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

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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

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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

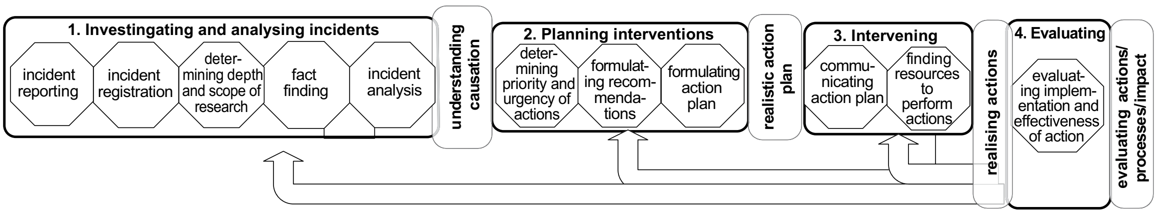

Figure 1. Model of the learning from incidents process.

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 9 001:1997 [20]), ISO 14 001:2004 [21] and OHSAS 18 001:2007 [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

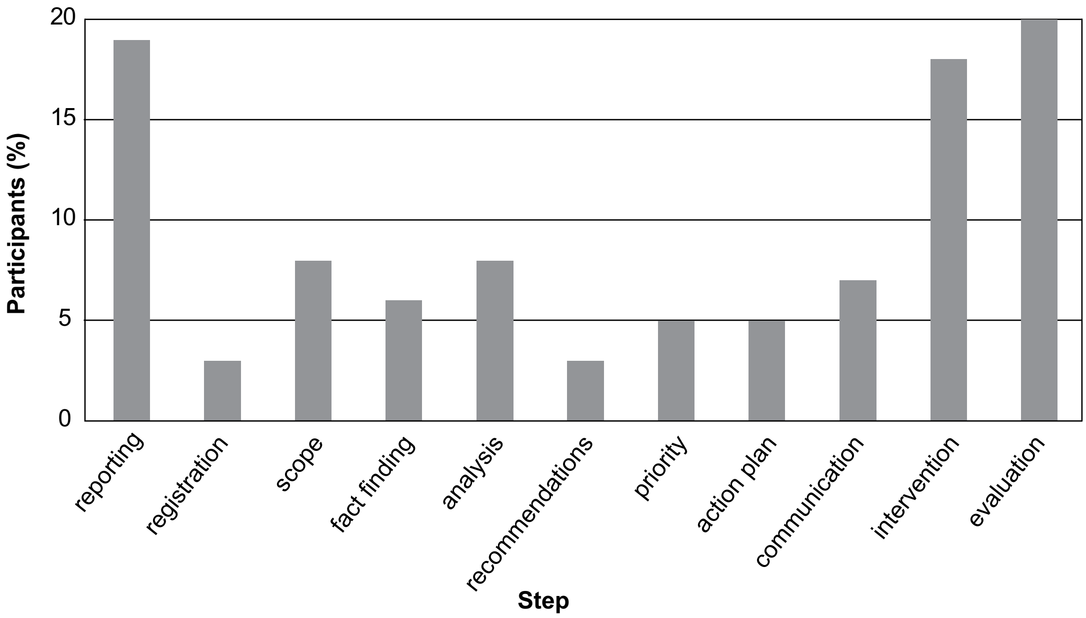

Figure 2. Step in which main bottleneck is located according to participants.

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	Construction	Energy and Waste	Food	Government	Metal	Transport	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	Construction	Energy and Waste	Food	Government	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,

