned by the participants in relation to incident investigation and the generation of recommendations. A blame culture was only mentioned in one organization, where it strongly influenced the reporting of incidents. A lack of trust was not explicitly mentioned by the participants as a cause for ineffective learning. Limited sense of urgency and lack of motivation are however factors that are related to trust in the organization and its management.

An important finding is that in none of the organizations explicit management commitment was emphasized, except by the health and safety managers. According to Zwetsloot et al. (2013), a strong commitment of senior management, such as in the zero accident vision companies, could however facilitate the realization of safety improvements. An absence of such commitment may therefore be a limitation to learning from incidents and could be underlying other behavioral and cultural issues, such as the sense of urgency and motivation for learning. As most companies could be expected to have other management systems in place, for instance on quality assurance, a closer integration with such systems could be a way forward to strengthen learning from incidents.

Another interesting finding is that in most of the organizations, time was mentioned by the participants as an important factor to hinder learning from incidents. Schein (2004) mentioned in his study that lack of time – or a lack of budget – is often a result of managerial decisions. Some actions are considered to be more important than others, and therefore more time and resources are available for those actions. This means for instance, that if too much time and effort is put into the selection of incidents from databases and into investigation, this time and effort cannot be used to follow-up on the incidents, i.e. to perform action.

A limitation of this study is that the failure to learn was studied in seven organizations that differed in size, organizational structure, in core business, and the type of incidents that the company aimed to learn from. Therefore caution must be applied, as these results may not be transferable to every organization. The focus group methodology could also be a reason for caution, as the methodology only tells about the participants' experience with learning and the actual learning processes as such are not identified. However, observation of learning from incident processes would require very time consuming longitudinal studies, and the current methodology is well suited to give the first knowledge which can be used for the design of intervention projects. Another limitation may be caused by the selection of participants for the focus group. A small number of participants were invited to discuss their experiences on how the organization learned from specific incidents, but other experiences may exist within the organizations that are studied here.

Despite these limitations, this work contributes to existing knowledge on learning from incidents and accidents from an applied research perspective.

6. Conclusion

In this study, an analysis of the causes for failure to learn is performed, instead of an analysis of the causes of an incident. The findings provide insight into causes for a failure to learn in practice and they illustrate that a distinction between direct causes and latent conditions could be useful. Studying the learning process itself allows for improvement from a less emotional perspective in comparison to the analysis of specific incidents. Moreover, the analysis of the learning process is possible in any type of organization, regardless of the number or the types of incidents in the organization.

The results from this study imply that organizations should put more effort into the identification of latent conditions for learning. A different mindset (learning to learn) within organizations could aid organizations in the prevention of accidents; whereas, they now often focus on learning lessons from incidents, not learning could in itself also be seen as an event to learn lessons from and therefore as a subject to study: not learning from incidents, is an incident to be analyzed in itself. By actively and systematically studying learning, more latent conditions might be identified

and indicators for a successful learning process may be determined. A systematic analysis of the learning from incidents process, could also aid in prioritization of actions and in the (re-)allocation of time and resources to other aspects of the process and so aid to structural improvements of safety. The use of methods from accident investigation could facilitate the identification of latent learning conditions.

From a research perspective, what is now needed, are more studies that investigate direct causes and latent conditions for a failure to effectively learn. More examples of why an organization did not learn are necessary to study differences between organizations and sectors, and to identify generic failures. More information on latent conditions might help to establish a common set of indicators that need to be addressed to improve learning. This information could be used to develop and test targeted interventions to improve learning from incidents.

Acknowledgements

I would like to thank the participants from the organizations for their contribution to this research and for their openness. Specifically, I would also like to thank my colleague Niek Steijger for participating in this project and for co-organizing the focus groups and Professor Gerard Zwetsloot, for his review of the draft version of this paper.

References

Argyris, C., Schön, D.A., 1979. Organizational Learning: A Theory of Action Perspective. Addison Wesley, Reading, MA.
Argyris, C., Schön, D.A., 1996. Organizational learning. II: Theory, Method and Practice. Addison Wesley, Reading, MA.
Cedergren, A., 2013. Implementing recommendations from accident investigations: a case-study of inter-organisational challenges. Accid. Anal. Prev. 53, 133–141.
Chevreau, F.R., Wybo, J.L., Cauchois, D., 2006. Organizing learning processes on risks by using the bow-tie representation. J. Hazard. Mater. 130 (3), 276–283.
Choularton, R., 2001. Complex learning: organizational learning from disasters. Saf. Sci. 39 (1), 61–70.
Le Coze, J.C., 2008. Disasters and organisations: from lessons learnt to theorising. Saf. Sci. 46 (1), 132–149.
Dekker, S.W.A., 2009. Just culture: who gets to draw the line? Cognit. Technol. Work 11 (3), 177–185.
Drupsteen, L., Groeneweg, J., Zwetsloot, G.I.J.M., 2013. Critical steps in learning from incidents: using learning potential in the process from reporting an incident to accident prevention. Int. J. Occup. Saf. Ergon. 19 (1), 63–77.
Drupsteen, L., Zwetsloot, G.I.J.M., Groeneweg, J., 2012. Learning from events: a process approach. In: International Conference on Health, Safety and Environment in Oil and Gas, Perth.
Drupsteen, L., Guldenmund, F.W., 2014. What is learning? A review of safety literature on learning from incidents. J. Conting. Crisis Manage. 22 (2), 81–96.
Groeneweg, J., 2002. Controlling the Controllable, Preventing Business Upsets, fifth revised ed. Global Safety Group, Leiden.
Hollnagel, E., Woods, D.D., Leveson, N. (Eds.), 2006. Resilience Engineering. Concepts and Precepts. Ashgate Publishing, Aldershot.
Hovden, J., Størseth, F., Tinmannsvik, R.K., 2011. Multilevel learning from accidents—case studies in transport. Saf. Sci. 49 (1), 98–105.
ILO, 2013. Safety and Health at Work, ⟨www.ilo.org⟩ (retrieved September 29 2013).
Jacobsson, A., Sales, J., Mushtaq, F., 2009. A sequential method to identify underlying causes from industrial accidents reported to the MARS database. J. Loss Prev. Process Ind. 22 (2), 197–203.
Jacobsson, A., Ek, A., Akselsson, R., 2011. Method for evaluating learning from incidents using the idea of level of learning. J. Loss Prev. Process Ind. 24 (4), 333–343.
Körvers, P.M.W., Sonnemans, P.J.M., 2008. Accidents: a discrepancy between indicators and facts! Saf. Sci. 46 (7), 1067–1077.
Kontogiannis, T., Leopoulos, V., Marmaras, N., 2000. A comparison of accident analysis techniques for safety-critical man–machine systems. Int. J. Ind. Ergon. 25 (4), 327–347.
Lampel, J., Shamsie, J., Shapira, Z., 2009. Experiencing the improbable: rare events and organizational learning. Organiz. Sci. 20 (5), 835–845.
Leveson, N., 2004. A new accident model for engineering safer systems. Saf. Sci. 42 (4), 237–270.
Lindberg, A.K., Hansson, S.O., Rollenhagen, C., 2010. Learning from accidents—what more do we need to know? Saf. Sci. 48 (6), 714–721.
Lundberg, J., Rollenhagen, C., Hollnagel, E., Rankin, A., 2012. Strategies for dealing with resistance to recommendations from accident investigations. Accid. Anal. Prev. 45, 455–467.
Mancini, P., 1998. Risky information: social limits to risk management. J. Conting. Crisis Manage. 6, 35–44.
Pidgeon, N., O'Leary, M., 2000. Man-made disasters: why technology and organizations (sometimes) fail. Saf. Sci. 34 (1–3), 15–30.
Rasmussen, J., 1997. Risk management in a dynamic society: a modelling problem. Saf. Sci. 27 (2–3), 183–213.
Rasmussen, H.B., Drupsteen, L., Dyreborg, J., 2013. Near miss reporting in the Danish oil & gas industry. Saf. Sci. Monit. 17 (2).
Reason, J.T., 1990. Human Error. Cambridge University Press, Cambridge.
Reason, J.T., 1997. Managing the Risks of Organisational Accidents. Ashgate Publishing Limited, Aldershot.
Reinach, S., Viale, A., 2006. Application of a human error framework to conduct train accident/incident investigations. Accid. Anal. Prev. 38 (2), 396–406.
Sanne, J.M., 2008. Incident reporting or storytelling? Competing schemes in a safety-critical and hazardous work setting. Saf. Sci. 46 (8), 1205–1222.
Schein, E.H., 2004. Organizational Culture and Leadership, third ed. Jossey-Bass, San Francisco, CA.
Senge, P.M., 1990. The Fifth Discipline; The Art and Practice of the Learning Organization. Doubleday, New York, NY.
Sklet, S., 2004. Comparison of some selected methods for accident investigation. J. Hazard. Mater. 11 (1), 29–37.
Zwetsloot, G.I.J.M., Aaltonen, M., Wybo, J.-L., Saari, J., Kines, P., De Beeck, O.R., 2013. The case for research into the zero accident vision. Saf. Sci. 58, 41–48.

