Final report – ACCILEARN
Accident investigation and learning effects within emergency organisations and across societal sectors.
Learning processes in a comparative perspective

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1. Introduction

The major goal of ACCILEARN has been to reveal different patterns in the learning processes from accident investigations. Also direct scrutiny of learning processes within emergency organisations has been an important part of the project. We have been interested in the very construction of and change in learning processes. We also wanted to analyse how these learning processes were dependent on their specific societal contexts. Thus, it became early evident that we needed to focus on how learning processes were designed, perceived and followed up in various organisations and sectors.

Historically, major accidents have been claimed to be the initial change tool. From the establishment of investigation boards within the transport sector there has been developed systematic approaches to investigations. In many respects the Accident Investigation Board Norway (AIBN) has been regarded as the pioneer of what might be perceived as best practice in accident investigations. This report presents the results from the research project ACCILEARN (Accident investigation and learning effects within emergency management organizations and across societal sectors. Learning processes in a comparative perspective.) This project has been part of the Norwegian Research Council's SAMRISK programme.

ACCILEARN is closely related to the University of Stavanger (UiS), Accident Investigation Board Norway, Norwegian Board of Health Supervision, SINTEF and Lund's project in the RISIT programme; "Accident investigation and learning effects within transport modes and across societal sectors." ACCILEARN has been a joint project between IRIS (International Research Institute of Stavanger - project lead), the universities of Stavanger (Norway) and Lund (Sweden), and Norwegian Board of Health Supervision in Oslo (Norway).

1.1 Hypothesis

Accident investigations are often considered an important tool for learning from accidents – not only to avoid the recurrence of the exact same event but to improve safety in general. However, learning from accidents is not straightforward and there are a number of aspects that affect the potential for learning. Different ways of "reconstructing the truth" from the abundance of clues that can be found on the accident scene can depend on the framing of an event. Consequently, the attempt to identify causes in an accident investigation is to a large extent influenced by the underlying assumptions about how accidents happen, either explicitly

expressed by the technique or method adopted by the investigator or more implicitly by the investigator's experience or the traditions of the investigation team (Hollnagel, 2008).

Since there are no objective criteria, or ‘stopping rules’, for when it is no longer necessary to search for additional causes of an accident, there is arbitrariness in the attribution of contributory causes. The project has emphasized specific issues and judgements to be made in accident investigation, and particularly the investigators’ power as the narrators of the “true” stories. Ellinor Ochs (1997) describes narrative as: ”It is our cares about the present and especially about the future that organize our narrative recollection of past events”. Within this perspective, how are we to understand the investigations being carried out? Who are the actors in a power perspective given preference in relation to the interpretations, or even re-interpretation, of the accidents?

The project has challenged the main hypothesis that ***accident investigations play an insignificant role in the learning at individual, organizational and cross sectoral levels in society***. This perspective has guided us as a starting point towards a critical stance of learning in line with Dekker et.al (2008). Before we present the results from ACCILEARN we provide the results presented from ACCILEARN II, which was finalized in 2010 (Njå et al., 2010).

1.2 Results from the ACCILEARN II project

The research work in ACCILEARN II showed the following results:

1. A new tool to analyse the potential of learning (Braut & Njå, 2010).
2. A historical analysis of the organizational development of accident investigation, revealing that even though learning has been referred to no attempt has been made to define either what constitutes learning or how learning processes should be designed (Jakobsson, 2010).
3. The historical study on the development towards multi-modal accident investigation boards concerns the *lack* of references to different investigation methods or contemporary risk and safety research (Jakobsson, 2010).
4. The hypothesis that unique major accidents had an important impact on political decisions has proved probable and could also contribute to explaining the chronological discrepancy between Norway and Sweden (Jakobsson, 2010).
5. The structure and mandate of the investigation boards puts limitations on the scope of investigations and hence on the potential for learning from accidents. Moreover, the investigation reports generally lack, or do not specify, the intended process of actions at different societal levels. The Swedish board has the broadest mandate (Cedergren & Petersen, 2011).
6. The most important factor for learning from an incident or accident is how the information and knowledge generated by the accident itself is dealt with immediately after the event has occurred (Braut & Njå, 2010).
7. Our scrutiny of single investigation reports (mostly ad-hoc based) revealed that they tend to come very late, and the contents are only partly or occasionally directed toward learning (Braut & Njå, 2010).
8. Investigation processes or systems for investigation of accidents are not designed on the basis of risk analyses. (Braut & Njå, 2010)

9. By taking on a *multilevelled* approach to learning, accident investigation is 'by default' seen as part of a bigger picture (Hovden, Størseth, & Tinmannsvik, 2011). Key results may be outlined along the axis of learning inhibitors – learning contributors. The following were identified as *learning inhibitors*: 'Remote control' (describing how the organization 'in question' feels forced or almost threatened e.g. by authorities to act, fast), tactless and rude disaster journalism (i.e. how the media tweak, twist and destroy the necessary focus after an accident, in their disrespectful race to sell a story), theatre and puppet-play (referring to the empty 'rituals' and 'ceremonies' that are typically enforced and put into play after the accident; i.e. various hasty actions set in motion to show that things are being done), the 'safety snobs' (referring to safety tending to become a self-serving academic discipline, void of operative relevance), the procedure alibi (the inclination to load the system with procedures as a way of demonstrating change). The following were identified as *learning contributors:* Dismiss the question of blame - aim for understanding, do not forget - keep history alive, accept learning as a skill – it must be maintained, curb the urge for procedures (Størseth & Tinmannsvik, 2010).

