Modelling the effects of a large-scale safety culture programme: A combined qualitative and quantitative approach

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Abstract

In many industries it has become common to implement safety programs aimed at improving behavioural and cultural safety; however, in general little research has been conducted to understand the dynamics and causality of such programs. This study sought to explore the effects of a large-scale safety program implemented by a Norwegian petroleum company using a combined methodological approach; results from qualitative interviews and fieldworks were used to develop a hypothetical structural model tested on questionnaire data (N=1221) using Structural Equation Modelling (SEM). Five theoretical concepts were validated before they were included in a hypothetical structural model: 1) participation in a two day kickoff, 2) personal programme commitment, 3) effectiveness of programme implementation, 4) safety behaviour change, and 5) safety culture change. SEM indicated that the suggested structural model fitted the data, but two of the hypothesised structures were not significantly supported. Based on this, a modified model was developed and estimated, resulting in a more robust model in which all hypothesized influences were supported. Results are discussed in light of the qualitative and quantitative results, program characteristics, and previous research. This study demonstrates the significance of developing worker commitment to program implementation and the importance of a comprehensive implementation of programme activities to increase the likelihood of cultural and behavioural effects concerning safety.

Keywords: Safety programmes; Safety interventions; Safety behaviour change; Safety culture change; Structural equation modelling

Introduction

A database search for the term *safety culture* retrieves many hits in scientific research databases such as Web of Science. Since the 1980s, researchers have documented that organisational and cultural factors are underlying causal factors of accidents (Cheyne et al., 1998; Flin et al., 2000; Mearns, Whitaker, and Flin 2003; O'Toole, 2002; Weick, Sutcliffe, and Obstfeld, 1999; Zohar, 1980). The interest in safety culture has become common in organisations operating in high risk environments. The petroleum industry in Norway is an example of this. In 2002, The Norwegian Petroleum Safety Authority made an explicit demand in safety regulations that enterprises must have a sound health, safety, and environmental (HSE) culture. This new demand in safety regulation has been followed up and cultural and behavioural interventions are now common within the industry (Foss, 2006). Consequently, today's petroleum industry includes widespread implementations of cultural and behavioural safety programmes and interventions (Foss, 2006). Despite the interest in safety culture, researchers have fallen behind when it comes to developing and testing hypothetical structural models that can demonstrate the effects of safety programmes. Testing such models will bring new insights about the influences between interventions and outcomes, which is of both practical of scientific interest.

The current study has two aims: 1) to gain insight into important factors that influence and mediate the effects of a large-scale safety programme and 2) to develop and test a hypothetical structural model that illustrates important effects of the safety programme. The present study builds on an important rationale that qualitative and quantitative methods represent different ontologies that, when combined, contribute to valuable insight into the effects and dynamics of safety interventions. Thus, a combined methodological approach will be used in order to understand the dynamics and effects of a large-scale safety programme.

The hypothetical structural model developed and tested on questionnaire data will be based on interview data, programme characteristics and previous research.

The current study is conducted in the organisation with the largest share of employees in the Norwegian petroleum sector. The safety programme includes both the company's employees and workers employed in contractor companies working for them. Approximately 33,000 workers attended the two-day kickoff of the safety programme, which was intended to last for more than three years. As such, the dimensionality of the programme likely reflects the largest safety promotion activity ever implemented by any company in Norway.

Theoretical Background

The Concept of Safety Culture

The term safety culture was first cited in a report by the International Nuclear Safety Advisory Group (INSAG) following the 1986 Chernobyl disaster. Since then, several reviews have been published on the topic (Choudhry, Fang, and Mohamed 2007; Glendon and Stanton 2000; Guldenmund 2000; Pidgeon 1998; Sorensen 2002) and therefore the concept of safety culture will be only briefly summarised here.