ARTICLE IN PRESS

Safety Science xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/ssci

Assessing propensity to learn from safety-related events

Linda Drupsteen [a,*], Jean-Luc Wybo [b]

[a] TNO, Polarisavenue 151, Hoofddorp, The Netherlands
[b] Mines Paristech/CRC, CS10207, Sophia Antipolis, France

ARTICLE INFO

Article history:
Received 18 November 2013
Received in revised form 10 February 2014
Accepted 26 February 2014
Available online xxxx

Keywords:
Propensity
Pro-active
Safety leading indicator
Learning from experience
Attitude

ABSTRACT

Most organisations aim to use experience from the past to improve safety, for instance through learning from safety-related incidents and accidents. Whether an organisation is able to learn successfully can however only be determined afterwards. So far, there are no proactive measures to assess whether an organisation will be able to learn from experience, meaning whether an organisation has the propensity to learn. In this study we aimed to develop a set of indicators for the propensity to learn as part of the leading indicators for safety. To assess the propensity to learn, the individual perception of learning from experience is measured, through a set of indicators. These indicators are validated through interviews on a French production site. This organisation showed a high propensity to learn, despite some minor weaknesses with respect to involvement of employees and sharing information. On an individual level, 17% of the employees had a very positive attitude towards each step of the learning process. The proposed indicators could support the identification of weaknesses with respect to learning on an organisational level and they could facilitate the identification of training needs of the employees. Further development and tests of the indicators are however needed to apply them on a wider scale.

1. Introduction

A key aspect of safety improvement is the use of past experience, such as incidents, accidents and good practices. An organisation could learn from warning signals, from mistakes, from incidents, from accidents, or to put it more generally: an organisation could learn from experience. Learning from experience means that relevant events are detected and analysed, and that lessons are determined and used for improvement of the situation and the organisation. The term "*learning from experience*" is often used after negative events, to claim that lessons will be learned from it, implying that such an event will not occur again.

Experience is sometimes difficult to grasp, especially when it concerns individual knowledge. This individual knowledge or experience often remains tacit inside working communities where a group of individuals experienced stressful situations together. Such a collection of experiences is an organisation's wealth available for managing difficulties but also innovation challenges. The aim of organisational learning is to identify this knowledge, to formalise it, and to create a momentum of progress based on three basic principles: respect individuals, trust their capacity to manage planned and unattended situations and make lessons learned available to every concerned person (adapted from Wybo, 2012).

With hindsight one can determine whether an organisation did successfully learn from experience. However, so far there is no model or a set of instruments available to predict if an organisation can learn in case an event happens. This paper aims to identify a set of indicators that enables managers or safety representatives to determine how likely their organisations are to learn from experience. In other words, this paper aims to determine a set of indicators to assess the propensity to learn. The word propensity means "*to be inclined*", it implies a natural tendency or disposition. An organisation with a high propensity to learn therefore means that an organisation is likely to learn in case an event happens.

Existing knowledge on propensity, on organisational learning and on safety is used in this study to propose a model for propensity to learn. Our objective is to define two sets of indicators, the first set related to propensity to learn at the organisational level and the second set at the individual level.

The objective of the first set of indicators (organisational level) is to help identifying strengths, weaknesses and ways of improvement as part of the leading indicators of safety. The objective of the second set (individual level) is twofold: to identify people who may play the role of "*learning agents*" by promoting the process in their area, and to identify groups of people that need specific

* Corresponding author.
E-mail address: linda.drupsteen@tno.nl (L. Drupsteen).

http://dx.doi.org/10.1016/j.ssci.2014.02.024
0925-7535/

Please cite this article in press as: Drupsteen, L., Wybo, J.-L. Assessing propensity to learn from safety-related events. Safety Sci. (2014), http://dx.doi.org/10.1016/j.ssci.2014.02.024

training to improve their willingness, attitude, or skills to achieve the different tasks of the learning process.

2. The notion of propensity

The word propensity originates from the Latin word "*propensus*", meaning "*to be inclined*". Propensity generally means that there is a natural tendency or disposition: the aptness of iron to rust; the propensity of a disease to spread. Popper (1959) proposed an interpretation related to technology: probabilities measure propensities that tend to produce possible singular events; they belong to the physical world; they cannot be used to interpret conditional probabilities. At the individual level, propensity corresponds to a driving force influencing one's behaviour. At the group level, it is related to the group's culture and uses. The notion of propensity is used in a quite large number of studies. We briefly describe five of them here.

Serra et al. (2012) studied SME's propensity to export; he argued that it is possible to identify a profile associated with propensity to export, based on firm size, competitive advantage, or number of languages spoken. Keil et al. (2000) addressed the risk propensity related to the decision to continue a project. His study concluded that managers risk perceptions are more influenced by the amount of potential loss and that risk perception was more influential than risk propensity on decision-making. Sasidharan and Donnell (2013) studied the effectiveness of traffic safety countermeasures, based on propensity scores and potential outcomes. Among his results, he found that fixed roadway lighting reduced night-time crashes by 6%. Ryan and Tipu (2013) studied how leadership influenced innovation propensity in Pakistani firms. They identified two major types of leadership that influenced innovation propensity: active leadership, which had a strong influence, and passive-avoidant leadership, having a weak influence. Ryan and Tipu proposed an explanation for this non-intuitive finding "*Intrinsically satisfying tasks may act as a substitute for leadership in self-motivated subordinates who do not expect support from a passive-avoidant leader for carrying out innovative activities*". From a literature survey, Schnake (2007) proposed a model of effort propensity. Schnake identified seven direct positive effects: job satisfaction, job scope, organisational commitment, personality traits, ability to perform work related tasks, group performance norms and group size, moderated by evaluation apprehension.

2.1. Propensity as an attitude

In studies by Hatfield and Fernandes (2009), Rohrmann (2005) and Smits et al. (2012), propensity is defined as an attitude. Hatfield and Fernandes (2009) studied risk propensity in driving behaviour for young drivers. They defined risk propensity as a positive attitude towards risk. Rohrmann (2005) also considers risk propensity as one end of risk attitude, whereas the other end is risk aversion. In his paper, he described four instruments to measure risk attitudes, amongst which the Risk Propensity Questionnaire. This questionnaire is composed of holistic propensity questions, in which a description of propensity is given and the respondent is asked to rate himself for this propensity. Smits et al. (2012) consider propensity as an attitude which contrasts the attitude 'resistance'. They base their study on that of Rohrmann (2005). They studied propensity as an orientation towards participative evaluation (PPE). To study propensity towards participative evaluation, they studied the propensity towards each of four components of PPE. Sharma et al. (2009) consider propensity not as a type of attitude, but they state that attitudes, consciousness and perception are manifestations of propensity. This concept was applied in a study of consumer behaviour, where propensity was considered to be the tendency towards either risk taking or risk avoiding.

Other approaches towards propensity are described by Gilliland and Schepers (2003), Fuller (2005) and Grabowski et al. (2007). Gilliland and Schepers (2003) for instance regarded organisational propensity as a form of culture, predicted by both organisational and managerial factors.

3. Learning from experience

We consider learning from experience as an organisational learning process. People within the organisation and the interaction amongst them are critical to this process, since they detect situations and events to learn from and collect related information. Their experience is captured, processed, transferred and shared through the organisation.

A definition of learning that is proposed by Carroll (1998) is: "*Organisational learning takes place through activities performed by individuals, groups, and organisations as they gather and digest information, imagine and plan new actions, and implement change*". In doing so, an important notion is that: "*Knowledge is more than lists of facts that can be summed together. Organisational knowledge is embodied in physical artefacts (equipment, layout, data bases), organisational structures (roles, reward systems, procedures), and people (skills, values, beliefs, practices)*" (Carroll, 1998).