The work carried out in ACCILEARN consists of many different approaches and perspectives on learning, which have contributed to a rich and reflective understanding of the complex phenomenon. In the following chapters 2, 3 and 4 we will present the main results of our work at the present time. Several of the activities will be continued after the project period in other projects.

2. A further development of the theoretical framework on learning

Researchers on learning does not agree on how to understand the concept of learning, neither as a general concept nor related to professional practice and work. No single definition covers all aspects of the concept of learning, and different research traditions use different approaches to learning. However, in general literature in educational science as well as in literature on organizational learning and workplace learning, it is possible to identify a shift from learning viewed as acquisitions of individual knowledge and skills (a psychological cognitive perspective) towards learning views as participation and involvement in social systems (a socio-cultural perspective). Learning in this perspective seems to emphasize knowledge as something achieved, constructed, modulated and possibly abandoned through collective reflection and interactive relationship between persons working with the same or similar tasks.

In our scrutiny on learning we have elaborated on various learning theories, we have developed a tool to reveal learning potential from accident investigations, we have scrutinized accident investigations in a risk management perspective and finally we have developed the concept of risk images as a measure on personnel's and organisations' learning abilities. The work conducted forms important parts of Geir Sverre Braut's dissertation.

2.1 The individual concept of learning

The following presentation of the concepts of learning is based on Braut & Njå (2010), Braut et.al. (2012), Njå & Braut (2010, 2011) and Sommer, Njå & Braut (2012). Current theories in educational science are chosen as a theoretical background for our proposed elements of assessing the learning potential from accident investigation reports.

Research on learning in organizations is often occupied with the ability of the new knowledge to lead to *changes* in the relevant settings. In our individual concept of learning we assume

that learning also covers *confirmation* of existing knowledge and gaining deeper *comprehension* of existing practice. The concept of knowledge used here includes theoretical (factual) knowledge as well as practical skills and the attitudes needed for integration of the knowledge and skills in individual or collective behaviour. Learning therefore may be defined as *processes related to establishing new knowledge aiming to implement changes to, gaining deeper comprehension of and/or confirming the basis for current apprehensions and practices* (Braut & Njå, 2010). We further assume that the least unit applicable in studying learning must be the single individual. Even when studying larger units as groups, organizations and societies we also think that the study of learning on individual level is of crucial interest. Not merely individual cognitive processes but also behaviour and changes in social systems rely upon participation from individuals.

Constructions presented in the texts of investigation reports must be argued and presented so that they are suitable as objects for scrutiny in learning processes. The list of elements is designed as a set of questions to support the analysis through close reading. Each question is intended to reveal explicit or embedded elements of the text that can facilitate the use of the text as a didactic tool in a learning process.

2.2 A tool to approach learning potential

In sorting these didactic elements into groups we have been inspired by the triad established by Donald Schön on information, context and reflection. We have accordingly sorted the elements into these three groups:

1. Elements related to *contents*, information, message, epistemological basis and desired cognitive structures.
2. Elements related to relevant *context* and involved communities.
3. Elements related to *commitment*, objectives and measures for learning, rewarding, motivation and evaluation.

To make the elements explicit, we have developed a tool consisting of specific questions (Njå & Braut, 2010). An investigation report with a well designed and elaborated text should according to our view be able to give answers to these questions. This tool is operationalized through issues on the investigation reports' contents, contexts and commitments. As such, the tool enforces the assessor to critically reflect upon how the major causal explanations are substantiated and adapted to provide active speculation and responses amongst significant target actors. For most cases we claim that the tool is sufficiently detailed and adequate, but further empirical studies are needed.

Multimodality is a commonly acknowledged concept in research related to literacy. Meaning can be expressed in several ways, not only through written texts. In this project the analytic instrument was applied to conventional texts consisting of written sentences and some illustrations (Njå & Braut, 2010). A possible topic for future research is to study if this or similar instruments can be applied to a more extensive learning process based on investigation of incidents. It could be conjectured that a multimodal approach, taking into account not only the report in itself but also other sources of knowledge relevant for the incident studied, such as newspapers, broadcasted news, narratives in any form (videos, pictures, verbal) told by relevant actors, research papers etc, might stimulate a reflective learning process more efficiently than merely distributing the written report to interested parties.

2.3 Combining historical investigations and future risk assessments – risk images

The use of risk analyses for planning and maintenance purposes has increased in recent decades. Not only has this been the case in the industry and transport sectors, but risk analyses

have gained increasing popularity also for societal planning purposes, e.g. in local community development and emergency preparedness.

The overall aim of risk analyses is to reduce the number of undesired incidents and their potential outcomes. But since risk is a phenomenon with stochastic properties, we cannot expect even the best performed risk analysis to guarantee absolute risk control and no unexpected, undesired incident or negative outcome.

Scant interest has been shown in how prior risk analyses are dealt with in subsequent incident investigations. Accident investigations often criticize involved parties for not having carried out risk analyses, especially assessments that could have prevented the accidents. We regard this as a narrow interpretation of what risk management can provide. Analyses of root causes and background variables during an incident investigation process must be seen as representations of investigators' preconceptions of good safety management principles, regarded as acknowledged practice. It is a misconception to regard highlighted background risk management variables as true explanations of accidents.

In a risk management system based on risk acceptance limits, the operator needs to demonstrate to the authorities that the limits have been met. This is often achieved by referring to the risk results, and involvement by the authorities is sometimes rather superficial.