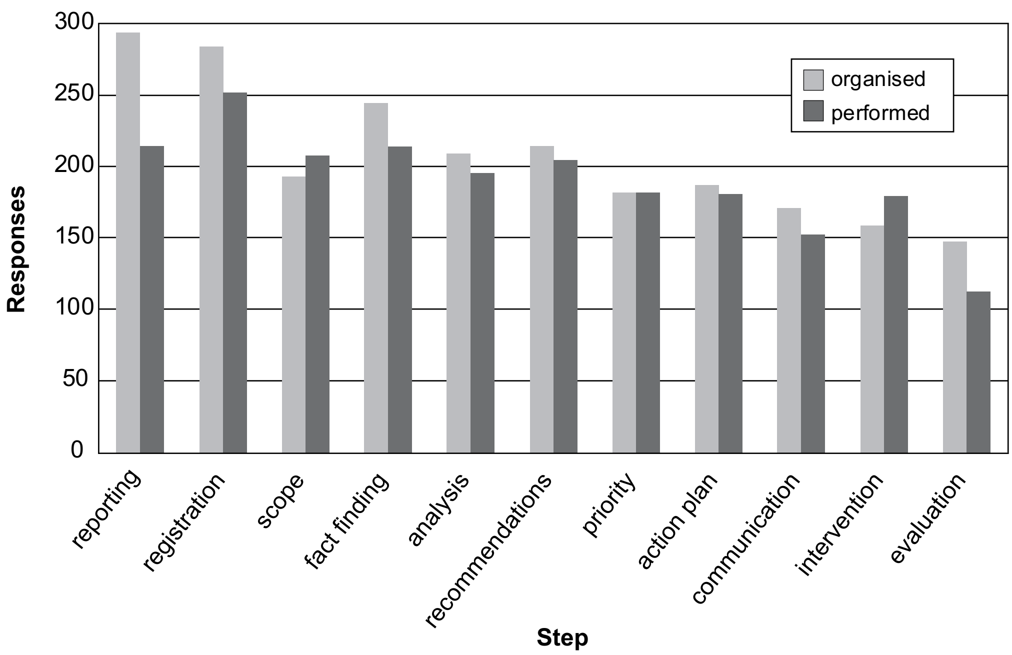

Figure 3. Overall comparison in responses per step on what is organised and what is performed well. *Notes. n* = 303.

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.

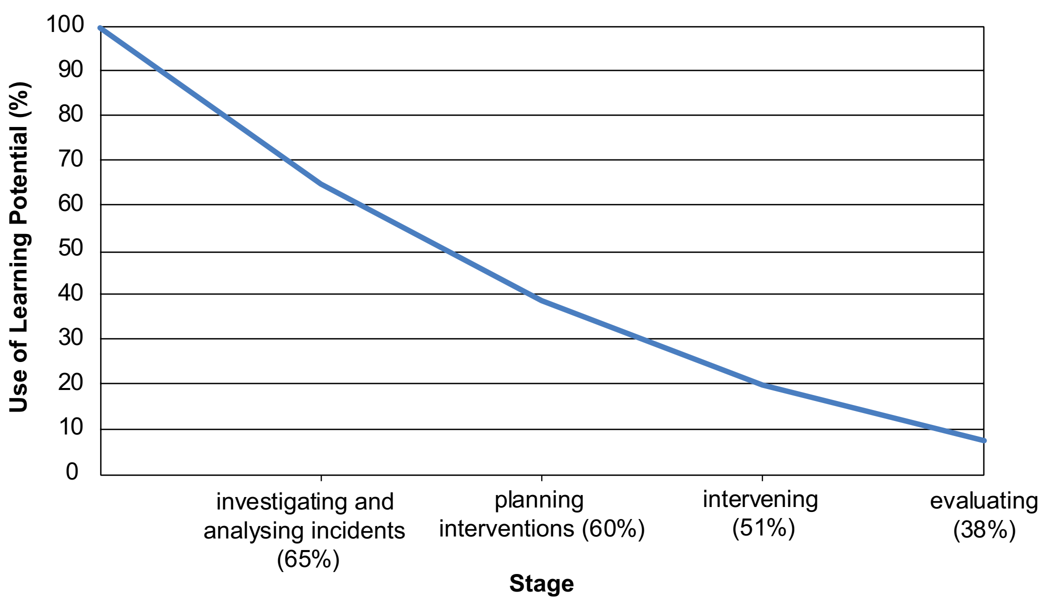

Figure 4. Use of learning potential. *Notes.* The percentages on the horizontal axis indicate the percentage of respondents that indicated that the stage was performed well in daily practice. Learning potential is calculated by multiplying the proportions of successive stages.

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.