There is a difference between deliberate learning and learning through experience. Lampel et al. (2009) described that when deliberately learning from experience, experiences – such as the events that are registered in incident reports- are retrieved and collected to search for valuable lessons. This learning contrasts with learning through experience, which occurs instantly when an event is experienced. This kind of learning is the main focus of our study and it starts if something is detected and noted by someone as interesting to learn from. Events, such as incidents or accidents are often easily detected. Weak signals or dangerous situations are however more difficult to identify. In our study, we therefore consider two processes of learning from experience: 'learning from incidents' and 'learning from weak signals'.

3.1. Learning from incidents

Several models exist that represent learning from incidents as a stepwise process (see for instance Drupsteen et al., 2013). In these stepwise processes, after an event occurs and is noticed, follow up steps are performed including the implementation and evaluation of actions. Successful learning in this approach means successful completion of the steps in the learning process. The learning from incidents process as described by Drupsteen et al. (2013) for instance, contains four phases in the learning process – investigation and analysis, planning of actions, intervening and evaluation, each consisting of several sub steps. They used the model of the learning from incidents process to identify weaknesses in learning and to study the difference between the formal and the actual learning process within organisations.

When learning from incidents, it is first of all necessary that an incident is noticed and recognised as a relevant situation to learn from. Mac Donald (1997) argues, "*The capacity to learn from accidents and develop preventive measures therefore depends on the ability to elicit information*". If the incident is noticed and considered relevant, it can be registered and reported in a system and/or shared through formal/informal communication. The ability to elicit information is however also relevant at other levels in the organisation. An HSE manager might for instance collect the report of an event (instead of the event itself) and start learning from that information. He might also assess and analyse the situation and

Please cite this article in press as: Drupsteen, L., Wybo, J.-L. Assessing propensity to learn from safety-related events. Safety Sci. (2014), http://dx.doi.org/10.1016/j.ssci.2014.02.024

decide whether it should be followed-up on and whether it should be shared with top management and other departments. Assessing the situation might also include an analysis to determine causation of the incident, or a comparison with historical information.

If experience is considered valuable to learn from, a strategy for follow-up could be determined. Is it sufficient to share the story of the event? Or does the experience reveal the need to make changes, to act differently? Stern (1997) argues: "*A key pre-requisite for experience-based learning is the extent to which institutional memory is cultivated and accessible to participating actors*". When learning from accidents, causes are identified and prioritised, recommendations are formulated, and the feasibility of the recommendations is assessed. This is followed by the implementation of proposed changes. During this process, or even after implementation, some lessons learned may however be refuted by more recent experiences. The knowledge that is extracted from experience is not everlasting and it is therefore also needed to unlearn those lessons. "*Managers could be better prepared for future crises by facilitating employees' unlearning of behaviours that were previously effective but which are no longer viable in light of the evidence from failure events*" (Carmeli and Schaubroek, 2008). It is also possible that experience is still valid, but it is lost because people with the experience move in the organisation or leave. "*Valuable competence and stores of experience are routinely lost through staff attrition. As a result, organisations forget, as well as learn*" (Stern, 1997).

The final step, if the learning process is completed successfully, is an evaluation of the implemented action. Besides the evaluation of the action, also the evaluation of the learning process is important. An evaluation of what people learned and what the organisation learned may again lead to an experience – about applying the learning process – from which lessons can be learned. This corresponds to deutero-learning as formulated by Argyris and Schön (1996).

3.2. Learning from weak signals

A more proactive approach than learning from incidents is learning from weak signals, or from early warnings. Learning from experience is often associated to negative events (incidents and accidents) but one should not underestimate the value of near-misses and best practices for organisational learning. Similar to learning from incidents, weak signals can create input to learn from, to make changes and to prevent future unwanted situations.

Boin and Hart (2003) addressed the reasons why leaders run a big risk of becoming the victim of "silences" in the organisational communication pattern: "*Warnings do not come with flashing lights; they are hidden in expert reports, advisory memos, or a colleague's casual remark. The warnings have to be distilled from a series of seemingly minor and insignificant indications. An additional problem is that information passageways to leaders often are obscured.*"

Schoemaker and Day (2009) analysed how managers can "*develop their peripheral vision to see what's ahead more sharply*". They argued that the true relevance of various "snippets of information" could be appreciated only when they are "*debated with others and merged into a large mosaic*".

Brizon and Wybo (2009) investigated the main difficulties in the lifecycle of a weak signal: detection, interpretation, transmission and priority setting (Fig. 1). They described how detection of weak signals is mainly dependent on the vigilance and attention of people. In their paper, Brizon and Wybo (2009) stated, "*being vigilant means being alerted by any abnormality, while being attentive means looking for signals that are known in advance*".

Transmission, communication and exchange of information are crucial aspects when learning from weak signals. For organisational learning, individual experiences of weak signals have to be shared. Making a parallel with insect's vision using localised intelligence at the level of each eyelet, Schoemaker and Day (2009) suggest, "*Accessing distributed intelligence takes a culture of alertness and information sharing across multiple social networks*".

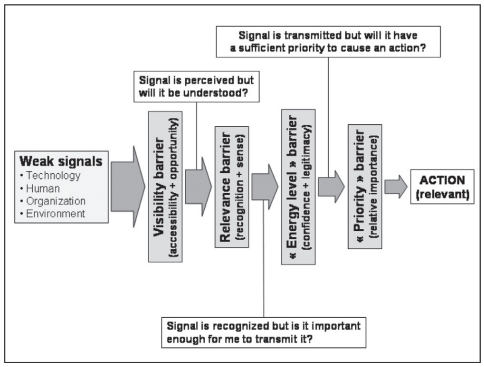

Fig. 1. Life cycle of a weak signal (Brizon and Wybo, 2009).

Transmission of weak signals is a matter of communication between two individuals: who transmit it and who receives it; it depends on the perceived importance of the signal and on their mutual trust. If the signal is not strong enough to motivate the sender and/or the sender does not trust the receiver, it will not be emitted. On the other end, the receiver will only use information from a sender that he or she trusts (Brizon and Wybo, 2009); transmission of weak signals in an organisation depends on the source credibility (Schoemaker and Day, 2009) and confirmation through other information (Julien et al., 2004). To be fruitful and beneficial for the organisation, methods and tools are needed to formalise and to share experiences and lessons learned.

The organisation plays an important role in the management of weak signals by providing people with practices, methods and tools to develop reactive and proactive behaviours when faced with weak signals. Proactive behaviour involves telling operators what signals are important to detect and report to their managers; reactive behaviours involves telling managers what information is important and who may provide them with such information. Vaughan (2001) uses the term 'social democracy' to describe organisational patterns of information provision: "*Subordinates, new comers in an organisation frequently have useful information and points of view, but they don't communicate them. Initiatives of 'civil democracy' give those people opportunities to express themselves and organisations should do their best in that way*".

3.3. A model for the Learning from experience (LFE) process

The two learning processes, learning from weak signals and learning from incidents, differ with respect to the collection of information used to learn from. If a weak signal is detected and interpreted it can be followed up upon in the same way as when learning from incidents: actions are formulated, performed and evaluated for their effect. Fig. 2 summarises the learning from experience processes, where each step needs to be performed and the results should be shared.

Our **first hypothesis** is that an organisation with a propensity to learn has a propensity to perform each of the steps in the learning process.

Our **second hypothesis** is that in an organisation with a propensity to learn from experience, the members have the propensity to share information throughout the learning process.

Please cite this article in press as: Drupsteen, L., Wybo, J.-L. Assessing propensity to learn from safety-related events. Safety Sci. (2014), http://dx.doi.org/10.1016/j.ssci.2014.02.024

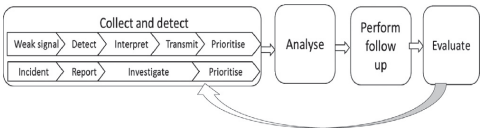

Fig. 2. Model for learning from experience.

3.4. Facilitating or impeding the learning process

From the safety literature several factors are known that impede or facilitate the learning process, and that therefore influence the propensity of an organisation to learn from experiences. Carmeli and Gittell (2009) for instance studied the conditions that facilitate the learning process in an organisation. He proposed to distinguish two facilitating contexts: the existence of '*high quality relations*' among people – meaning shared goals, shared knowledge and mutual respect, and the existence of a 'psychological safety' – which "*refers to one's beliefs about how others will respond when he or she would ask questions, seek feedback, report an error, or come up with a new idea*". According to Carmeli and Gittell (2009) the lack of psychological safety is an impeding factor for learning: "*When employees who work together have competing goals, a lack of understanding of each other's roles and a lack of respect for each other's roles, they are more likely to blame each other for failures, and therefore are less likely to experience the psychological safety needed to embrace failure as an occasion for learning*".

