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

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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*

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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

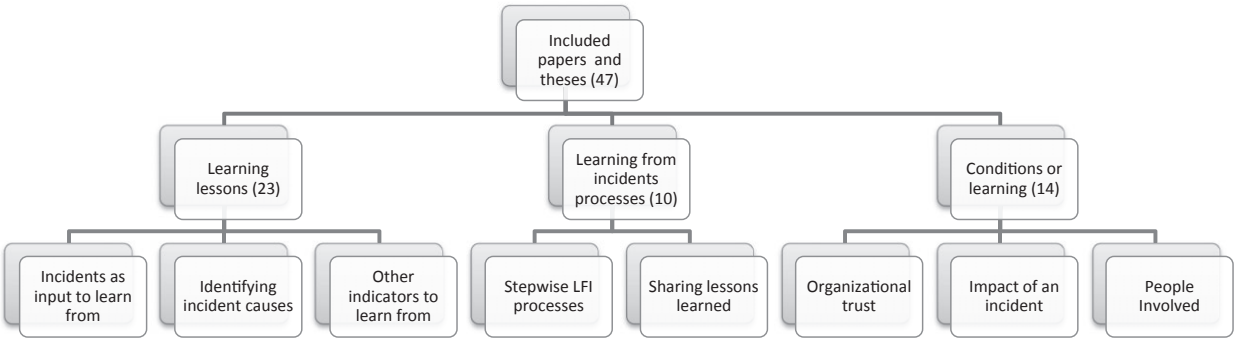

Figure 1. Overview of the topics on learning from incidents in the literature.

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.

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