With an As Low As Reasonable Practicable (ALARP) approach, this also implies that authorities' involvement needs to be stronger. ALARP requires continuous updating of the risk image. The authorities, as supervisory bodies before a possible accident as well as investigators after an accident, must therefore concentrate on how the organizations establish and continuously maintain and make use of a valid risk image. The reflections and discussions on this risk image both among the employees and on managerial level are probably more important than the risk image itself. The ALARP demonstration is more comprehensive than merely inspecting risk results. For authorities to review an ALARP demonstration, an extensive evaluation process will normally be needed to determine if a sufficiently wide search for alternatives (e.g. possible risk reducing measures) was taken, and whether arguments relating to gross disproportion are valid. This means that more effort is required on the part of the authorities.

Our main hypothesis in this work (Njå & Braut, 2011) was that the investigators' preconceptions of good safety management would dominate the investigations. We conclude that our empirical data support this view, but different approaches are found in the literature. Andrew Hopkins (Hopkins, 2010) based his criticism upon his evidence collected in the vicinity of "bad decisions". The Groth commission (NoU 2000: 30) and the PSA (PSA, 2009) related their view to regulations and risk management guidelines. Hopkins sees the balance between risk based and prescriptive based regulations as a pendulum in which he advocates stronger emphasis on prescriptive regulation (Hopkins, 2011). One might expect that organizations with highly professional personnel with clear tasks in a well structured environment need less prescriptive regulations, but it is also possible to argue that some values are so important that they should be protected and supported by prescriptive regulations and clear norms. A prescriptive regulatory regime must at least make allowance for continuous development on the basis of contemporary and relevant scientific knowledge. In the same way corporate risk analyses must not be confined to the presentation of a static, once-upon-a-time picture of the risk in an enterprise.

As risk analyses presume to say something about the future, it is difficult to see that any particular risk analysis can be judged as right or wrong. At least it cannot be done alone on the basis of hindsight as to what really happened in the aftermath of the analysis. That said, risk analyses can still be judged as good or bad. To emphasize the constructivist interpretation of a

risk analysis we propose to use the notion risk image instead of risk picture, which is the term commonly used today. We contend that a good risk analysis, for either managerial or for learning purposes, must possess the following properties:

1. The analysis must invent a risk image based on up to date knowledge and subsequent attempts to construct valid causal relationships between identified and shared opinions on threats and hazards and connected consequences.
2. The analysis must encourage sharing of the risk image among the relevant actors, and give them the opportunity to comment upon identified threats and hazards as well as connected consequences.
3. The analysis must establish a platform for continuing development of the risk image so that the risk image depicts the current operational situation in a valid way.

2.4 Towards a comprehension of risk images as part of the learning processes

The British sociologist Anthony Giddens has introduced the concept of fateful moments. However, it is not easy to recognise fateful moments in the real world, and lack of time and competence coupled with structural and organisational barriers and unawareness of system complexity make the task difficult. Tools for risk and vulnerability analysis can lend powerful decision-making support and help to ensure optimal outcomes. Drawing on the concept of fateful moments and common risk analytic approaches, we have studied the use of risk based thinking in two different decision-making settings, neither of which is typical of the current use of risk analyses (Braut, et al., 2012). Both situations however, may be interpreted as fateful moments as described by Giddens.

It is the decision makers themselves who need a valid risk image for their judgements and decisions. Experience may indicate that the presented risk analysis tools help decision makers to be more open to evidence-based reflection on the possible risks related to the activities or systems involved. It is not the analysis in itself that is of interest in these situations but the need to arrive at reasonable and sound decisions. Both approaches are extremely operational, enabling the involved parties to evaluate the quality of the decisions made and vary more or less ad hoc the actions and decisions to come. The risk analyses tools could thereby be a valuable means of learning, providing feed-back that can be used in assessments of change, assessments of confirmation and assessments of comprehension (Braut & Njå, 2010). It will also lay the ground for storytelling, which will further increase learning effects beyond the narrower perceptions of the decision makers (Sommer & Njå, 2011).

We suggest that training practitioners who act as decision makers in constructing risk images and bear in mind the concept of fateful moments with focus on uncertainty before and during their routine decision making may help decision-makers arrive at better decisions, opening up for a broader perspective on possible outcomes and forcing decision makers to become aware of their beliefs in the different outcomes.

Instead of seeing this as constructing a risk picture in a more traditional way through ordinary risk analysis, we claim that this approach makes use of the intellectual capacity of the professionals to build images of possible outcomes based upon their own experiences, their professional knowledge and discussions with relevant other people. They thereby become more aware of the dynamic and comprehension of risk. Possibly they will also be more aware of what personal experiences they draw on to construct the risk image and thus may communicate the foundations for the risk image more clearly to other persons they cooperate

with. To distinguish this from the risk picture produced by traditional risk analytic approaches, we here prefer to call this a risk image.

3. Learning – comparative cases

3.1 The Norwegian and Swedish energy sectors[1]

Jakobsson (2010) analyzed the development from sector specific boards to permanent multi-modal commissions in Sweden and Norway. One finding was the importance of the independence of investigating commissions, and another was the lack of discussions on incorporating, on one side the Norwegian offshore oil & gas system and on the other side the Swedish nuclear system, into the new multi-modal accident investigation organization. The silence of the sources on these two new, dominant and grand technical systems, built up parallel in time to each other and parallel to the political discussion on accident investigations, brought on new questions on how accident investigations in these two national technical systems became organized.

