Safety Science 62 (2014) 28–36

Contents lists available at ScienceDirect

Safety Science

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

Knowledge sharing in a complex organization: Antecedents and safety effects

Torstein Nesheim [a,*], Leif Jarle Gressgård [b,1]

[a] Institute for Research in Economics and Business Administration (SNF), Breiviksveien 40, N-5045 Bergen, Norway
[b] International Research Institute of Stavanger (IRIS), Thormøhlensgt. 55, N-5008 Bergen, Norway

ARTICLE INFO

Article history:
Received 7 November 2012
Received in revised form 26 April 2013
Accepted 14 July 2013

Keywords:
Organizational complexity
Knowledge sharing
Knowledge application
Safe work conduct
Survey
Petroleum industry

ABSTRACT

In a safety perspective, exchange of experiences and information within and across departmental, organizational, and geographical boundaries is important. Valuable knowledge may reside in different organizational units and locations, and the ability to learn from failures thus depends on efficient knowledge exchange processes. This paper focuses on sharing and application of knowledge in a high risk, inter-organizational setting. Based on data from a survey with respondents from a petroleum operating company and eight of its main contractors, the paper investigates the antecedents and effects of knowledge sharing behavior. The overall results show that work experience, training, intrinsic motivation, job autonomy, location, and management support influence the level of knowledge sharing behavior, which again affects knowledge exploitation related to safe work conduct. However, the analyses also reveal that work location is an important conditioning variable, as the effects of education, training, job autonomy, and management support on knowledge sharing behavior depend on whether the respondents work offshore or onshore. An implication is that work location is a significant factor to consider when initiatives for improving knowledge sharing behavior are to be designed and implemented.

1. Introduction

In the organizational safety and health literature, issues of organizational learning and knowledge sharing have gained increasing attention (Hopkins, 2008; Doytchev and Hibberd, 2009; Wahlstrøm, 2011; Read, 2011). From an organizational perspective, learning implies that the enterprise is able to change its actions, build on experiences, develop and apply knowledge and learn from mistakes, incidents and accidents. At the employee level, the presumption is often that people should have the necessary qualifications for their positions, attend safety training organized by the enterprise, understand and use operating procedures, and be able to obtain information and knowledge from their colleagues. Learning and knowledge transfer in organizations may take place through a number of different mechanisms. Examples are training in operative procedures, learning by-doing, as well as information and knowledge exchange between employees and organizational units. In closely-knit interorganizational systems, exchange of experience and information sharing across organizational boundaries is especially important (Read, 2011; Austnes-Underhaug et al., 2011).

Here, we analyze knowledge sharing and application in a high risk setting; drilling and well activities in a large operator firm on the Norwegian Continental Shelf. The firm operates several installations that involve a number of operative and support units internally, as well as several specialized suppliers and subcontractors. In such an inter-organizational setting knowledge sharing across units is vital, since experiences and information exist at several locations and units in the organizational system. Building on the extensive research on knowledge transfer and knowledge sharing in the organization and management literature, this article analyzes empirically the determinants of and the effects of knowledge sharing in the involved organizations. The study is based on responses from 2.653 employees of the operator firm, suppliers and subcontractors.

2. Theoretical background

2.1. Learning, knowledge sharing and organizational safety

Knowledge sharing is important in several organizational contexts. Studies in the field of safety management have addressed interaction and collaboration at different levels as a requirement for safe operations, although the sharing of information and knowledge between individuals may be treated in an implicit rather than an explicit manner. At the industry level, Wahlstrøm (2011) says

* Corresponding author. Tel.: +47 55959772.
E-mail addresses: Torstein.Nesheim@snf.no (T. Nesheim), ljg@iris.no (L.J. Gressgård).
[1] Tel.: +47 55543866.

0925-7535/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.ssci.2013.07.018

that the nuclear industry has a long tradition for sharing knowledge, resulting in formalized systems for the exchange of information, operated by the International Atomic Energy Agency (IAEA) and the World Association of Nuclear Operators (WANO). Organizational learning may involve two or more interacting organizations, including customer–supplier relationships. Examples are power plants in Finland and Sweden that have built long term contracts with supplier organizations to improve mutual organizational learning. Wahlstrøm (2011) also describes the The Learn Safe project that was set up in order to analyze organization and management issues that influence nuclear safety. Internal openness and trust were identified as vital factors for organizational learning to occur. Hindrances to trust included items such as lack of questioning, thinking in "territories" and fear of losing face.

With regard to effective responses from physical separate experts in emergencies, Mendonca et al. (2000) modeled how one best could influence the speed of implementing the response strategy and the quality of expert knowledge. As the petroleum industry has used information and communication technology to establish distributed work processes and increased collaboration between offshore and onshore locations, the question of cooperation across geographical sites and organizational units has become more important. Skjerve et al. (2011) investigated how resilient collaboration was achieved by coaching. Resilient collaboration is characterized by a high ability to cooperate, high possibility for cooperation as well as high willingness to collaborate. Cox et al. (2006) argued that workplace trust has been recognized by researches and practitioners to be an important aspect of an effective safety culture. A high level of trust makes it possible to establish or maintain well-functioning organizational relations over time.