The concept of safety culture evolved from the concept of organisational culture, which has been studied from two principal perspectives—a functionalistic and an interpretive perspective (Glendon and Stanton, 2000). Following the functionalist approach, culture is viewed as a critical variable that influences certain outcomes: safety, reliability and so forth. The interpretive researchers, on the other hand, conceive of culture as a root metaphor for the organisation, and they approach organisations as if they were cultures (Burrell and Morgan, 1985). According to the functionalistic approach, safety culture refers to shared attitudes, values, beliefs, and practices concerning safety and the necessity for effective control; as such, safety culture relates to the product of individual and group values, attitudes, competencies, and patterns of behaviour that determine the commitment to as well as style

and proficiency of an organisation's safety programmes (ACSNI, 1993). Meanwhile, the interpretive researchers do not focus on the "function" of culture, but rather on the aspects of culture that affect safety (Waring, 1992). Using culture as a metaphor for the organisation involves directing attention to the shared patterns of meaning which members of organisations draw on as they interpret their beliefs, behaviour and collective identity. Although the interpretive perspective gives valuable insight into safety culture characteristics, the functionalistic perspective is more clearly aimed at reducing risk (Glendon and Stanton, 2000).

Researchers interested in the functionalistic perspective search for answers to two essential questions: 1) what kind of theoretical models best reflect the effects of safety interventions and 2) to what degree can empirical research give support towards such models. Undoubtedly, it creates safety challenges when we do not know enough about the effects of safety interventions, safety training, or education. Shannon et al. (1999) point to several criteria that can increase the understanding of safety interventions, recommending, for example, thorough descriptions of programme objectives, the conceptual basis of safety programmes, and interventions. Another important recommendation is the use of qualitative methods to supplement quantitative data. Shannon et al. further emphasise that safety researchers seldom comply with these important criteria, which results in a poorer quality of safety research and reduces the potential understanding about the effects and dynamics of safety interventions. Lack of methodological triangulation probably stems from the general fact that most organisational researchers have been trained in either quantitative or qualitative methods (Martin, 2002).

Improving safety through Safety Programmes

A safety programme can be described as a dynamic set of intervention activities implemented at a worksite where the aim is to prevent incidents. Safety programmes often include activities

such as safety training, equipment and housekeeping inspections, safety meetings, and safe behaviour observations (Lyer et al., 2005). Safety programmes can also be regarded as an environmental factor that facilitates change in the employees' work behaviours (Idsøe, 2007). The aim of such interventions is experimental treatment or change in one or more independent variables that should contribute to change in target dependent variables (Guzzo et al., 1985). The treatment is typically related to some kind of safety training courses (Shannon et al., 1999).

In safety research the dependent variable can typically relate to different criteria—e.g., safety behaviour (Cooper & Phillips, 2004), safety climate (Zohar and Luria, 2005), safety culture (Pronovost et al., 2005), or accident rates (Zohar, 2000). At first glance, accident rates may present an indisputable direct outcome measure for safety interventions; however, the use of accident rates as a criterion measure results in certain problems. First, accidents are normally rare, resulting in unreliable accident frequency rates. Second, accidents may not be due to job incumbents, but rather extraneous random influences that contribute to accidents in unclear paths. Third, accidents are not always consistently recorded; incentives may influence the risk of both under-reporting and over-reporting of accidents. Based on these problems and previous research (Dejoy, 1994; Hofmann et al., 1995; Janssens, Brett and Smith, 1995), Thompson et al. (1998) state: "self reports of safety behaviour and perceptions offer an alternative criterion measure for determining workplace safety…it is hard to believe that anonymous respondents would under-estimate their level of workplace safety if people around them were being injured on a regular basis" (p. 18).

Dejoy (2005) clarified an important distinction between behavioural and cultural approaches to safety management, leading to the ability to characterise safety programmes according to this distinction. The behavioural approach mainly refers to behaviourism (Skinner, 1938). Essentially, in the behaviour-based approach, "applied behaviour analyses

hold that behaviour is under the control of environmental contingencies" (Dejoy, 2005, p. 107). The methodology used in behavioural safety programmes is based on observational and feedback processes that often require frontline staff to carry out behavioural safety observations on their colleagues. When it comes to changing behaviours, several fundamental issues are likely to influence positive behaviour; such issues concern the development of trust and cooperation, an environment for consultation and communication, sufficient information and training, and the commitment and involvement of workers (Stanton, 1996). Safety behaviour programmes seem to be the most characteristic form of safety programmes in UK workplaces (Fleming and Lardner, 2002). Still, such programmes have been criticised for the fallacy of mono-causality and for not taking the multi-causality of accidents seriously (Hopkins, 2006).