Ramanujam and Goodman (2011), Boin and Hart (2003), Fahlbruch and Schöbel (2011) and Wybo (2012) each also identified one or more factors that impede the learning process. Ramanujam and Goodman (2011) identified a series of difficulties for learning: fix a problem without taking time to extract more general lessons, keep what we learn for ourselves, don't perceive the benefit of centralising experiences and, above all, reuse experience - especially knowledge stored in databases. He also addressed the question of forgetting experience: "*The length of time that might lapse between the occurrences of similar events inhibits retrieval. The rate of organisational forgetting can be high and that subsequent learnings can interfere with prior learnings*" (Ramanujam and Goodman, 2011). A factor that was identified by Boin and Hart (2003), is the lack of recognition for people participating in the LFE process. LFE is a laborious process that requests patience and a low-conflict atmosphere, but it also generates activities, such as technological improvements and adaptation of routines (Boin and Hart, 2003). Fahlbruch and Schöbel (2011) identified a series of factors that limit the depth of analysis at a micro level; among them premature hypotheses, mono-causal thinking, and ignoring factors that are not written down in the method. Another final factor that was identified as impeding factor, was a political factor; LFE puts weaknesses and errors in the spotlights and challenges competencies and organisational patterns. This is at least uncomfortable and at most unacceptable for operators and managers (translated from Wybo, 2012).

The list of studies in this section indicates that many factors could influence the success of learning from experience. It can be expected that these factors also have an effect the propensity of an organisation to learn.

4. Propensity to learn from experience

In this study we aim to set up a set of indicators to evaluate the propensity of the organisation and the propensity of individuals to learn from experience. When determining the propensity of an organisation to learn from experience, we use three aspects of propensity: the drive or attitude towards learning, the organisational conditions for learning and the systems or tools that facilitate learning. These aspects could also be labelled as human, organisational and technical conditions. The technical conditions include the formal processes and systems that facilitate learning from experience. The organisational conditions are based on the model of organisational learning capability as described by Jerez-Gómez et al. (2005), including the four dimensions: 'managerial commitment', 'systems perspective', 'openness and experimentation' and 'knowledge transfer and integration'. For individual propensity to learn, the attitude towards learning is evaluated. People are involved in all steps of learning and therefore it is important that they have the willingness to perform and share the steps in learning.

4.1. Propensity to adopt a safe or unsafe attitude

Several studies are performed to identify why people are inclined to act safely (or unsafely). According to Grabowski et al. (2007), risk propensity originates in risky activities. They studied leading indicators in virtual organisations and showed that whereas both in traditional and virtual organisations the technology, organisational conditions, structures and culture influence the risk propensity, the structures and culture of a virtual organisation are much more complex.

Simard and Marchand (1997), Geller et al. (1996) and Dahl and Olsen (2013) studied aspects of the propensity to act safely. Simard and Marchand (1997) studied the determinants of propensity of workers to comply with safety rules. They showed that a cooperative workgroup-supervisor relationship, participative leadership – meaning decentralised process of safety regulation – and workgroup cohesiveness were predictors of the propensity for compliance. Dahl (2013) also studied the propensity of workers to comply with safety rules and showed that the leadership involvement did not have a direct effect on the propensity to comply. He showed however that through role clarity or employee competence and involvement, leadership indirectly predicted propensity to comply with safety rules. Geller et al. (1996) studied the propensity to actively care for safety, meaning the propensity to go beyond what is necessary or obligatory, beyond compliance. He identified three factors that influenced this propensity: group cohesion, personal control and extraversion. Henning et al. (2009) studied the influence of individual differences on organisational safety attitudes. The findings of their study suggests "*individuals who are 'riskier' in their personalities hold more negative safety attitudes*"'.

In these studies, the propensity is regarded as a drive or attitude to perform a given behaviour. One has for instance a propensity to take risk, a propensity to aggression, or a propensity to follow rules.

Our **third hypothesis** is that in an organisation with a propensity to learn, the members have a positive attitude towards learning, i.e. towards performing the steps in the learning process.

4.2. Organisational conditions

Learning from experience is a process that can be completed successfully if several conditions are met. As Goh and Richards (1997) stated "*learning is a collective activity that takes place under certain conditions or circumstances*". Several authors studied these conditions that enable an organisation to learn and aimed to identify what determine an organisation's learning capability. The organisational learning capability consists of the organisational and managerial characteristics that allow an organisation to learn (Chiva and Alegre, 2009; Goh and Richards, 1997; Jerez-Gómez et al., 2005). Julien et al. (2004) use the term of 'absorptive

Please cite this article in press as: Drupsteen, L., Wybo, J.-L. Assessing propensity to learn from safety-related events. Safety Sci. (2014), http://dx.doi.org/10.1016/j.ssci.2014.02.024

capacity' to mean "*acquisition of new, possibly tacit information, its conversion into new opportunities and its ultimate use*". They suggest that gatekeepers and boundary spanners are needed to absorb the information, to give it meaning and to convert it into knowledge.

Jerez-Gómez et al. (2005) developed a questionnaire to measure organisational learning capability, consisting of four dimensions: managerial commitment, systems perspective, openness and experimentation, knowledge transfer and integration as the basic elements for organisational learning capability. Management commitment means that the management should recognise and articulate the relevance of learning. They should drive the process of change and eliminate old beliefs when necessary. Clear objectives should be stated and effectuated. In an organisation that consists of many individual parts, it is relevant to consider the organisation as a system. The dimension systems perspective emphasises the importance of a common language, shared mental models and clear objectives to enable collective learning. To learn, an organisation has to be open to new ideas and points of view. This includes ideas from internal processes, but also the use of experience of other organisations as examples. Openness and experimentation also relates to the ability to question existing knowledge. Trying out new ideas and options to search for innovations also includes the possibility to make mistakes and thus to learn from failures. The fourth dimension refers to two processes: internal transfer and integration of knowledge. Signals, lessons learned, and other information are shared throughout the organisation and should also be integrated so that a collective body of knowledge can be created and organisational memory is formed. This is especially relevant, since turnover and subcontracting create less coherence in the workforce and communication is limited. The idea of an organisational memory is that "*the knowledge can be subsequently recovered and applied to different situations, guaranteeing the firm's constant learning in spite of the natural rotation of its members*" (Jerez-Gómez et al., 2005). The dimensions listed above, such as openness and leadership, are similar to aspects of safety culture or safety climate. Clearly an organisation that prioritises safety will also aim to learn from experience, and use experience for safety improvement. An organisation that has the conditions for learning in place is an organisation that is likely to have a positive safety climate.

Chiva et al. (2007) and Goh and Richards (1997) describe other dimensions of organisational conditions for learning. Chiva et al. (2007) identified five essential factors for learning as part of OLC: experimentation, risk taking, interaction with external environment, dialogue and participative decision-making. The interaction with external environment is partly similar to what Jerez-Gómez et al. (2005) labelled systems perspective. It is important to also look outside the borders of the organisation, to gain new ideas and experiences. Jerez-Gómez et al. and Chiva et al. also mention experimentation as an important factor. Although Chiva et al. identify participative decision making as a separate dimension, this is also part of the management commitment as described by Jerez-Gómez et al. Specific for the model of Chiva et al. is the factor 'risk taking'. Goh and Richards (1997) identified another five dimensions, but they also list experimentation as an aspect of learning capability. These five dimensions are: clarity of purpose and mission, leadership commitment and empowerment, experimentation and rewards, transfer of knowledge, teamwork and group problem solving. Not only is experimentation overlapping with the model by Jerez-Gómez, but there are also other similarities. Goh and Richards (1997) emphasise the importance of leadership commitment and empowerment, whereas Jerez-Gómez et al. (2005) identified managerial commitment as a relevant factor. Transfer of knowledge is also overlapping between both models. Specific for the model by Goh and Richards are 'group problem solving' and 'clarity of purpose and mission'.

Our **fourth hypothesis** is that if the organisational conditions for learning exist within an organisation, the propensity for learning from experience to occur is higher.

4.3. Systems and tools

The performance of the steps in learning from experience, and the dissemination of information throughout these steps (on relevant signals, on incidents, on identified causation, on planned action, etc.) could be facilitated by the presence of systems and tools. An organisation that has the systems and procedures in place, will be more likely to successfully learn. However these systems will only be useful in interaction with the people in the organisation. They deliver the input or information for the systems and they maintain and use the systems. Well-known systems are reporting systems and databases to collect and store historical incident data. These systems are pull-systems, meaning that a person must initiate the action: information is retrieved if an employee searches for specific information. Pull-systems are more common than push-systems, in which action is initiated by the system. Automatic emails, reminders or message feeds are examples of such push-systems (Bonney et al., 1999; Cheverst and Smith, 2001).