In a study of how organizations learn from accidents, Størseth and Tinmannsvik (2011) identified a number of learning inhibitors and learning promoters. One theme that emerged from the study was fragmentation, where the extended use of external consultants led to fragmentation and weak ownership of work processes. A report on the Deepwater Horizon accident identified a number of factors that were related to the incident; including the lack of sharing of information (Read, 2011). That is, vital information was available, but was not shared between units and the various firms involved in the drilling operation. Technical experts were not contacted and there was lack of interaction between the installation offshore and management onshore (Read, 2011). Hefeng et al. (2011) identified three mechanisms for obtaining safety knowledge; training, learning-by-doing and knowledge sharing between coworkers, and found that organizational climate had a positive effect on knowledge sharing.

Thus, several studies in safety management have addressed issues of organizational learning and knowledge sharing in organizations. While knowledge sharing across organizational units and geographical distance has been acknowledged as a dimension of organizational learning, there are no analyzes of the determinants and consequences of knowledge sharing as such in this stream of research. In order to develop a better understanding of this phenomenon, we will draw on the extensive literature in the field of organization and management.

2.2. Knowledge sharing in the organization and management literature

Knowledge is a critical resource for organizations, and provides the basis for performance and competitive advantage. There are different knowledge processes such as knowledge creation, knowledge sharing and knowledge application. Contributors to the knowledge literature share the presumption that staffing systems that enable the selection of employees with specific skills and abilities, and training systems that help employees acquire relevant knowledge, are vital, but not sufficient to ensure organizational performance (Wang and Noe, 2010). Organizations must also emphasize and contribute to the transfer of expertise and knowledge from those who have it to novices. Thus, in order to reach its performance goals it is important to exploit the knowledge resources that already exist in the organization (Wang and Noe, 2010).

Knowledge sharing refers to "the provision of task information and know-how to help others and to collaborate with others to solve problems, develop new ideas, or implement policies and procedures" (Wang and Noe, 2010, p. 117). It may occur via written or face-to face communication through networking with others or through documenting, organizing and capturing knowledge for others. Further, it is a vital activity through which employees may contribute to knowledge application, innovation and the competitive advantage of the organization (Jackson et al., 2006).

Knowledge sharing between employees, teams and departments enables the organization to capitalize on knowledge-based resources. Many organizations have invested in various formal knowledge management systems to facilitate the collection, storing and distribution of knowledge, but these systems have often failed to live up to expectations (Babcock, 2004; Carter and Scarbrough, 2001). Obtaining information from colleagues and other professional relationships is often preferred, since "we not only end up with the information we were looking for, but also learn where it is to be found, how to reformulate our question or query... (and also)... 'metaknowledge' about our search target and our search capabilities" (Dalkir, 2005, p. 112). Thus, direct contact and exchange of information and experiences between employees are vital supplements to formal systems of knowledge management.

A number of perspectives and factors have been employed to explain why some employees tend to share knowledge while others are less inclined to do so. For example, in a recent article, Reinholt et al. (2011) found that opportunity (network position), ability (own knowledge) and motivation had positive impacts on knowledge sharing. In a review article, Wang and Noe (2010) identify five groups of factors that influence knowledge sharing; (1) national culture; (2) organizational context (organizational culture, management support, incentives and organizational structure); (3) interpersonal and team characteristics (team processes, diversity, social networks); (4) individual characteristics; and 5) motivational factors (knowledge ownership, perceived benefits and costs, interpersonal trust and justice, individual attitudes). Based on this literature, we will now develop hypotheses on determinants of knowledge sharing in a drilling and well organizational context.

3. Hypotheses

3.1. The level of expertise and ability of knowledge sharing

In order to be able to understand, adopt and use new information, the existent level of knowledge is important. Employees differ in their abilities to share knowledge. Cohen and Levinthal (1990) argue that the diversity of the knowledge possessed by employees provides better grounding for absorbing new knowledge, since it enhances the chance that the incoming knowledge is related to what is already known. For those who provide knowledge to others, such diversity implies that they more easily understand how their knowledge may be valuable in other contexts, and are therefore better able to frame the knowledge in a way that makes sense to potential acquirers (Reagans and McEvily, 2003; Reinholt et al., 2011). Constant et al. (1994) found that individuals with a higher level of education and longer work expertise are more likely to share their expertise and have positive attitudes toward sharing.

Constant et al. (1996) also found that individuals with higher expertise were more likely to share useful knowledge asked by other employees. Reinholt et al. (2011) found no direct impact of ability on knowledge sharing behavior, although ability strengthened the effect of network position on knowledge sharing.

We hypothesize that knowledge sharing behavior is related to three dimensions of ability and expertise; the level of education, the amount of experience in the given functional area, as well as training provided for the present job position. Each of these variables are expected to increase the potential for absorbing new knowledge and providing useful knowledge to others, and therefore to have a positive impact on knowledge sharing behavior.

H1. The level of education is positively related to knowledge sharing behavior.
H2. The length of experience in the given functional area is positively related to knowledge sharing behavior.

H3. Training provided for the present job position is positively related to knowledge sharing behavior.