While the behavioural approach is considered more of a "bottom-up" approach, the cultural approach to safety is considered a "top-down" approach, adopting clearly different aspects heavily related to management and organisational behaviour theory (Dejoy, 2005). In the cultural approach, in which terminology and methods are borrowed from ethnography, the aim is often to change fundamental values and beliefs of the organisation to make lasting improvements on safety. However, organisational culture is thought to be self-perpetuating, which "means that cultures are often resistant to change and that producing culture change can be an unpredictable and slow process" (Dejoy, 2005, p. 108). It is more challenging to evaluate the efficacy of culture change initiatives due to the fact that no core set of procedures exists to evaluate. The behaviour-based approach, on the other hand, has as core set of procedures to evaluate change initiatives.

Despite the clear differences between the behavioural and cultural approaches to safety, the two schools of thought are often integrated in practice (Dejoy, 2005). This relates to inter-dependency of these theoretical distinctions in the management of safety (Cox, Jones,

and Rycraft 2004). Both approaches have in common the importance of external influences and the treatment of independent variables as a foundation for human behaviour change.

It seems natural that safety theory should be related to more general theory concerning organisational behaviour and safety. Social cognitive theory (Bandura, 1986) is an example of a widely used theory that has been applied within safety research (Cooper, 2000; Geller, 2001). According to social cognitive theory, people are both products and producers of their environment. The interplay among persons and between people and the environment is dynamic and reciprocal; people's actions are not entirely determined by situational or personal characteristics. Because of the influence of other organisational systems, safety researchers should not consider safety culture in a vacuum (Cooper, 2000). The social cognitive perspective can also be applied to the understanding of a safety programme; such programmes do not exist in a vacuum and the effects depends on the interplay between environmental and worker characteristics. Environmental factors include both programme characteristics, such as the goodness of interventions, and organisational characteristics such as systems, goals, and trust between workers.

The goal of safety programmes is to implement various preventive measures used in combination effectively. Such interventions should affect not only individuals, but also social norms and cultural factors (Lund and Aarø, 2004). Determining the optimal combinations of preventive measures and effectively implementing them through a clever marketing strategy (Vecchio-Sadus and Griffiths, 2004) are crucial steps; if an organisation successfully implements such recommendations, it is reasonable to expect changes in workers' individual behaviour and the safety culture of the organisation.

Safety Intervention Program

In the study of safety programmes, it is important to explain programme objectives and characteristics (Shannon et al., 1999). The following sections will explain the objective

and theoretical foundation of the safety programme as well as the programme's structure and activities.

Objective and Theoretical Foundation

The background for the development and implementation of the safety programme in the study organisation was that accident rates had reached a "plateau"; in other words, negative outcome data had bottomed out at an asymptotic value. Key stakeholders in the organisation felt that most requirements related to technology and systems had been met, but unnecessary accidents still occurred. Therefore, the objective of the safety programme was to improve safety performance through improved safety behaviour and safety culture, which has been characterised as a typical background for safety culture initiatives (Reason, 2000).

The safety programme includes all personnel in the company as well as contractors and consultants bound by contract for a longer period of time (approximately six months). A broad range of messages is communicated throughout the programme: 1) the vision of zero accidents; 2) accidents can be prevented with human safety barriers; 3) workers' commitment is key to improved safety behaviour; 4) care is an essential human safety barrier; 5) improved safety involves all personnel at all hierarchical levels; 6) safety should be prioritised before production; and 7) long-term efforts are needed to change safety culture.