A review on IT and organisational learning by Robey et al. (2000) emphasises the possibilities of IT to provide an infrastructure for a learning organisation. They emphasise two main systems as enablers of organisational learning; the organisational memory and communication systems. The design of the first system type, organisational memory, could be divided into sub processes. As Robey et al. (2000) state in their review: "*Information technology now has a greater potential to support organizational learning through the capture, representation, storage and retrieval of structured data*", meaning the support of an organisational memory.

In the safety field, the facilitation of organisational memory is mainly limited to capture of information through incident registration systems and incident investigation, and to the storage of information, through incident or event-databases. Johnson (2002) stresses the growing importance of incident reporting systems in safety–critical industries and encourages participation amongst software engineers in the design of reporting software. Lindberg et al. (2010) state that "*Reports about accidents are often collected in databases. Several such databases have been well described in the literature*". However, they also refer to the limited use of these databases: "*According to Trevor Kletz, accident databases have been used less than expected. It seems as if persons responsible for accident prevention do not use accident databases as a tool for general learning but only refer to them when they are already aware of a hazard*"(Lindberg et al., 2010). Downsides of databases as part of the organisational memory are the fact that all information that enters the database should be validated beforehand, and the limitation of the database with respect to updating and overwriting information. Once information is entered in a database it remains there, also if the information is incorrect or if the information is outdated. A system is in itself not able to check the quality of information, or to renew, update and delete this information.

In 1998, Chung and Jefferson identified several other problems with existing accident databases, such as the indexing of information – to enable location of relevant information easily, retrieving and ranking information in relation to query's and retrieving information automatically. Similar statements were made by Sepeda (2006), who stated that for incident databases to be effective, they must have proper goals, scope and attributes. These attributes are accessibility, user friendliness, accuracy, sufficient volume, standardisation, a query system or search engine and data security or confidentiality. A study into accidents' reporting and registration systems in Europe by Jacinto and Aspinwall (2004) illustrated that

Please cite this article in press as: Drupsteen, L., Wybo, J.-L. Assessing propensity to learn from safety-related events. Safety Sci. (2014), http://dx.doi.org/10.1016/j.ssci.2014.02.024

there were large differences in current databases, especially with respect to the accessibility, the main purpose (besides use for prevention), main indicators that are used in the database. Whereas this study focussed on national databases, there are also many sectors and organisations with specific reporting systems (Lindberg et al., 2010).

Although this heterogeneity of databases has little impact on learning within an organisation, it may create difficulties for inter-organisational learning. The second type of systems that is described in the review (Robey et al., 2000) are systems to support communication and discourse. Tools that are used to facilitate communication are for instance group support systems or collaborative tools. The promotion of discourse is however important, because if more people contribute and use the information, this increase the shared knowledge and expands the organisational memory. The tools provide a vehicle for communication that may support debate and discussion. In a review of the literature on information sharing in organisations, Yang and Maxwell (2011) state that IT applications may facilitate intra organisational communications, but only if the applications are user-friendly, easy and perceived as useful.

Both reviews (Robey et al., 2000; Yang and Maxwell, 2011) also emphasise that the use of systems and tools has some disadvantages. As Yang and Maxwell, 2011 noted, there are many different systems and difficulties may arise in the integration of several information systems, or databases with different platforms, formats and data-types. Robey et al. (2000) state that IT may even enable learning because: "*Organisations may become overly dependent on formal systems and thereby lose their appreciation for less formal representations of organizational memory, such as those residing in the heads of experienced employees*".

Our **fifth hypothesis** is that in an organisation with a propensity to learn from experience, the systems that facilitate the performance of the learning process are present.

5. Methods

Harrison et al. (2005) achieved a systematic review of instruments that measure risk propensity of patients for use in the health setting. They identified 14 instruments in their set of 3546 articles, eight of them measuring risk propensity and six measuring personality traits associated to risk propensity. Most of these instruments 9 on 14 used questionnaires and a Likert scale. We use the same methodology in our study.

5.1. Model to study propensity to learn from experience

The theory in the previous subsections leads us to a model to study the propensity to learn from experience. The propensity, meaning whether an organisation is likely to learn from experience, is measured through indirect measures of the conditions and attitudes for learning. Two sets of indicators are determined: one set to assess the propensity of an organisation and one set to assess the propensity of individual members of the organisation (employees and managers). These propensities are assessed through people's perceptions on indicators related to the learning process.

5.1.1. Organisational indicators

An organisation with a high propensity to learn is an organisation with a high propensity to successfully complete the learning from experience process and to share information throughout this process. To study propensity of the organisation we use three categories, each with two indicators:

- Attitudes.
- Organisational conditions.
- Systems.

This results in six indicators for the propensity of an organisation to learn from experience:

- Attitude to perform the learning process.
- Attitude to share information.
- Organisational conditions to facilitate learning 1 (management commitment and openness).
- Organisational conditions to facilitate learning 2 (systems perspective and knowledge transfer).
- Systems supporting the learning process.
- Systems supporting information sharing.

5.1.2. Individual indicators

A second set of indicators is developed to assess the attitude of individuals towards learning from experience. Five indicators are determined that are related to the stages of the learning process:

- Attitude towards detection.
- Attitude towards analysis.
- Attitude towards follow up.
- Attitude towards evaluation.
- Attitude towards sharing information.

Fig. 3 summarises the aspects to study propensity to learn from experience in a model.

5.2. Test of the model in a pilot study

In this study we aim to assess an organisation's propensity to learn from experience. However, an organisation cannot learn without its individual members. Moreover, the actions that are involved with learning from experience steps might differ slightly, depending on who is involved. For instance: an employee detects an event, whereas a direct manager or a HSE representative might learn from the report of that event, instead of from the event itself. This example illustrates that to measure the propensity of an organisation to learn from experience, multiple roles in the organisation have to be studied. Therefore, attitudes towards learning from experience and learning steps will be studied for employees and for management.

5.2.1. Questionnaire

To determine the propensity of the organisation and individuals to learn, we have developed a questionnaire based on the indicators. A selection from the validated questionnaire on organisational learning capability of Jerez-Gómez et al. (2005) was used for the questions on organisational conditions. The questionnaire was developed in English and in French, and contained forty-eight questions to evaluate the propensity to learn. Moreover, each participant is asked how he/she perceives the propensity of the organisation to learn from experience.

Each of the questions was asked on a 4 point Likert-scale, with 4 (Absolutely) being the highest score and 1 (Not at all) being the lowest. Scales with an even number of points do not have a midpoint and in that sense force a choice. There has been some debate about the optimal number of answer categories when using a Likert scale, e.g. (Cox, 1980; Friedman et al., 1981) and about elimination of the midpoint, e.g. (Armstrong, 1987; Garland, 1991; Kulas and Stachowski, 2009), because elimination may impact measurement reliability and validity. However, the meaning of the mid-

Please cite this article in press as: Drupsteen, L., Wybo, J.-L. Assessing propensity to learn from safety-related events. Safety Sci. (2014), http://dx.doi.org/10.1016/j.ssci.2014.02.024

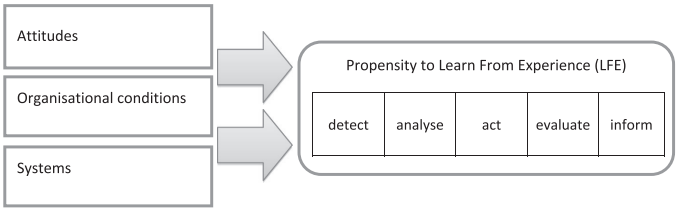

Fig. 3. Model to study propensity to learn from experience.

point can also be confusing, and elimination of the midpoint reduces social desirability bias (Garland, 1991). For the evaluation of each of the indicators, the mean value of the questions is used. Table 1 presents the questions related to one of the twelve indicators.

5.2.2. Participants

The organisation chosen to validate the methodology is a production plant in France. This plant produces consumer products for cooking. 1900 people work on this site. According to the EU Seveso III directive (Seveso III, 2003), this site is part of the high hazard category. The top management is committed to safety and health of personnel and to protection of the environment as the top priorities, and the statistics of accidents demonstrate continuous progress. In 2013, the improvement of the learning process was chosen as one of the key actions to engage in.

The experiment consisted in passing a questionnaire (see below) to a selected group of operators, and to a selected group of managers (HSE, maintenance, production and HR departments).