3.2. Motivation

In order to explain knowledge processes in organizations, it is important to take into account employees' motivation for knowledge sharing (Foss et al., 2009). Previous research has distinguished between autonomous and extrinsic motivation. The former type refers to "the inherent tendency to seek out novelty and challenge, to extend and exercise one's capabilities, to explore and to learn" (Deci and Ryan, 2000, p. 70). Autonomous motivation is advantageous for the willingness to learn, for activities that involve tacit knowledge and also when knowledge sharing involves a voluntary dimension (Osterleh and Frey, 2000). If a person is autonomously rather than extrinsically motivated, he or she will tend to be more open to obtaining knowledge from the experience of others and more likely to seek out knowledge to improve competencies (Deci and Ryan, 2000). Empirically, support has been found for the association between this type of motivation and knowledge sharing behavior (Reinholt et al., 2011; Foss et al., 2009), as well as knowledge application (Nesheim et al., 2011).

H4. Autonomous motivation is positively related to knowledge sharing behavior.

3.3. Job design: autonomy

Job design refers to the manner in which job roles or positions are constructed, and is therefore a vital aspect of organizational design. Previous research has emphasized how specialization (and especially job roles with a low degree of autonomy) may decrease the cognitive ability to absorb knowledge and therefore may impede knowledge sharing (Aoki, 1986; Foss et al., 2009). Autonomy is "the degree to which the job provides substantial freedom, independence and discretion in scheduling the work and in determining the procedures to be used in carrying it out" (Hackman and Oldham, 1976, p. 258). When a job is designed to provide an employee with a large degree of discretion, the sense of responsibility for work-related outcomes is increased (Hackman and Oldham, 1975). A high level of autonomy may also influence propensity to share knowledge with others for motivational reasons. A high degree of discretion supports a basic psychological need for autonomy, and therefore leads to more motivated employees (Foss et al., 2009).

H5. Job autonomy is positively related to knowledge sharing behavior.

3.4. Goal conflict and short-term focus

Activities in the petroleum industry as in other safety intensity operations are related to a range of goals; such as efficiency and effectiveness in production; time and quality in project execution; low risk and no accidents, as well as other HSE outcomes. In general, there is a potential for goal conflict, since prioritizing one aim may reduce the chances of achieving other aims. Since time and resources are limited it is difficult to maximize economic achievements at the same time as prioritizing safety issues. If short term considerations of cost efficient production are prioritized, it may have negative consequences for HSE. According to Perrow (1999), while there are institutions and regulations to ensure safe operations, the importance of highlighting the balance between safety and production goals is still prevalent. A report on the Deepwater Horizon accident in the Gulf of Mexico in 2010 found that a number of decisions were taken, without thorough considerations of the consequences for safety (Read, 2011). In an organization where short-term economic consequences have priority, employees may not have the time for, or be encouraged to, share experiences with others concerning safety matters. They concentrate on the operative, daily activities and the task at hand. The more such short term goals are emphasized, the less the extent of knowledge sharing behavior is expected to be.

H6. The emphasis on short-term goal attainment is negatively related to knowledge sharing behavior.

3.5. Location

Separate locations and physical distance imply a number of challenges for knowledge sharing in organizations (Minbaeva, 2005; Kauppila et al., 2011). In the petroleum industry, some employees work primarily offshore while others work primarily onshore. Those located offshore are mainly involved in operative activities, while those who are located onshore to a larger extent are involved in planning, support and monitoring functions. While the installations offshore are geographically distributed, the planning and support units may be located at the HQ or at a few support "hubs". Since the probability that employees communicate directly decreases with increasing physical distance between their respective work locations, onshore employees would be expected to be involved in knowledge sharing to a higher degree than those who work offshore. The type of work may also influence the level of knowledge sharing. If one works in an office (onshore), there may be more opportunities for interaction with people in similar functions through electronic communication and telephone, compared to a more operative position (offshore).

H7. Employees who work onshore will more involved in knowledge sharing behavior than employees who work offshore.

3.6. Management support

Line managers influence actions and behavior of employees in organizations. Managers may influence people through the goals they emphasize, the attention given to certain activities or through direct instructions and support. Management support for knowledge sharing has been shown to be related to employees' perceptions of a knowledge sharing culture and willingness to share knowledge (Connelly and Kelloway, 2003; Lin, 2007). Support from supervisors and their encouragement of knowledge sharing increases knowledge transfer and the perception of usefulness of knowledge sharing (Cabrera et al., 2006; Kulkarni et al., 2006). To

engage in knowledge sharing behavior with employees in other units or in external networks may sometimes be perceived as disruptive by a line manager, since it competes for scarce time and resources and may be perceived as a competing source of knowledge. Schønstrøm (2005) analyzed how line managers with limited interest in supporting knowledge activists were found to hamper the effectiveness of knowledge communities in the organization. Nesheim et al. (2011) found that line managers' support was positively associated with employees' application of knowledge gained from participation in intraorganizational networks.

H8. Management support is positively related to knowledge sharing behavior.

3.7. Knowledge sharing and knowledge application

While knowledge sharing involves exchange of advice and information concerning daily accomplishment of tasks (i.e. questions about methods, choice of technologies and procedures, etc.), knowledge application refers to the actual use of knowledge to improve the quality of the work. It may involve more timely responses, better quality decisions and improved coordination between activities and team members. In order to apply knowledge across a distributed organization, one is often dependent on sharing and dissemination of the appropriate information. A high level of knowledge sharing behavior will tend to increase the number of ideas and knowledge elements being discussed. If employees activate and extend their networks of relations internally or with people in other organizations, knowledge dissemination will be more intensive, compared to a situation where formal communication channels dominate. A higher level of knowledge sharing in a safety context, therefore should improve the quality of work.