In the article the Norwegian offshore and the Swedish nuclear system are studied as socio-technical systems. In this perspective accident investigation institutions will be considered as part of these systems. Generally there are very few accidents in these technical systems compared to for example transportation systems. In this aspect there is one important distinction between the Norwegian offshore and the Swedish nuclear system. The former has up to now experienced some major accidents and the latter has not. How is accident investigations organized when there are little or none experience of major accidents? Will the national understanding and traditions influence the road that is chosen?

However, there are many similarities between the two socio-technical systems. The systems are highly embedded in both nations, and have for example continuously been on the political agenda. They are political controversial; on for example environmental risk and localization in Norway. In Sweden there was a referendum on the nuclear system itself and there has been a long lasting debate on the disposal of radioactive waste. The states occupy many roles in these technical systems; they have considerable economic interests, both act as owners and operators (Statoil, Vattenfall), and on a national level (economy, energy). Though the Swedish nuclear system is built on an existing industrial technological development and the Norwegian system was built up around oil and gas findings, they both represent new technology to the national states. New societal institutions had to be developed parallel to the build-up of the technical system. Methods for risk analyses and research, systems for graduating incidents, accidents and near accidents, plans for emergency preparedness are developed for both systems. Risk perception and attention are central for those who work in the systems. How did these new technologies influence how accident investigations were organized?

In this research activity a historical comparative method will be used to trace the development of how the accident investigating organization has been constructed. The historical perspective opens for identifying changing positions and examines how singular episodes (in this case major accidents) have had influence over the institutions that forms parts of the socio- technical systems. The historical method will also reveal societal path-dependence – how for example ideas of “best practices” to organize societal institutions are performed. The

[1] This project has been considerably delayed by a cancer diagnosis and a year of treatment and sick leave for Jakobsson. The forthcoming article will be submitted to an international scientific journal addressing safety issues.

comparison between two countries and two dominating technical systems will further highlight how these systems are embedded in the national organization.

As this is a historical study, the empirical sources are published documents. Research literature, state reports, political documents and texts of law, both contemporary and historical, will be used. They will be used to trace the discussions, views and decisions on accident investigations in the socio-technical systems.

In Norway, the independent ad hoc investigation seems to be deeply rooted. The Petroleum Act describes how ad hoc investigations are to be accomplished. In Sweden the regulatory authority and the operator have responsibility for accident investigations. The Norwegian solution is following a tradition on how to carry out independent investigations. The Swedish solution, on the other side, seems to be an inconsistency to the idea of the independent accident investigations. At the same time they are kept outside the parallel system of accident investigation boards in both Sweden and Norway, maybe because of the dominant and complex nature of these technical systems. These grand systems create their own universes of technology and institutions, at the same time as they are highly embedded in the Norwegian and Swedish societies.

3.2 Learning from accident investigations – A cross-country comparison

There are no objective criteria specifying what aspects to focus on in the aftermath of an accident. Rather, the investigators make these (implicit or explicit) choices, with support from the method adopted and from previous experience. These choices influence what lessons will be learned and what remedial actions that will be suggested and implemented. In order to study what kind of lessons that are drawn from accidents, one of the activities in the ACCILEARN project has therefore focused on studying what factors that have been described as attributed causes in a number of accident investigation reports. All reports on railway accidents issued by the national accident investigation boards in Sweden, Norway and Denmark during a two-year period have been included in the analysis. The results revealed that all three investigation boards paid significant focus on aspect referred to as the micro-level, which relates to physical processes, actor activities and equipment. This indicates that investigators are inclined to focus on aspects that reflect their own skills and competences, since many investigators have operational or technical backgrounds. Less focus was paid to organisational factors (the meso-level) and factors related to regulatory bodies, associations and governments (the macro-level) in the investigation reports. Since failures at the micro-level in many cases merely are symptoms of trouble at higher levels of the system, it is therefore suggested that competences among investigators that supplement entirely technical and/or operational backgrounds are necessary. This would provide greater diversity in perspectives, and is consequently a prerequisite for a more varying type of lessons to be learned. The multi-modal structure of investigation boards, which to some extent has been adopted in all three studied investigation boards, can potentially contribute to this diversity by sharing resources, training, method development and expert competences. However, interviews show that these synergies are not always fully exploited. This means that the organisational structure and work processes of the investigation boards contribute to the ability to achieve effective learning from accidents (Cedergren & Petersen, 2011). These works are part of Alexander Cedergren's PhD-work carried out at Lund University.

Studying similarities and differences in accident investigation reports written in Norway, Sweden and Denmark provides a way of analysing how similar types of accidents are investigated in the different countries. Yet another contribution to our understanding of how investigations of unwanted events are performed in different contexts comes from a study of the Norwegian and the Swedish investigation of the response to the Indian Ocean tsunami in

2004 (Tehler & Njå, 2009). The seriousness of the event and the scope of the investigation are far greater than in any one of the accident investigations referred to above. What makes the comparison of the investigations interesting is the seriousness of the event and the fact that the investigations evaluated the response of different actors (usually various governmental agencies), not focusing so much on why the event occurred (why there was a tsunami with many affected citizens). Moreover, since both Sweden and Norway responded to the tsunami it is the "same" event that is investigated which is also something that distinguishes the tsunami investigations from the other accident investigations.