The questionnaire was used in face-to-face interviews, with managers ($N = 17$) and operators ($N = 50$) who were chosen from the different departments of the production site. The interviews took 20 to 40 minutes and were performed by a student, who was an intern in the Environment, Health and Safety (EHS) department for a 6-month period. The individual interviews were seen by employees as an opportunity to provide personal feelings about safety concerns in the company. A majority of interviewees appreciated that someone from the EHS department came to meet them individually, to listen to them and get their comments. More precisely, interviewees appreciated that it was somebody from the company who submitted the questionnaires, as he knew the company's specificities in terms of safety and work practices. The interviewees found some questions difficult to understand, in which case the interviewer provided explanations.

Most of the interviewees were prone to talk about what was going well and what should be improved. They highlighted the reactivity of the EHS department when incidents or accidents occurred and they highlighted the good communication about safety-related events. They also indicated what should be improved, making a number of suggestions even on matters that were not addressed in the questionnaire.

6. Results

6. Propensity of the organisation

6.1.1. Learning

Overall, the groups of both operators and managers were positive about how well the organisation learns from experience. Each participant was asked whether they thought that their organisation learns from experience and both groups had a positive view on this. Despite some low scores, the mean value was 3.46.There was no difference between operators and managers, on how the organisations learn. Also, four general questions about learning were asked. The question on which the mean value of operators differed from that of managers was: 'you are used to apply examples from other people to your own practices'. Managers had a higher score than the operators.

6.1.2. Attitude to learn from events

The attitude to learn from events is measured by two indicators: the first indicator is the attitude to perform steps in the learning process, which is measured by 16 questions: 4 questions for each of four learning steps, and the second indicator is the attitude to share information, which is measured by 4 questions.

The mean value for attitudes to perform steps in the learning process is 3.2 and there is no significant difference between the attitude value of operators and managers. There are however some differences between operators and managers for specific questions. The managers have a higher mean value for questions about discussing causes with colleagues/staff, valuing the opinion of colleagues/staff, involving staff in formulating actions and about finding it useful to get explanations about incidents. Operators more often than managers indicated that they strongly agreed on the statement that management valued the opinion of staff.

The mean value for attitudes to share is 3.09 and there is no significant difference between the attitude value of operators and managers. There are also no differences between the two groups for specific questions about attitudes to share information. The lowest overall mean value was 2.82, for the question 'you colleagues inform you on events they report'.

6.1.3. Organisational supporting factors to learning

Two indicators are used to determine the organisational aspects for learning. The first indicator covers 'management commitment

Table 1
Example of questions to assess one of the indicators.

Indicator: attitude towards detection (operators)	Not at all	Not really	A little	Absolutely
You are vigilant to anomalies and weak signals				
You are used to report incidents				
Abnormal situations are often reported				
If there is a deviation you rapidly identify it				

Please cite this article in press as: Drupsteen, L., Wybo, J.-L. Assessing propensity to learn from safety-related events. Safety Sci. (2014), http://dx.doi.org/10.1016/j.ssci.2014.02.024

and 'openness and experimentation' and contains 7 questions. The second indicator covers questions on 'systems perspective' and on 'knowledge transfer and integration', containing 8 questions.

The mean value of organisational indicator 1 is 3.31. On this indicator, managers have a significant higher mean score (3.57) than operators (3.22). The differences mainly consist on the questions about openness and experimentation. The managers have a higher score than operators on three questions, indicating that they more often agree on these. The questions on which operators and managers differ are: 'You can express your opinions and make suggestions regarding the procedures and methods in place for carrying out tasks'; 'You consider that experiences and ideas provided by external sources (contractors, customers, etc.) are useful for learning'; 'You are supported when you make suggestions for safety improvements'.

The mean value for organisational indicator 2 is 3.00. Although operators have a slightly higher score than managers, this difference is not significant. There are significant differences for specific questions. Operators score higher when asked if they are well aware how they contribute to safety, in comparison to when managers are asked if people in the company are well aware on how they contribute to safety. Managers score higher when asked about knowledge of their colleagues (meaning managers) of the safety objective, than operators do when asked about their colleagues (meaning operators).

6.1.4. Systems that support learning from events

The indicators that are used to determine the systems for learning are: systems to facilitate the performance of learning steps (systems 1) and systems to facilitate sharing of information (systems 2).

The mean value for systems 1 is 2.79; this is not significantly different between managers and operators. There is however a significant difference between operators and managers for the question 'you know the process to analyse accidents occurring in your site'. Managers more often agreed on this question than did operators.

The mean value for systems 2 is 3.06; this value is not significantly different between operators and managers. There are also no questions in which the values of operators and managers differ.

6.1.5. Relations

Fig. 4 illustrates the significant correlations between the indicators for propensity to learn, and the questions representing learning. The figure shows that perceived learning, meaning how well the respondents think the organisations learns, is mainly correlated to attitude to perform and the two organisational factors. The figure also shows that whether people believe all accidents can be prevented (zero accidents) is not correlated to attitudes to learn, organisational conditions to learn, or systems to learn.

6.1.6. Impressions from the interviews and results

Overall, the managers and operators are sensitive to safety events and they learn a lot from past events. A majority of them thinks that not all accidents can be avoided; they do not systematically perceive all *deviations* from procedures and rules, and they are not fully convinced that all *abnormal situations* are reported. A majority of managers and operators does however think that all *safety events* are reported and that information about incidents and related actions is good. The consensus is weaker on the involvement of operators in the choice of actions for improving safety.

At an organisational level, managers are committed to safety and open to suggestions, but operators indicate that they are not always rewarded for proposing new ideas, even if there is a good freedom of speech on working methods and procedures. Mistakes and errors are not always discussed and analysed and people are not systematically encouraged to share experiences, especially false alarms, failures and successes.

6.2. Individual propensity

Assessing individual propensity to learn is important on one hand to identify people who show a strong willingness to commit themselves in the five phases of the learning process and on the other hand to identify people who show some deficiencies in their motivation to participate in one step or the other. Fig. 5 shows two examples: on the left, an operator (N°8) showing a good attitude for the five phases and on the right a manager (N°10) showing deficiencies in two learning steps: analysis and sharing of information.

Individuals showing a high propensity to learn should be used as "*learning agents*" to promote the learning process in their group, to train colleagues and disseminate learned lessons. If the proportion of such people in the organisation is high and they interact frequently, they contribute to a good percolation of knowledge through the organisation (Wybo, 2013),

In the experiment, 2 managers and 10 operators show a score higher than 3 on every question (17% overall). They considered themselves as highly committed to the learning process and dissemination of lessons learnt (Fig. 5, left). This figure and the high score of more than 50% for each phase may explain why this company/site has an efficient learning process.

People showing deficiencies in one or several learning steps (Fig 5, right) represent the target of specific training sessions, to make them understand why and how such learning steps should be achieved and what benefit they will gain from achieving them.

We then analysed the average value of these five indicators for each group: managers and operators (Fig. 6). We founded slight differences for four of the steps and only a difference between operators and managers for the follow-up indicator. Operators might need some more attention with respect to this step.

7. Discussion and conclusions

The purpose of the current study was to develop a set of indicators to investigate the propensity of an organisation to learn from events. Among the different aspects we accounted for in defining these indicators, three out of the five principles that govern High Reliability Organizations (Weick and Sutcliffe, 2007) are present: preoccupation with anything that may be wrong from weak signals to incidents, sensitivity to front line operations and deference to expertise, wherever it stands. Propensity to learn represents a tendency of individuals or an organisation, which means an anticipation of what their behaviour will be in the future. We argue that learning propensity indicators are part of a set of leading indicators that can be used by managers to improve their organisation's resilience. "*Leading indicators also referred to as 'input indicators' and 'activity-based indicators', are most useful as precursors to safety degradation for early management reaction (…) Leading indicators can be seen as measures of the quality and implementation of safety management processes and programmes*". (Oien et al., 2011).