H9. Knowledge sharing will have a positive impact on knowledge application.

The proposed hypotheses are summarized in Fig. 1.

4. Data and method

4.1. Sampling and response

As described in section 1, important experiences and knowledge exist at several locations in distributed high risk organizations. In order to capture knowledge sharing processes across units within such an organizational setting, the sample should have certain characteristics. The study should take place in a (a) geographically distributed organizational context, where (b) both intra- and inter-organizational knowledge sharing occur on a regular basis. Meeting these requirements, the context of this study was knowledge sharing related to drilling and well activities in a large operator firm on the Norwegian Continental Shelf. The operator is responsible for several installations and involves several contractors and external specialist firms in its activities.

A web-based survey was conducted in the spring of 2011 among employees/consultants of the operator firm and employees of eight main subcontractors. Two set of questionnaires were developed; one for operator respondents and one for subcontractor respondents. The questionnaires consisted of 105 questions/items (including background information), covering aspects like perception of leadership, organizational factors, compliance, work characteristics, and knowledge sharing and application. 93 items were relevant for all respondents, while the remaining 12 items were "follow-up questions" and their relevancy were thus dependent on the respondents' work situations and answers provided at foregoing questions. Further, the specific wording of some questions was adapted to the target groups (i.e. operator employees and subcontractor employees), although measuring the same aspects. The questions on knowledge sharing and knowledge application, as well as the items measuring the independent variables depicted in Fig. 1, were identical for both operator respondents and subcontractor respondents, enabling us to include all responses in one analysis.

The questionnaires were distributed by use of email to personnel in the target groups. A cover letter with information presenting the purpose of the survey and practical details was also distributed by use of email. Distribution lists were provided by the respective firms, but all survey administration and coordination was handled by the research team. The survey was open for responses for a period of 6 weeks in order to cover all work shifts offshore. Two reminders were sent during this period, and the potential respondents in the target groups were also requested to participate in the survey by their union representatives.

The overall population was 5856 employees/consultants, of which 1398 were part of the operator's work organization and 4458 were employees of subcontractors. The response rates of these groups were 63% (880 completed questionnaires) and 40% (1773 completed questionnaires), respectively. The total response rate was 45% (2653 responses). Among the responses from the operator, 17% were consultants and 83% were employed by the operator (on a permanent basis). Approximately 99% of the respondents from the subcontractors reported that they were permanent employees (app. 1% consultants). Regarding work position, 33% of the operator respondents held management positions, while the corresponding number for subcontractors was 44%. Whether this

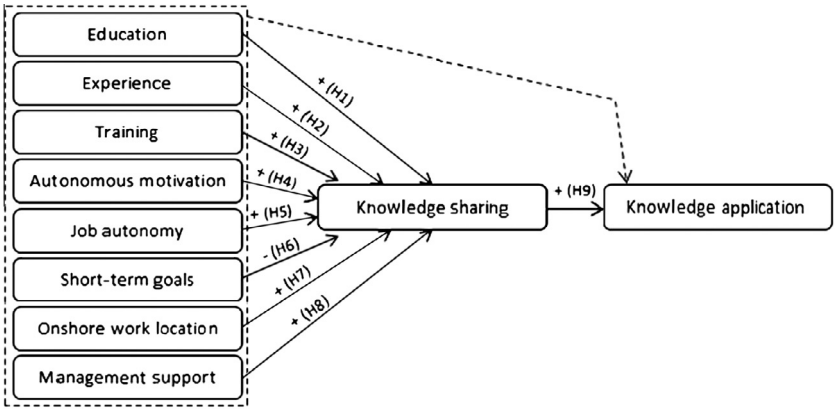

Fig. 1. Hypotheses.

response ratio is consistent with the actual proportions of managers in the operating company and the subcontractors is not known, but potential effects of this difference are accounted for in the analysis. Further details of the response rates of the three main target groups are given in Table 1.

4.2. Measures

Measures of dependent and independent variables were developed based on existing literature. In addition, we obtained feedback from key informants of the operator in order to ensure use of measures that were relevant for the particular context. The four measures of knowledge application (dependent variable) are all related to safety issues. For constructs that were measured by use of multiple indicators, additive indexes were calculated. All indicators/questions pertaining to the various variables, measurement scale, and alphas (where relevant) are given in Table 2.

5. Results and analysis

5.1. Correlation matrix

Bivariate correlations between all variables applied on the study are shown in Table 3. Means, standard deviations, minimum and maximum values are also shown. As can be seen from Table 3, multicollinearity between the independent variables (1–8) is not a problem. The strongest correlations are between training and intrinsic motivation ($r = .37$) and between training and management support ($r = .33$), but collinearity statistics show that all variables are far below the suggested cutoff threshold of variance inflation factors (VIF value of above 10) (Hair et al., 1998). VIF statistics are from 1.32 and below, and thus within acceptable limits.

5.2. Regression analysis

The individual relationships hypothesized in H1-H8 were tested using multiple regression analysis, including all independent variables and knowledge sharing as dependent variable. This represents a strong test of the hypotheses as the relationships must be significant within the context of all other possible relationships between the independent variables and the dependent variable. The results of the multiple regression analysis are depicted in Table 4.