To some extent, the safety programme is theoretically based on Reason's (1977) Swiss Cheese Model of Defences; a modified version of this model is actively used as a symbol of safety throughout the organisation. According to the Swiss Cheese Model, each defence has weaknesses and gaps; the function of each layer varies according to local conditions that influence the functionality or dysfunctionality of the different barriers. Because the defensive layers and their associated holes are not static, several layers and barriers should be developed in order to prevent accidents from happening. In order to make the Swiss Cheese Model meaningful and functional in the organisation, five soft barriers were defined in the safety

program as the most important in enhancing safety culture and safety behaviour within the company:

1) Correct prioritisation: Involves taking the time needed to work safely; safety shall be prioritised before production when a conflict arises.
2) Compliance: Emphasises the importance of following procedures, requirements, guidelines, and decisions.
3) Open dialogue: Underscores that employees shall all feel open to discuss safety with line management at any level as well as with colleagues.
4) Continuous risk assessment: Taking the time to evaluate what kinds of accidents can happen if something unexpected occurs.
5) Caring about colleagues: Involves taking care of oneself and one's colleagues when they do something that puts themselves or others at risk.

The different activities in the safety programme actively focus on these barriers. The Swiss Cheese Model is used as a symbol of safety on different posters that illustrate the five barriers in the SP. It is important to emphasise that the SP studied is clearly related to the cultural approach described by Dejoy (2005) and not to behavioural safety observations combined with feedback processes.

Structure and Activities in the SP

The implementation of the SP starts with a two-day kickoff gathering that all personnel, including contractors and consultancies, are obliged to attend. During this gathering, dramatic stories related to safety are told by employees on the podium or through different movies. The various messages communicated during the two-day gathering reflect the key messages in the safety programme. In addition, all personnel work to solve different safety tasks and commit themselves to personal safety improvements.

After the introductory two-day kickoff, employees pursue a systematic three-year follow up programme. A “colleague-group” is established in each organisational area consisting of the head manager, safety leader, and head safety delegate. The members of the group attend an extra one-day training workshop. The role of the colleague-group is to administer programme materials throughout the organisation. In addition, they function as enthusiasts in the follow-up of the programme.

Furthermore, a project group consisting of about 20 persons was established centrally in the organisation. This group has ultimate responsibility for the safety programme and was responsible for the production and distribution of programme material to all colleague groups. Representatives from the project group followed up with the colleague groups one or two times each year.

The programme materials used in the follow-up activities consist of different films, posters, and tasks that all departments are obliged to discuss. For example, employees in all departments define their own measures on how to improve care between employees. Department leaders also have a central role in the implementation of programme activities; they facilitate programme activities, try to integrate messages into daily work tasks, and are expected to remind employees to make use of the five barriers.

As the implementation of the safety programme is perceived as an organisational change process, significant involvement and management commitment are considered vital factors. Consequently, top managers, unions, and representatives from contractor companies were informed about the programme in pre-implementation meetings that sought to build trust and generate general acceptance of the programme among key stakeholders.

Method

Overview of Sample

As shown in Table 1, 151 interviews as well as fieldworks were conducted on three offshore installations, one onshore gas-plant, and different office departments within the organisation. In addition, a survey carried out on seven offshore installations, one gas plant, and six onshore units yielded a response rate of 40 percent (N=1221); the relatively low response rate can be explained by the difficulty of implementing effective routines for distribution and collection of questionnaires due to the complexity of the organisation. However, the sample was deemed to be representative of the organisation based on the following sample characteristics: 76.6 percent of the respondents worked on offshore installations, 19 percent had management responsibility, 86.7 percent had participated in the two-day kickoff, 34.5 percent were employed in a contractor company, and 58.3 percent were at least 40 years old. Both the interviews and the survey were carried out one to two years after the respondent units initiated the programme.

Table 1

Overview of the qualitative and quantitative sample studied

Method	Number of respondents	Units attending			Total units attending
		Offshore installations	Gas plant	Onshore units	
Questionnaire survey	1221	7	1	6	14
Interviews and fieldwork	151	3	1	2*	5

* One of the units had several subdepartments.