The conclusions from the study of the tsunami investigations are several. First of all, the two investigations seem to differ in terms of how they perform evaluations. "The Swedish investigation uses the actions of other countries, the citizens' expectations, and their own judgement in evaluating the performance of the Swedish authorities. The Norwegian investigation, on the other hand, compares how the situation was managed considering the existing plans and the requirements put on governments regarding long term, modern leadership and organisation development, and how crisis management work is organised" (Tehler & Njå, 2009, p. 12). Secondly "It is often difficult to determine the logical connection between the evaluation of the operation and the suggested measures. For example, none of the improvement measures seems to be motivated by counterfactual scenarios. However, sometimes they are motivated by referring to deficiencies found within the two response systems. The latter seems to be more prevalent in the Swedish investigation" (Tehler & Njå, 2009, p. 13). Finally, both the Norwegian and the Swedish investigation seems to be focused on finding "errors" in the management of the disaster instead of trying to understand why the response to the tsunami turned out the way it did.

4. Learning in the emergency response sector (PhD-study Morten Sommer)

Emergency response organisations respond to accidents on a daily basis. The Fire Brigade, the Ambulance Service, the Police Service and the Joint Rescue Coordination Centre respond mainly to minor and "ordinary" accidents (such as building fires and car accidents) but also major and large-scale accidents (such as transport accidents). Earlier studies have shown that knowledge and practice in emergency organisations are mainly experience-based, and "on-the-job training" is prominent (Aase & Njå, 2004; Flin & Arbuthnot, 2002; Rake, 2008; Taber, Plumb, & Jolemore, 2008). The ability of emergency organisations to learn from failures occurring during emergency situations has been questioned (Dekker, et al., 2008).

Because learning amongst emergency personnel mostly takes place through their daily work within their own organisations, we adopted an explorative case study approach, with the use of participant observation, in order to have an open mind as to how, when and where learning took place. This method enabled us to become a part of the natural environment at the workplaces, acquire first-hand experiences of naturally occurring events, get an intuitive understanding of what was going on in the workplace, and develop sufficient insight to ask relevant questions. Hence, this research approach allowed access to the non-verbal tacit knowledge, skills and experiences of the emergency personnel, in addition to the contextual and cultural conditions within the emergency organisations.

The results presented in the following sections are based on (Sommer, 2012; Sommer & Njå, 2011, 2012; Sommer, et al., 2012).

4.1 Emergency personnel's learning

Emergency personnel's initial training mainly takes the form of a period of apprenticeship. Even though newcomers undergo some formal training and education, they mostly learn

through interaction with experienced personnel. Experienced personnel's learning, on the other hand, more or less solely takes place at the workplace. Consequently, the learning taking place within the emergency organisations are fundamental for emergency personnel's development of competence. This learning can be divided into two main categories: *informal learning* and *formalised learning activities*.

Informal learning

Newcomers under mentor supervision (experienced emergency workers) become socialised into the existing culture. The new emergency workers model their own behaviour on that of the old-timers and they are inculcated with the workplace practice and working methods. This is a process whereby new emergency workers move from the status of peripheral participants to becoming fully fledged members of the community of practice. Through this process, newcomers acquire the situated knowledge. Consequently, the ways in which new emergency workers learn to think and behave are strongly influenced by the knowledge residing in the emergency organisation.

Gaining personal experience is a critical factor in the development of emergency personnel's competence. This is evident in the way learning takes place within the emergency organisations. The period of apprenticeship is in essence about gaining personal experience (thus under guidance) from real incidents. However, for emergency workers that have completed the period of apprenticeship, practical experience is still crucial. A considerable part of emergency personnel's experience is acquired from responses to real incidents. Almost without exception, all of the emergency personnel highlighted their experiences from real incidents as an important and invaluable part of their competence development. Hence, some emergency workers indicated that it can take up to about ten years to get sufficient experience and become self-confident enough to be considered highly experienced.

These informal and practical ways of learning, however, poses challenges for introduction of new knowledge on how to respond to accidents (for instance from accidents investigations). For emergency personnel to change behaviour in accident responses, new knowledge needs to be embodied. To ensure that a new behaviour becomes automatic and chosen in critical situations, "getting it in the fingers" is necessary. Thus, emergency personnel have to be involved to such an extent that they get the opportunity to understand how and why the "new stuff" is better and more meaningful than the "old stuff". They need conformational evidence that the new working methods and behaviours are meaningful and advantageous in critical situations. Challenging exercises providing opportunities for emergency personnel to test new approaches and equipment is a way to enhance bodily experience.

Sharing experiences is crucial for learning amongst emergency personnel, since the self-experienced sample of responses to accidents (especially major accidents) is very limited. Emergency personnel interact and talk with each other much of the time on duty. These conversations have an informal character, and contribute significantly to emergency personnel's learning by enabling exchange of experiences, meanings and viewpoints. Characteristic for the stories told is that they are problem-oriented, focusing on what happened, why there were problems and how the problems/situations were resolved. Stories about problems, things that went wrong and "near misses" are more common than success stories describing situations where things went well. The stories usually have many contextual details, insights, surprises and a share of drama or humour. The practical inclined emergency workers can easily relate to such stories, and they have no problem picturing themselves in the same or similar situations.

Formalised learning activities

Formalised learning activities allow emergency personnel to get regular training and systematic updating of their skills and knowledge. All of the emergency organisations arrange training exercises on a regular basis, and the emergency workers consider exercises to be an important learning activity. Exercises span from training regarding specific procedures or use of tools and equipment, to full-scale incidents with complete responses. However, a tendency we observed was that exercises did not always appear to present sufficient challenges to the emergency workers, especially the more experienced personnel. Exercises normally took place in familiar settings, and they seldom provided surprising contents. It may therefore be questioned whether experienced emergency personnel actually learn from the traditionally exercise arrangements. For newcomers in the emergency organisations, however, exercises are a great opportunity to gain experience and become socialised into the existing culture.