From Table 4 we find that the model explains 19% of the variance in the dependent variable. We further find that all hypothesized relationships are significant, except for level of education (though close to significant at 5% level) and focus on short-term goals. Regarding level of education (H1), this variable had a significant effect on knowledge sharing when tested separately, but turned out insignificant when "Location" was included in the model. In order to explore this finding further, the respondents where split based on their primary work location (offshore vs. onshore), and multiple regressions testing the model on these groups (separately) were conducted (Table 5).

The results show that education has a positive effect on knowledge sharing behavior in the offshore group, but not for employees working onshore. Moreover, the opposite effect is found regarding the relationship between training and knowledge sharing behavior (H3), while experience (H2) is significant in both groups. As these hypotheses are based on the same reasoning and the same overall concepts (expertise and ability to share knowledge), this represent important findings that will be elaborated upon in the discussion of the results.

Table 4 further shows that the relationship between job autonomy and knowledge sharing is significant at the 5% level, while the remaining relationships are all at the 1% level. From Table 4 we also find that intrinsic motivation and location are the most importance predictors in the model, followed by level of experience from work within the particular context (drilling and well). However, separate tests on the offshore and onshore groups (Table 5) indicate that work location is an important conditioning variable also for the effects of job autonomy (H5) and management support (H8) on knowledge sharing behavior. Regarding the former relationship, the analysis shows that job autonomy has a positive significant effect only in the offshore group. Management support on the other hand has a positive significant effect only in the onshore group, while intrinsic motivation has a significant effect in both groups.

Regarding the final hypothesis (H9), simple regression analysis shows that there is a significant relationship between knowledge sharing and knowledge application ($t = 10.0$, $\beta = .21$, $p = .000$), providing support for the hypothesis. In order to test whether knowledge sharing has an effect on knowledge application above and beyond the other predictor variables in the model (left hand side of Fig. 1), multiple hierarchical regression analysis was conducted, where the first order predictors were included in block 1 and knowledge sharing was included in block 2. The results are presented in Table 6.

As shown in Table 6, knowledge sharing has a positive effect on knowledge application when the other predictor variables are included in the model. However, we also see that the change in explained variance is very low (though significant), indicating that the practical relevance of the relationship is limited. The table further shows that intrinsic motivation is the most important predictor of knowledge application, followed by management support and knowledge sharing. Some interesting findings also appear when comparing the effects of the predictors on knowledge application with the results presented in Table 4 (regression with knowledge sharing as dependent variable). First, we find that experience has a significant negative effect on knowledge application, while the effect of this predictor was positive (and significant) for knowledge sharing. Second, we find that location is not a significant predictor of knowledge application, indicating that location has an effect of knowledge application only through knowledge sharing.

In order to increase the robustness of the findings, tests of hypotheses were also conducted in the operator and subcontractor groups separately. Except for H8, similar effects were found in these two groups for all relationships, which strengthen the findings. Regarding H8, a positive relationship between management support and knowledge sharing behavior was found only for the subcontractor group (not for the operator). This may be explained by the larger portion of leaders in the subcontractor group compared to the operator group (Table 1). Further, as the response rates of the operator company and the subcontractors were somewhat different (i.e.

Table 1
Population and response.

Group	Population	Responses	%	Leaders (%)
Group A: Employees – operator	1165	730	62.7	33
Group B: Consultants – operator	233	150	64.4	
Group C: Employees/consultants – subcontractors	4458	1773	39.8	44
Subcontractors (group c)				
A	342	132	38.6	43
B	767	173	22.6	43
C	737	408	55.4	39
D	1358	525	38.7	46
E	560	249	44.5	37
F	457	152	33.3	64
G	187	102	54.5	51
H	50	32	64.0	25

Table 2
Constructs and indicators.

Construct	Indicator(s) / question(s)	Scale	Alpha
Education	– What is your highest level of education?	– Primary and secondary school – Upper secondary school – Higher education > 4 years – Higher education < 4 years	
Experience	– How long experience do you have from work within Drilling & Well?	– Less than one year – 1–3 years – 3–5 years – 5–10 years – More than 10 years	
Training	– I receive the training required related to new tasks and responsibilities	1–6(totally disagree – fully agree)	
Autonomous motivation	I participate in knowledge sharing: – to determine whether my experiences suggestions are relevant – because I want to learn more – because I want to contribute to better accomplishment of tasks	1–6(totally disagree – fully agree)	0.72
Job autonomy	– I am sufficiently involved/have a say in decisions related to my work – I can decide how to complete my tasks	1 – 6(totally disagree - fully agree)	0.67
Focus on short-term goals	– My leader is primarily concerned with short term goals	1–6(totally disagree – fully agree)	
Location	– Where do you mostly work?	– Mostly offshore – Mostly onshore	
Management support	My leader encourages us to seek knowledge and learn from others	1–6(totally disagree – fully agree)	
Knowledge sharing behavior	– I frequently get in touch with people at other installations/entities to get good advice. – People at other installations/entities often get in touch with me to give me good advice. – I frequently contribute with advice to other installations/entities	1–6(totally disagree – fully agree)	0.89
Knowledge utilization	Assess how the following statements about sharing of knowledge with others have affected your work: – I feel more secure when I make decisions – I accomplish tasks in a safer way – I make fewer mistakes in my work – I have become better at complying with governing documents	1–6(totally disagree – fully agree)	0.87

Table 3
Correlation matrix.