In this paper the indicators and the results of application of these indicators in one organisation were presented. We proposed a set of 6 indicators, to determine the propensity of an organisation to learn from experience, meaning the propensity to perform steps in the learning process and the propensity to share information. Two indicators aimed to measure the attitude towards learning, two indicators aimed to measure the organisational conditions for learning and two indicators aimed to determine the availability of systems that facilitate learning. Moreover, five indicators were used to determine the individual propensity: attitude to detect,

Please cite this article in press as: Drupsteen, L., Wybo, J.-L. Assessing propensity to learn from safety-related events. Safety Sci. (2014), http://dx.doi.org/10.1016/j.ssci.2014.02.024

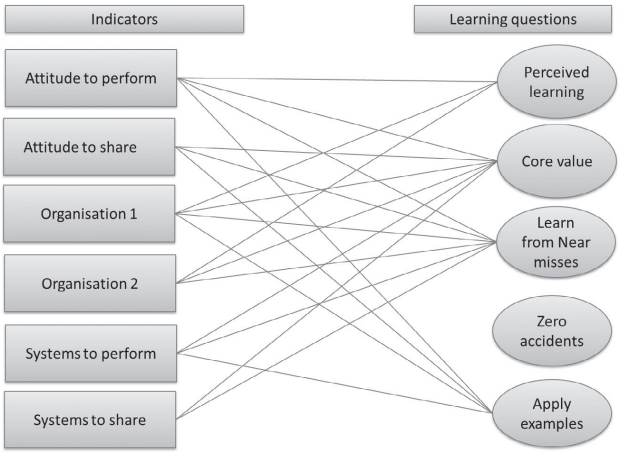

Fig. 4. Correlations between indicators and questions (organisational level).

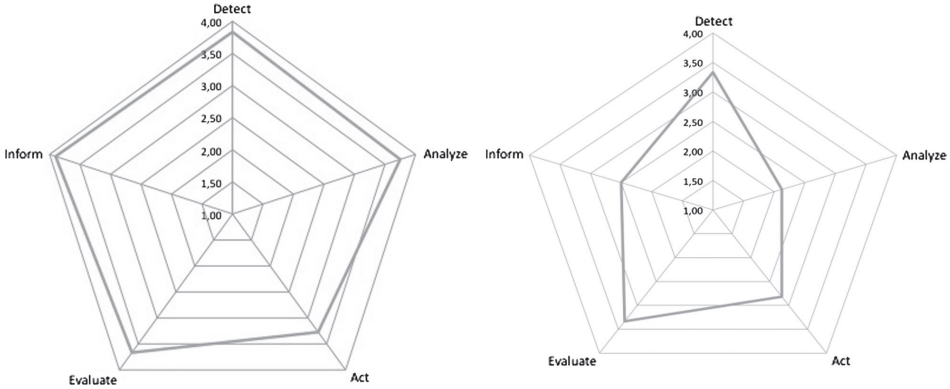

Fig. 5. Individual propensity as the attitude towards the five learning steps.

attitude to analyse, attitude for follow up, attitude to evaluation, and attitude to share information.

The results from the test company suggest that both operators and managers have a positive view on how well the organisation learns from experience. A majority of the respondents does however not believe that all accidents can be prevented. The results also illustrate that the opinion on how well the organisation learns mainly depends on the attitude to perform steps in the learning process and the score on the two organisational indicators. These results imply that this organisation has a high propensity to learn, meaning that it is likely to successfully learn from future events as it did so far.

Another major finding was that differences in opinion between managers and operators seem to exist on questions about involvement of colleagues. The results suggested for instance differences in opinion on: how ideas of employees about procedures, tasks and safety improvements are appreciated; the involvement of employees in discussing causes of accidents and when formulating actions; the extent to which people are encouraged to share experiences such as false alarms, failures and successes. In this study, managers were found to have a more positive view on involvement of the employees, than the employees did themselves.

The organisational indicators enabled the identification of weaknesses in the propensity of the organisation, which may help the managers to improve the learning process of their organisation at a global level. Besides the organisational propensity, the individual propensity was assessed, through the attitude to learning. The individual indicators assess whether there are specific groups or subjects that need attention, which may help to identify training needs. The results indicated that overall, the attitudes to perform the steps were high. Only for follow-up there was a difference between operators and managers, and operators might need some more attention with respect to follow up. 17% of the people in the organisation had a very positive attitude towards each aspect of the learning process. These people could be examples for others in the organisation and stimulate the learning process.

Please cite this article in press as: Drupsteen, L., Wybo, J.-L. Assessing propensity to learn from safety-related events. Safety Sci. (2014), http://dx.doi.org/10.1016/j.ssci.2014.02.024

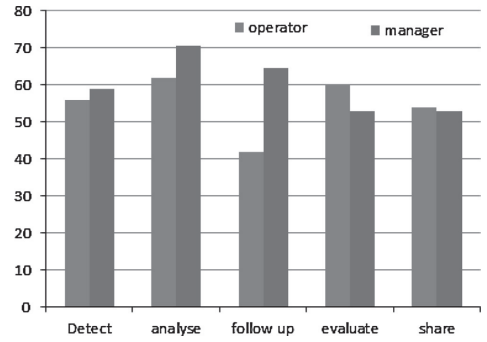

Fig. 6. Percentages of people with high indicator (3 or more on all questions for the step).

A number of caveats need to be noted regarding the present study. The most important limitation lies in the fact that the results cannot be compared to actual learning. The proposed indicators aim to identify weaknesses and strengths within the organisation that may predict whether an organisation will be able to learn from events. However, the predictive value of these proactive measures cannot be tested, since there was no specific event to learn from. The comparison between the assessment of the propensity of an organisation to learn and actual learning from experience may be addressed in future (longitudinal) research. Another limitation of this study lies in the fact that the indicators are only assessed through self-reports and in a limited group (17 managers and 50 operators). The advantage of self-reported answers is that they directly give the view of the respondents, however, self-reported measures are susceptible to social desirability bias and therefore represent a threat to the validity of the results. By increasing the number of participants within the organisation, validity may be increased and a more detailed analysis might be performed. But, this was not the objective of this preliminary field validation of the methodology. Despite these limitations, the indicators that are proposed in this study may support managers in improving the overall learning process.

Further investigation and experimentation into the propensity of an organisation to learn is strongly recommended. This model of indicators could be tested on a broader scale to determine the applicability in a wide range of companies. Also, more in-depth analyses and comparisons between departments and organisations could increase the knowledge on how to predict the capability of an organisation to learn (its learning propensity).

Acknowledgments

The authors would like to thank the participants of the organisation for their contribution to the research. We specifically would like to thank Sandrine EICHENLAUB, Graduate student at Mines Paristech (France) for participating in this project and for distributing the questionnaires amongst managers and employees.