The ambulance service requires that each of their ambulance personnel participate in four separate training days yearly at a special training centre for acute medicine. A typical training day at the centre consists of a lecture, followed by skill proficiency training and full-scale simulation-based training the rest of the day. In the lectures, the existing medical knowledge and ways of treatment are repeated and new knowledge or methods for treatment introduced. After the lecture, the ambulance personnel carry out hands-on training related to the topic of the day. These training tasks include skill training (procedures for treatment) and simulation-based training in teams (complete responses to ill or injured "patients") with the use of manikins and patient simulators. Each training task ends with a thorough debrief, where the instructor lead a discussion about what the ambulance personnel had done and how they had been thinking. The instructor asks questions that challenge them and make them reflect. The instructor also instructs them and explains aspects of the case and the treatment. This combination of questioning and instruction appeared to help the ambulance personnel to get a better understanding. According to the instructors, these debrief/discussions are a vital part of the learning. The ambulance service's experience is that new knowledge is most successfully introduced in the mandatory training days. Here all of the ambulance personnel get access to the new knowledge, which they learn with individual hands-on training combined with discussions and reflection.

The Joint Rescue Coordination Centre (JRCC) arranges regular get-togethers for all of their personnel, i.e. monthly meetings where responses are discussed and reflected upon, to ensure that all of the personnel at the centre can learn from the experiences made. Even though the personnel at the centre create reports after every response they coordinate (which is available for everyone at the centre to read) and sporadically share and discuss experiences informally, the centre does not consider this to be sufficient to ensure good learning for *all* of their personnel. The main purpose of the regular meetings is therefore to share experiences, thus to gain knowledge from coordination of emergency responses and share this knowledge amongst the centre's personnel. The focus is not to identify failures made by individuals and expose those responsible to criticism. Instead, the focus is on *what* had been done, and *why*. The aim is simply to understand the judgements and assessments made during responses and to scrutinise the rationale behind the decisions made. To increase the learning potential from the experiences, they try to problematise and think "what if...". This way of sharing experiences and discussing responses proves to be highly valuable for the learning to the personnel at the centre.

4.2 Areas of improvement – practical implications

ACCILEARN has revealed some areas of improvement related to learning in the emergency response sector.

The lack of systematic sharing of experiences from responses is a barrier to learning. Except from the Joint Rescue Coordination Centre, exchange of experiences largely takes the form of informal storytelling and ad hoc discussions. Consequently, to get hold of and learn from others' experiences, emergency personnel simply has to be at the right place at the right time. To improve learning from responses to accidents, it is therefore necessary for the emergency organisations to transfer experiences from responses to their entire organisations and between different emergency organisations.

The emergency organisations' approach to responding to accidents is strongly standardised. This may be necessary in stressful and uncertain situations, but over-standardisation might be inappropriate in abnormal complex responses where the "standard" response is insufficient. Risk and uncertainty management is not part of emergency personnel's standard training. Uncertainty is not conceptualised and the personnel in general is not challenged on how to respond to situations that are abnormal to them. Enhancing risk assessment approaches could therefore contribute to realisations of strength and weaknesses within the emergency organisations and their response approaches, thus contribute to improve the ability to cope with abnormal, complex and highly uncertain situations (typically the rare and "unexpected" kinds of accidents).

A system that ensures feedback to emergency personnel on their responses could improve the learning. The emergency personnel in general value feedback on their responses. However, external feedback is rarely given. To enable emergency personnel to learn from their responses, they need to know if they should do the same in future similar situations or if they need to change their behaviour.

Evaluating responses and common practices is necessary if one is to challenge the rationale for the normal response approaches to accidents. By critically analysing responses and questioning established knowledge and practice, emergency personnel will be able to evaluate if they are performing at the highest standard. Thus, becoming more reflexive practitioners will enable them to better evaluate the rationale of common practice and to maintain a high-level of competence. In addition, focusing on counterfactual scenarios and drawing on theoretical (scientific) literature could improve flexibility and reflection of emergency organisations' own practice, and thus improve emergency personnel's ability to make "correct" decisions and behave appropriate during responses to accidents.

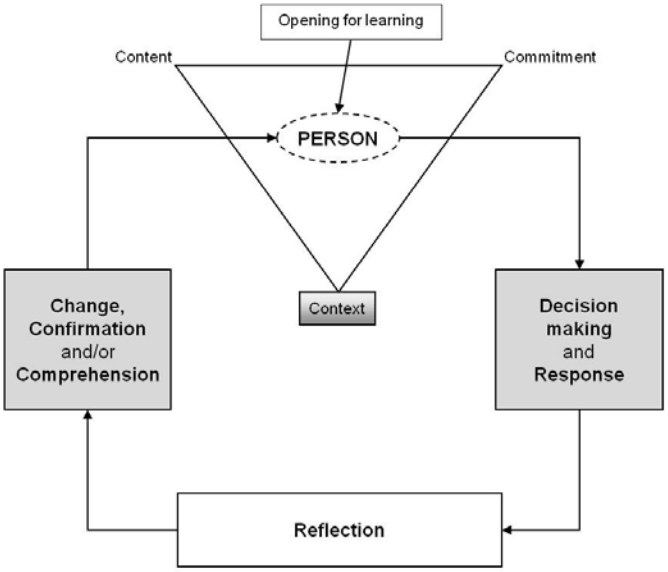
4.3 A model for learning in emergency response work