	1	2	3	4	5	6	7	8	9	10
(1) Education	–									
(2) Experience	−.06**	–								
(3) Training	−.08**	−.09**	–							
(4) Intrinsic motivation	.02	−.1**	.19**	–						
(5) Autonomy	−.00	.04	.37**	.2**	–					
(6) Focus on short-term goals	.03	−.02	−.16**	−.1**	−.09**	–				
(7) Location	.3**	−.1**	−.07**	.08**	.1**	−.02	–			
(8) Management support	−.03	−.07**	.33**	.28**	.21**	−.21**	.07**	–		
(9) Knowledge sharing	.1**	.07**	.14**	.31**	.17**	−.06**	.26**	.19**	–	
(10) Knowledge utilization	−.03	−.1**	.18**	.46**	.19**	−.08**	.04*	.24**	.23**	–
Mean	2.8	4,2	4.5	4.9	4.7	3.0	1.5	4.8	3.7	4.9
Std. dev.	.84	1.2	1.1	0.6	0.9	1.2	0.5	0.9	1.1	0.6
Min	1	1	1	1	1	1	1	1	1	1
Max	4	5	6	6	6	6	2	6	6	6

Table 4
Regression analysis. Dependent variable: Knowledge sharing.

Dependent variable	Predictors	B	Std. err.	β	t	Sig.
Knowledge sharing (R^2 = 0.19)	Education	.051	.252	.039	1.92	.055
	Experience	.125	.019	.130	6.55	.000
	Training	.080	.022	.080	3.61	.000
	Intrinsic motivation	.470	.037	.267	12.84	.000
	Autonomy	.052	.026	.043	1.99	.047
	Focus on short-term goals	.003	.018	.004	0.19	.850
	Location	.537	.046	.245	11.7	.000
	Management support	0.80	.026	.068	3.13	.002

Table 5
Regression analysis Onshore vs. offshore work location.

Dependent variable = knowledge sharing	Onshore			Offshore		
Predictors	β	t	Sig.	β	t	Sig.
Education	−.02	−0.65	.519	.07	2.37	.018
Experience	.17	5.50	.000	.11	3.95	.000
Training	.13	3,80	.000	.06	1.82	.070
Intrinsic motivation	.29	9.08	.000	.27	9.28	.000
Autonomy	−.00	−0.11	.913	.07	2.39	.017
Focus on short-term goals	−.01	−0.21	.831	.01	0.34	.732
Location	–	–	–	–	–	–
Management support	.12	3.55	.000	.04	1.38	.167

Table 6
Regression analysis. Dependent variable: Knowledge utilization.

Dependent variable = Knowledge utilization	Step 1			Step 2		
Predictors	*t*	*β*	Sig.	*t*	*β*	Sig
Education	−1.4	−.03	.154	−1.6	−.03	.116
Experience	−2.5	−.05	.014	−2.9	−.06	.003
Training	2.4	.05	.016	2.1	.05	.034
Intrinsic motivation	19.7	.39	.000	18.0	.37	.000
Autonomy	3.0	.06	.003	2.8	.06	.005
Focus on short-term goals	0.6	.01	.547	0.6	.01	.538
Location	−0.4	−.01	.679	−1.3	−.03	.193
Management support	4.4	.09	.000	4.1	.09	.000
Knowledge sharing				3.7	.08	.000
ΔR^2				.01		
ΔF				13.6 (p = .000)		
R^2	.22			.23		
F	79.1 (p = .000)			72.3 (p = .000)		

Table 7
Summary of tests of hypotheses.

Dependent variable	Independent variable	Hypothesis	Result	Comment
Knowledge sharing	Education	H1	Not supported	Significant for offshore personnel
	Experience	H2	Supported	
	Training	H3	Supported	Only for onshore personnel
	Intrinsic motivation	H4	Supported	
	Job autonomy	H5	Supported	Only for offshore personnel
	Focus on short term-goal	H6	Not supported	
	Location	H7	Supported	
	Management support	H8	Supported	Only for onshore personnel
Knowledge utilization	Knowledge sharing	H9	Supported	

differences between operator and subcontractor respondents regarding managerial positions) the regression analyses were also conducted on these groups (respondents with and without managerial positions) separately. The results show that the groups obtain the same overall effect patterns, with slight differences regarding the effects of experience and management support (experience are more important for non-leaders than for leaders, while the opposite is true for the influence of management support).

The results of the tests of hypotheses are summarized in Table 7.

6. Discussion

Organizational learning and knowledge processes have gained increasing attention in the organizational safety literature. In this paper we have analyzed knowledge sharing in an organizational setting where one would expect that both intra- and interorganizational knowledge sharing occur on a regular basis (as work processes in drilling and well operations involve employees from multiple companies, and take place at different geographical locations). Based on the management and organizational literature, we have developed and tested hypotheses on antecedents of knowledge sharing in a complex organizational setting, as well as the relation between knowledge sharing and knowledge application. The analyses provided support for six of the eight hypotheses on antecedents of knowledge sharing. Similar to several other studies, we found a large effect of autonomous motivation, supporting the argument that being autonomously rather that extrinsically motivated increases the likelihood of being open to obtaining knowledge from others. We also found an effect of geographical structure, where those who mainly work onshore tend to be more involved in knowledge sharing activities than offshore employees. This might be a result of two different mechanisms, the type of work one is engaged in as well as the opportunities for knowledge sharing.