References

Armstrong, R., 1987. The midpoint on a Five-Point Likert-Type Scale. Percept. Mot. Skills 64, 359–362.
Argyris, C., Schön, D.A., 1996. Organizational Learning II: Theory, Method and Practice. Addison-Wesley, Reading, MA, 305 p.
Boin, A., Hart, P., 2003. Public leadership in times of crisis: mission impossible? Publ. Administration Rev. 63 (5), 544–553.
Bonney, M.C., Zhang, Z., Head, M.A., Tien, C.C., Barson, R.J., 1999. Are push and pull systems really so different? Int. J. Prod. Econ. 59 (1–3), 53–64.
Brizon, A., Wybo, J.L., 2009. The life cycle of weak signals related to safety. Int. J. Emergency Manage. 6 (2), 117–135.
Carmeli, A., Schaubroek, J., 2008. Organisational crisis-preparedness: the importance of learning from failures. Long Range Plan. 41, 177–196.
Carmeli, A., Gittell, J.H., 2009. High-quality relationships, psychological safety, and learning from failures in work organisations. J. Org. Behav. 30, 709–729.
Carroll, J.S., 1998. Organisational learning activities in high hazard industries: the logics underlying self-analysis. J. Manage. Stud. 35 (6), 699–717.
Cheverst, K., Smith, G., 2001. Exploring the notion of information push and pull with respect to the user intention and disruption. In: International workshop on Distributed and Disappearing User Interfaces in Ubiquitous Computing, pp. 67–72.
Chiva, R., Alegre, J., 2009. Organisational learning capability and job satisfaction: an empirical assessment in the ceramic tile industry. Br. J. Manag. 20, 323–340.
Chiva, R., Alegre, J., Lapiedra, R., 2007. Measuring organisational learning capability among the workforce. Int. J. Manpower 28 (3/4), 224–242.
Chung, P.W.H., Jefferson, M., 1998. The integration of accident databases with computer tools in the chemical industry. Comput. Chem. Eng. 22, S729–S732.
Cox, E.P., 1980. The optimal number of response alternatives for a scale: a review. J. Mark. Res. 17, 407–442.
Dahl, O., Olsen, E., 2013. Safety Compliance on offshore platforms: a multi-sample survey on the role of perceived leadership involvement and work climate. Saf. Sci. 54, 17–26.
Drupsteen, L., Groeneweg, J., Zwetsloot, G.I.J.M., 2013. Critical steps in learning from incidents: using learning potential in the process from reporting an incident to accident prevention. J. Occup. Saf. Ergonomics 19, 63–77.
Fahlbruch, B., Schöbel, M., 2011. SOL – safety through organisational learning: a method for event analysis. Saf. Sci. 49, 27–31.
Friedman, H.H., Wilamowsky, Y., Friedman, L.W., 1981. A comparison of balanced and unbalanced rating scales. Mid-Atlantic J. Business 19 (2), 1–7.
Fuller, C.W., 2005. An assessment of the relationship between behaviour and injury in the workplace: a case study in professional football. Saf. Sci. 43 (4), 213–224.
Garland, R., 1991. The mid-point on a rating scale: is it desirable? Marketing Bull. 2, 66–70.
Geller, E.S., Roberts, D.S., Gilmore, M.R., 1996. Predicting propensity to actively care for occupational safety. J. Saf. Res. 27, 1–8.
Gilliland, S.W., Schepers, D.H., 2003. Why we do the things we do: a discussion and analysis of determinants of just treatment in layoff implementation decisions. Human Resour. Manage. Rev. 13, 59–83.
Goh, S., Richards, G., 1997. Benchmarking the learning capability of organisations. Eur. Manage. J. 15 (5), 575–583.
Grabowski, M., Ayyalasomayajula, P., Merrick, J., Harrald, J.R., Roberts, K., 2007. Leading indicators of safety in virtual organisations. Saf. Sci. 45, 1013–1043.
Harrison, J.D., Young, J.M., Butow, P., Salkeld, Solomon, M.J., 2005. Is it worth the risk? A systematic review of instruments that measure risk propensity for use in the health setting. Soc. Sci. Med. 60, 1385–1396.
Hatfield, J., Fernandes, R., 2009. The role of risk-propensity in the risky driving of younger drivers. Accid. Anal. Prev. 41, 25–35.
Henning, J.B., Stufft, C.J., Payne, S.C., Bergman, M.E., Mannan, M.S., Keren, N., 2009. The influence of individual differences on organisational safety attitudes. Saf. Sci. 47, 337–345.
Jacinto, C., Aspinwall, E., 2004. A survey on occupational accidents'reporting and registration systems in the European Union. Saf. Sci. 42, 933–960.
Jerez-Gómez, P., Céspedes-Lorente, J., Valle-Cabrera, R., 2005. Organisational learning and compensation strategies: evidence from the Spanish chemical industry. Human Resour. Manage. 44 (3), 279–299.
Johnson, C., 2002. Software tools to support incident reporting in safety-critical systems. Saf. Sci. 40, 765–780.
Julien, P.A., Andriambeloson, E., Ramangalahy, C., 2004. Networks, weak signals and technological innovations in the land-based transportation equipment sector. Entrepreneurship Reg. Dev. 16 (4), 251–269.
Keil, M., Wallace, L., Turk, D., Dixon-Randall, G., Nulden, U., 2000. An investigation of risk perception and risk propensity on the decision to continue a software development project. J. Syst. Softw. 53, 145–157.
Kulas, J.T., Stachowski, A.A., 2009. Middle category endorsement in odd-numbered Likert response scales: associated item characteristics, cognitive demands, and preferred meanings. J. Res. Pers. 43 (3), 489–493.
Lindberg, A.K., Hansson, S.O., Rollenhagen, C., 2010. Learning from accidents – what more do we need to know? Saf. Sci. 48 (6), 714–721.
Lampel, J., Shamsie, J., Shapira, Z., 2009. Experiencing the improbable: rare events and organisational learning. Org. Sci. 20 (5), 835–845.
Mac Donald, N., 1997. Deriving organisational principles for safety management systems from the analysis of aircraft ramp accidents. In: Hale, A.W., Wilpert, B., Freitag, M. (Eds.), After the Event. Pergamon, pp. 95–112.
Oien, K., Utne, I.B., Herrera, I.A., 2011. Building safety indicators: Part 2 – application, practices and results. Saf. Sci. 49, 162–171.
Popper, K.R., 1959. The propensity interpretation of probability. Brit. J. Philos. Sci. 10–37, 25–42.
Ramanujam, R., Goodman, P.S., 2011. The challenge of collective learning from event analysis. Saf. Sci. 49, 83–89.
Robey, D., Boudreau, M.-C., Rose, G.M., 2000. Information technology and organizational learning: a review ad assessment of research. Account., Manage. Inform. Technol. 10, 125–155.

Please cite this article in press as: Drupsteen, L., Wybo, J.-L. Assessing propensity to learn from safety-related events. Safety Sci. (2014), http://dx.doi.org/10.1016/j.ssci.2014.02.024

Rohrmann, B., 2005. Risk Attitude Scales: Concepts, Questionnaires, Utilizations. <http://www.rohrmannresearch.net/rac.html> (retrieved 21.08.13).
Ryan, J.C., Tipu, S.A.A., 2013. Leadership effects on innovation propensity: a two-factor full range leadership model. J. Business Res. 66, 2116–2129.
Sasidharan, L., Donnell, E.T., 2013. Application of propensity scores and potential outcomes to estimate effectiveness of traffic safety countermeasures: Exploratory analysis using intersection lighting data. Accident Anal. Prev. 50, 539–553.
Schnake, M., 2007. An integrative model of effort propensity. Human Resour. Manage. Rev. 17, 274–289.
Sepeda, A.L., 2006. Lessons learned from process incident databases and the process safety incident database (PSID) approached sponsored by the Center for Chemical Process Safety. J. Hazard. Mater. 130, 9–14.
Serra, F., Pointon, J., Abdou, H., 2012. Factors influencing the propensity to export: a study of UK and Portugese textile firms. Int. Business Rev. 21, 210–224.
Seveso, III, 2003. Council Directive 2003/105/EC of the European Parliament amending Council Directive 96/82/EC on the control of major-accident hazards involving dangerous substances. Official Journal No. L, 345.
Sharma, D., Alford, B.L., Bhuian, S.N., Pelton, L.E., 2009. A higher-order model of risk propensity. J. Business Res. 62 (7), 741–744.
Schoemaker, P.J.H., Day, G.S., 2009. How to make sense of weak signals. MIT Sloan Manage. Rev. 50 (3), 81–98.
Simard, M., Marchand, A., 1997. Workgroups' propensity to comply with safety rules: the influence of micro-macro organisational factors. Ergonomics 40 (2), 172–188.
Smits, P.A., Champagne, F., Farand, L., 2012. Beyond resistance: exploring health managers' propensity for participatory evaluation in a developing country. Eval. Program Plann. 35, 256–268.
Stern, E., 1997. Crisis and learning: a conceptual balance sheet. J. Contingencies Crisis Manage. 5 (2), 69–86.
Vaughan, D., 2001. La normalisation de la déviance: une approche d'action située. In: Bourrier, M. (Ed.), Organiser la fiabilité. L'Harmattan, Paris, pp. 201–234 (in French).
Weick, K., Sutcliffe, K., 2007. Managing the Unexpected: Resilient Performance in an Age of Uncertainty. Jossey Bass, San Francisco, CA.
Wybo, J.L., 2012. Maîtrise des risques et prévention des crises, Lavoisier, 146 p. (in French).
Wybo, J.L., 2013. Percolation, temporal coherence of information, and crisis prevention. Saf. Sci. 57, 60–68.
Yang, T.-M., Maxwell, T.A., 2011. Information-sharing in public organizations: a literature review of interpersonal, intra-organizational and inter-organizational success factors. Government Inform. Quart. 28, 164–175.

Please cite this article in press as: Drupsteen, L., Wybo, J.-L. Assessing propensity to learn from safety-related events. Safety Sci. (2014), http://dx.doi.org/10.1016/j.ssci.2014.02.024

Improving organisational safety through better learning from incidents and accidents

Linda Drupsteen-Sint

The main objective of this dissertation is to contribute to better learning from safety-related incidents and accidents in organisations. The dissertation provides a method to systematically study learning from incidents, by using a model of five phases that represent the actions necessary to successfully follow-up on incidents and to learn from them. The model builds on existing theories from safety and organisational learning, that are now applied to learning from incidents. In addition, this dissertation explains causes for ineffective learning, and a set of indicators to assess the conditions that facilitate learning, is provided. Through creating and sustaining these conditions in which successful learning is likely to occur, the ability of an organisation to learn improves.

Thus, this dissertation increases the understanding of learning from incidents by providing empirical findings on how organisations learn from incidents in practice, and on hindrances and successes in the current learning approaches.

ISBN: 978-87-91831-64-5