The way emergency personnel learn explains how they develop their competence. Understanding these learning processes makes it possible to understand how they become competent emergency workers. Research on workplace learning usually views learning as participation and involvement in social systems, thus taking a socio-cultural perspective on learning. In contrast, crisis and emergency response research tends to take a psychological (individual) perspective on learning. The Naturalistic Decision Making (NDM) framework (Klein, Orasanu, Calderwood, & Zsambok, 1993), which focuses on experienced personnel operating in real life settings, does not consider what managerial background and experience incident commanders possess to make adequate decisions (Njå & Rake, 2009). In addition, both NDM theories and traditional decision theories have overlooked the possibility that organizational structures and climates play an important role in decision making (Eyre, Alison, Crego, & McLean, 2008).

ACCILEARN shows that the way emergency personnel think and behave are strongly influenced by the knowledge residing in the emergency organization (common practice, shared understanding, use of artefacts, attitude/identity etc.). Hence, how to understand and solve situations/problems during an accident is, to a large degree, a result of the professional

culture and tradition within the emergency organization. The knowledge "stored" within the emergency organisation is therefore essential in the assessment of emergency personnel's competence. On the other hand, our project also shows that gaining experience and embodiment of skills and knowledge is necessary for individuals to actually learn to respond appropriately during accidents. Therefore, to fully understand the learning processes one must analyse the arenas for learning, how information is made available and accessed, and individual embodiment. Consequently, a combined approach to learning is needed (learning as acquisition and learning as participation), and will make it possible to better explain learning processes in emergency response workplaces and organisations in general.

This project has resulted in a model for learning in emergency response work. This is a normative model, placing the individual at the centre of attention and focuses on the individual's need to learn. The model also takes into consideration the contextual elements as well as the "curriculum" (skills and knowledge) to be learned.



The model consists of four parts. *Person* is the starting point for understanding learning. This is the individual, open for entering a learning process. This opening for learning may be constituted in different ways, e.g. as a curiousness for achieving skills and knowledge, a desire to find out more about observed phenomena, formal or informal requirements as a responsible emergency responder, or a desire to become a member of an acting community. The grey boxes in the figure relate both to organizations and individuals, whereas the two others relate to individuals. However, the context depends very much on the type of organization concerned.

Decision making and response corresponds to individuals' performance in an emergency situation (either a real incident or a training situation). Individuals' behaviour and response is thus a result of the decisions they make, which consequently form the outcome of the emergency situation.

Reflection is emphasized by both Kolb (1984) and Schön (1991) as the very essence of learning. For individuals to learn they need to reflect their performance (decision making and response).

Change, confirmation, and/or comprehension are ways to categorize the outcome of learning. The reflection may result in *change* in structures, behaviours or working methods, *confirmation* of existing knowledge and procedures/working practices, and/or *comprehension* of knowledge, collaborations, involvement etc.

Learning as depicted in the model is a continuous process consisting of the four parts interrelated in a dynamic whole, where real and frequently devastating experiences are mixed with controlled exercises, training and lecturing activities. These matters encourage a need for practical contexts and real responses surrounding the learning activities. The experience that an individual gets from an emergency situation, and the subsequent reflection, will result in learning for the individual. This will then influence how the person acts in the next emergency situation he or she meets. This may be seen as an ongoing, continuous or iterative process where new knowledge and skills build upon and develop from previous knowledge and skills combined with reflected, new experiences.

Preliminary tests of the model, an evaluation of the training arrangement for snow avalanche response training (Njå & Sommer, 2010) and participants' learning in a major collaborative exercise (Sommer & Vastveit, 2012), found that the analytical approach based on the model gave new knowledge and perspectives that enhanced the emergency response organisations' reflection and gave a more balanced view of the participants' learning. However, the model needs further empirical testing to clarify how well it explains learning in emergency response systems, and to which degree it applies to other sectors.

5. Conclusions

Learning from accident investigations must be seen as a stimulus that is brought to the enterprises, groups and individuals. Learning must relate to the context and the individuals' proneness to integrate new knowledge. Morten Sommer's PhD-work documents these contexts in his study of emergency organizations. His work concludes as follows:

- Both informal learning and formalised learning activities at the workplace are crucial for individuals' learning and development of competence. These forms of learning fulfil different learning needs, thus complementing each other.
- Social and cultural aspects are decisive for individuals' possibilities to learn. Consequently, the context forms the basis of individuals' attitude towards learning, willingness to discuss and reflect, feeling of trust and openness, and opportunities to engage in activities resulting in learning.
- Given a proper learning context, embodiment of knowledge (i.e. reflection and/or hands-on training) is needed for individuals to actually learn. This highlights the importance of individuals' involvement (commitment).
- Learning in the emergency response sector can be improved by sharing experiences more systematically, ensuring (individual) feedback to emergency personnel on their responses, enhancing risk assessment approaches, and evaluating responses and common practice more critically.
- Our proposed model of learning in emergency response work appears to be promising in explaining individuals' learning. However, the model needs to be developed further in order to better explain learning en emergency responses systems and other sectors, and to be used as a practical tool for organisations to evaluate their learning.

Today it seems that the focus in accident investigation processes is placed much more on formalism related to the assignments and conducts during the investigation committees' work. How the work of the investigators is embedded in the organizations that could or are expected to learn from the investigations seems to be very little regarded.