The level of expertise is expected to improve the ability to learn from new knowledge and to provide useful information and advice to colleagues, and there was support for the effects of two variables related to the employee's level of expertise. As expected, the length of experience in the given functional area and training provided for the present position had positive effects on knowledge sharing. Level of education on the other hand was significant when tested individually, but turned out insignificant when other variables were accounted for.

There were also positive effects of variables at the level of the job role (job autonomy) and unit (managerial support) on knowledge sharing. Thus, from the results of the regression analysis, the propensity of knowledge sharing is influenced by variables on several levels and various mechanisms.

The hypotheses 1–8 are based on the presumption that there are similar effects across locations (onshore vs. offshore), and location is included as an *independent* variable in the model (H7). However, when the sample is spilt based on the respondents' work location, different effects of several variables (education, training, job autonomy and management support) are found in the two categories. These findings indicate that location is a vital *conditioning* variable and that the explanatory mechanisms for knowledge sharing behavior *differ* between the offshore and the onshore work context. These findings may be explained by differences in work tasks, knowledge needs and the context in which knowledge sharing takes place. For example, the stronger effect of training onshore may be a result of training taking place in a context more characterized by dialogue, discussions and exchange of experiences, compared to a larger degree of training for a specific job offshore. The positive effect of education among offshore employees may be due to a combination of a lower level of education in this category and that there is an effect of this variable only to a certain level/threshold.

We also hypothesized that there would be a statistical relation between knowledge sharing and knowledge application (H9). The regression analysis revealed a positive and statistically significant relationship between the two variables, but with a low degree of explained variance. One may ask why the effect of knowledge sharing on knowledge application is not larger. A viable explanation may be found in the operationalization of the variables. The former

variable was measured by the *frequency* of information exchange with people at other entities, while knowledge application was measured by asking the respondents to assess four statements about how sharing of knowledge has affected his or her work. Thus, this latter measure captures *the respondents' own perception of the effect* of knowledge sharing, in terms of safety, mistakes and compliance. The operationalization of the variables may therefore not be optimal. However, looking at the descriptive analysis, the mean of the knowledge application variable is 4.9 (maximum = 6), and the standard deviation is .06. This shows that a high percentage reported a positive perception of the effect of knowledge sharing, indicating that knowledge sharing behavior is of vital aspect regarding safety at work.

7. Conclusion

Studies in safety management have increasingly emphasized issues of knowledge management and organizational learning. While knowledge sharing and application among different units and locations are clearly relevant in complex organizational systems, there have been few systematic studies of these knowledge processes in high reliability settings. The contribution of this paper is that we have a) studied knowledge sharing and application in a complex interorganizational context where safety management is critical, b) with the application of concepts, variables and approaches from the literature in organization and management. This is one of the first systematic studies of knowledge sharing in the safety management field. In addition we have extended the range of application of knowledge sharing approaches to a new context, a high reliability setting.

We have found that respondents in our sample generally consider that knowledge sharing has a positive effect on their actions in terms of safety. There is also a significant, positive relationship between knowledge sharing on the one hand and the perception of the effect of knowledge sharing on the other hand. Further, six of the hypotheses on antecedents of knowledge sharing were supported, with the largest effects of autonomous motivation and location.

We have also investigated whether two dimensions of the organizational context (offshore vs. onshore location and operator vs. supplier) serve as conditioning variables for knowledge sharing. While there were similar findings along the second dimension, the effects of four of the variables in the model differed between the offshore and the onshore context. This finding indicates that location is a conditioning variable for knowledge sharing, and may be followed up in further research. This also has important practical implications as the effects of various improvement initiatives are likely to vary dependent on work location. For example, the significance of the various aspects of resilient collaboration proposed by Skjerve et al. (2011) (i.e. ability, possibility, and willingness to collaborate) may depend on whether the collaboration occurs within or between onshore and offshore locations. Design and implementation of initiatives that aim at improving knowledge sharing behavior should therefore take this into account.

Future research in safety management may build on our work along several dimensions. First, in relation to external validity one may study knowledge sharing in other activities in petroleum or in other sectors. We have studied knowledge sharing in a context that is both geographically distributed (several locations) and comprises several organizations (interorganizational). Further work could vary the complexity of the setting and investigate if the mechanisms are similar or different across sectors. Secondly, as discussed in the previous section, one should strive to improve the measures of knowledge sharing by including other indicators than those related to frequency of contact. Items that capture quality and relevance in addition to those on frequency may be complementary indicators of relevant knowledge sharing behavior. Similarly, one should develop indicators of the consequences of knowledge sharing in order to obtain a larger degree of variation in employees' actions.

Acknowledgements

Role of the funding source: The paper is based on data from a research project funded by an operator company in Norway. Representatives from the company were involved in the questionnaire design process (indicator development).

References

Aoki, M., 1986. Horizontal vs. vertical information structures of the firm. American Economic Review 76, 971–983.

Austnes-Underhaug, R., Cayeux, E., Engen, O.A., Gressgård, L.J., Hansen, K., Iversen, F., Kjestveit, K., Mykland, S., Nesheim, T., Nygaard, G., Skoland, K., 2011. Læring av hendelser i Statoil. En studie av bakenforliggende årsaker til hendelsen på Gullfaks C og av Statoils læringsevne. IRIS-rapport 2011/156.

Babcock, P., 2004. Shedding light on knowledge management. HR Magazine 49 (5), 46–50.