We conclude that it is the immediate reflections within exposed parties that governs the learning processes, and which could be said to imply systematic learning. From this it is clear

to us that future accident investigation work needs to obtain a learning perspective from the very start of the investigations to the final report and follow up processes are presented. The situation today is investigation reports from which the weak parties are easily extracted and the reports are addressing recommendations which are very difficult to conceptualize for the learner.

Project publications

Articles – scientific journals and books:

Braut, G. S., Rake, E. L., Aanestad, R., & Njå, O. (2012). Risk images as basis for two categories of decisions. *Journal of Risk Research, In Press*.

Njå, O., & Braut, G. S. (2011). INVESTIGATION OF INCIDENTS IN SYSTEMS DESIGNED OR DEVELOPED ON THE BASIS OF RISK ANALYSES. *Safety Science Monitor*, **15**(1).

Sommer, M. (2012). Professional development in the Ambulance Service. *Submitted for publication*.

Sommer, M., & Njå, O. (2011). Learning amongst Norwegian fire-fighters. *Journal of Workplace Learning, 23*(7), 435-455.

Sommer, M., & Njå, O. (2012). Learning in a Joint Rescue Coordination Centre: coordination and decision making. *Submitted for publication*.

Sommer, M., Njå, O., & Braut, G. S. (2012). A model for learning in emergency response work. *Submitted for publication*.

Sommer, M., & Njå, O. (2010). Scandinavian comparison of selection and training of incident commanders in the fire fighting sectors *Journal of Emergency Management* **8**(2), 75-86.

Cedergren, A., & Petersen, K. (2011). *Prerequisites for learning from accident investigations – A cross-country comparison of national accident investigation boards*. Safety Science, 49(8–9), 1238-1245.

Hummerdal, D., Wilhelmsson, A., and Dekker, S. (forthcomming) *Learning from failure*. Book chapter under review to “The Oxford Handbook of Cognitive Engineering”.

Papers – international conferences:

Sommer, M., & Njå, O. (2008). *Scandinavian comparison of selection and training of incident commanders in the fire fighting sectors* Paper presented at the SAMRISK-Conference, Oslo

Njå, O., & Braut, G. S. (2010). *Components of a Tool to Address Learning from Accident Investigation in the Offshore Industry*. Paper presented at the 29th International Conference on Ocean, Offshore, and Arctic Engineering, OMAE.

Tehler, H., & Njå, O. (2009). *Learning from disasters – a comparison of the Swedish and Norwegian Tsunami 2004 investigations.* Paper presented at the 36 th ESReDA Seminar on "Lessons learned from accident investigations", Coimbre, Portugal.

Njå, O., & Braut, G. S. (2010). *Investigation of incidents in systems designed or developed on basis of risk analyses*. Paper presented at the Working on Safety (WOS) Conference 2010.

Sommer, M., & Njå, O. (2010). *A discussion of learning in emergency response organizations.* Paper presented at the The International Emergency Management Society, Beijing, China.

Njå, O., Braut, G. S. & Vika, O. E. (2012). *Bending the rules in the commersial goods road transport sector*. Paper presented at the Transport Research Arena (TRA), Athens.

Seminars and conferences arranged:

During the project period we have organized many seminars and one large conference.

In 2008 we established a series of seminars together with the emergency management organisations in the region (Police, Fire departments, JRCC, Ambulance services) which have been a success because it has become an arena for interdisciplinary discussions facilitated by the University of Stavanger. The discussions are in general founded in scientific issues and works that are presented.

We have also organised these professional seminars based on major accidents and training events. In 2010 we arranged a seminar on the response work to the avalanche in Kattmarka, Namsos. We have organised a seminar related to the major emergency response rehearsal concerning a major fire event in the Lier-tunnel.

We have been involved in evaluation studies in two training and rehearsal projects; snow-avalanche responses in Rogaland (Njå & Sommer, 2010) and the international rehearsal SkagEX (Sommer & Vastveit, 2012). We have also provided input to the national 22 July committee (Njå, 2012) and participated in an official committee who worked out an Official Norwegian Report about the future educational needs for the Norwegian fire departments - NoU 20012:8.

In February 2010 a Scandinavian conference on "Accident investigation and learning" was held at the University of Stavanger. The conference lasted for two days and comprised three sessions, transport, petroleum/health and major accidents. Work from ACCILEARN was presented as well as invited presenters. 180 participants followed the two- day conference, which met with a very positive response and requests for follow up conference in due time. Similar conferences are also suggested for the other Scandinavian countries as well as specific sectors, such as the specialized medical sector. Presentations and further reading can be found from: www.uis.no/accilearn.

In May 2012 we will arrange a seminar on learning processes in the aftermath of the professionals' investigation reports after 22 July. At this seminar the reports from the Police, the Health Services and the response from the Fire departments will be presented. In addition the incident commander of the health services response to the Oslo bomb outside the government buildings will present experiences.

Future works:

In Stavanger we have established a new project "Learning from accidents and near misses in the process industry", which is financed by the petroleum industry (Statoil and LOTOS). This project includes two phd-projects gathering data from refineries, one in Norway and one abroad.

ACCILEARN has made it possible for us to form networks in positions for applications to the EU 7th frame programme, and other funding in Europe. We will explore these opportunities in the near future.

The Norwegian emergency authorities have shown significant interest in the project which encourages us to join forces for future initiatives.

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