Cabrera, A., Collins, W.C., Salgado, J.F., 2006. Determinants of individual engagement in knowledge sharing. International Journal of Human Resource Management 17, 245–264.

Carter, C., Scarbrough, H., 2001. Towards a second generation of KM? The people management challenge. Education and Training 43, 215–224.

Cohen, W., Levinthal, D., 1990. Absorptive capacity: a new perspective on learning an innovation. Administrative Science Quarterly 35, 128–152.

Connelly, C.E., Kelloway, E.K., 2003. Predictors of employees' perceptions of knowledge sharing cultures. Leadership and Organization Development Journal 24, 294–301.

Constant, D., Kiesler, S., Sproull, L., 1994. What's mine is ours, or is it? A study of attitudes about information sharing. Information Systems Research 5, 400–421.

Constant, D., Sproull, L., Kiesler, S., 1996. The kindness of strangers: the usefulness of electronic weak ties for technical advice. Organization Science 7, 119–135.

Cox, S., Jones, B., Collinson, D., 2006. Trust relations in high-reliability organizations. Risk Analysis 26, 1123–1138.

Dalkir, K., 2005. Knowledge Management in Theory and Practice. Elsevier Butterworth-Heinemann, Burlington, MA.

Deci, E.L., Ryan, R.M., 2000. The "what" and "why" of goal pursuits: human needs and the self-determination of behavior. Psychological Inquiry 11, 227–268.

Doytchev, D., Hibberd, R.E., 2009. Organizational learning and safety in design: experiences from German industry. Journal of Risk Research 12, 295–312.

Foss, N.J., Minbeava, D.B., Pedersen, T., Reinhold, M., 2009. Encouraging knowledge sharing among employees: how job design matters. Human Resource Management 48, 871–893.

Hackman, J.R., Oldham, G.R., 1975. Development of the job diagnostic survey. Journal of Applied Psychology 60, 159–170.

Hackman, J.R., Oldham, G.R., 1976. Motivation through the design of work: test of a theory. Organizational Behavior and Human Performance 16, 250–279.

Hair, J.F., Anderson, R.E., Tatham, R.L., Black, W.C., 1998. Multivariate Data Analysis, 5th ed. Prentice-Hall, New Jersey.

Hefeng, X., Qingguo, M.A., Jing, X., 2011. Impact of organizational climate on employee's safety behaviors. Management School, Zhejang University, China. Unpublished paper.

Hopkins, A., 2008. Failure to Learn. The BP Texas City Refinery Disaster. CCH Australia.

Jackson, S.E., Chuang, C.-H., Harden, E.E., Jiang, Y., Joseph, J.M., 2006. Toward developing human resource management systems for knowledge-intensive teamwork. In: Joseph, J.M. (Ed.), Research in Personnel and Human Resources Management 25. Emerald Group Publishing, Amsterdam, pp. 27–70.

Kauppila, O.-P., Rajala, R., Jyrama, A., 2011. Knowledge sharing through virtual teams across borders and boundaries. Management Learning 42, 395–418.

Kulkarni, U.R., Ravindran, S., Freeze, R., 2006. A knowledge management success model: theoretical development and empirical validation. Journal of Management Information Systems 23, 309–347.

Lin, H.-F., 2007. Knowledge sharing and firm innovation capability: an empirical study. International Journal of Manpower 28, 315–332.

Mendonca, D., Rush, R., Wallace, W.A., 2000. Timely knowledge elicitation from geographically separate, mobile experts during emergency response. Safety Science 35, 193–208.

Minbaeva, D.B., 2005. HRM practices and MNC knowledge transfer. Personnel Review 34, 125–144.

Nesheim, T., Olsen, K.M., Tobiassen, A., 2011. Knowledge communities in matrix-like organizations: managing knowledge towards application. Journal of Knowledge Management 15, 836–850.

Osterleh, M., Frey, B.S., 2000. Motivation, knowledge transfer and organizational form. Organization Science 2000, 538–550.

Perrow, C., 1999. Normal Accidents. Living with High-Risk Technologies. Princeton University Press, New York, NY.
Read, C., 2011. BP and the Macondo Spill: The Complete Story. Palgrave Macmillan, New York, NY.
Reagans, R., McEvily, B., 2003. Network structure and knowledge transfer: the effects of cohesion and range. Administrative Science Quarterly 48, 240–267.
Reinholt, M., Pedersen, T., Foss, N.J., 2011. Why a central network position isn't enough: the role of motivation and ability for knowledge sharing in employee networks. Academy of Management Journal 54, 1277–1297.
Schønstrøm, M., 2005. Creating knowledge networks: lessons from practice. Journal of Knowledge Management 9, 17–29.
Skjerve, A.B., Kaarstad, M., Størseth, F., Wærø, I., Grøtan, T.O., 2011. Planning for resilient collaboration at a new petroleum installation – a case study of a coaching approach. Safety Science 50, 1952–1959.
Størseth, F., Tinmannsvik, R.K., 2011. The critical re-action. Learning from accidents. Safety Science 50, 1977–1982.
Wahlstrøm, B., 2011. Organisational learning – reflections from the nuclear industry. Safety Science 49, 65–74.
Wang, S., Noe, R.A., 2010. Knowledge sharing: a review and directions for future research. Human Resource Management Review 20, 115–131.