In addition to the data presented in Table 1, focus discussion groups were employed immediately after the first (N=11) and second (N=12) two-day kickoff gatherings implemented in the organisation. The focus discussion groups were carried out for two reasons: 1) to understand how individuals evaluate all measures used during the gathering and

2) to obtain knowledge for further improvement of the gathering before it was implemented in the remaining parts of the organisation[1]. Other relevant information was also collected through meetings, seminars, and documents.

Qualitative Approach

A semi-structured interview guide was developed before the interviews were conducted. The focus of the interview guide was to identify the interviewees' thoughts, understandings, experiences, and perceptions about the safety programme design and implementation in the context of the organisation in which they worked. All interviews were anonymous and voluntary. The qualitative interviews were carried out in the interviewees' workplaces. Both managers and employees representing both contractor companies and the operator company at each workplace were interviewed. The interview sample also included safety deputies and employees representing unions.

The fieldwork lasted for about six days each time. It consisted of stays in the departments of contractors and operators, informal discussions during coffee breaks, etc. In most of the fieldwork, researchers also participated in the meetings of the safety deputies and in several manager meetings.

Concern regarding validity was stressed at all stages of the qualitative research process, as suggested by Kvale (1996) and Miles and Huberman (1994). In order to validate the findings at the unit level, summary field notes were written for each work unit. These field notes were handed to key personnel in each unit, who in turn functioned as validity checks of the results. This approach made it possible to assess dynamics related to individual and work characteristics, which again were related to the implementation and effects of the programme.

[1] To ensure that all participants attended the two-day kickoff, more than 200 gatherings were held over a 4-year period.

Quantitative Approach

Development of questionnaire items. A survey instrument was developed in cooperation with researchers and experts within the participating organisation. Three meetings were organised to determine which topics and variables should be included on the survey. The first meeting focused on brainstorming ideas to explore a wide area of topics that could be covered by the instrument. Before the next meeting, two researchers sorted and categorised the results from the first meeting and developed items with response categories. In the second and third meetings, the survey was further discussed and developed. The development of survey items was based on methodological knowledge about survey development (DeVillis, 2003)—e.g., double barrelled, lengthy, and difficult vocabulary should be avoided. The final version of the survey consisted of 83 items; all items were rated on Likert-type scales with verbal anchors.

Statistical analyses. Basic descriptive statistics, exploratory factor analysis (principal component analyses), and internal reliabilities (Cronbach's alpha) were estimated using SPSS 13.0. The Linear structural equation (LISREL) programme, version 8.70, was used to conduct confirmatory factor analysis and estimate the hypothesised structural model.

Due to the relatively few response categories, participation in the two-day kickoff and the items measuring personal programme commitment were treated as ordinal variables in the LISREL analysis. Ordinal variables include tests of thresholds, estimation of polychoric correlations, and tests of underlying normality (Du Toit and Du Toit, 2001; Jöreskog and Sörbom, 1996). The Robust Maximum Likelihood procedure was used as the estimation method in the conducted analysis; this method is recommended if the data do not follow a multivariate normal distribution. To implement the Robust Maximum Likelihood method for covariance structures, an asymptotic covariance matrix needs to be computed. The asymptotic covariance matrix is used as a weight matrix or as a matrix that adjusts the normal-theory

weight matrix in the sense that the chi-square statistic and standard-errors are less biased (Du Toit and Du Toit, 2001). The asymptotic covariance matrix is defined as the covariance matrix of parameter estimates (Preacher, Curran, and Bauer 2003).

In addition, the Root Mean Square of Error Approximation (RMSEA), the Non Normal Fit Index (NNFI), and the Comparative Fit Index (CFI) were also used to evaluate the goodness of fit of the estimated models. RMSEA measures discrepancies per degrees of freedom and requires no comparison with a null model. Values on the RMSEA below 0.10 have traditionally been interpreted as acceptable fit to the data at hand (Steiger, 1990). CFI compares the existing model fit with a zero model that assumes that the latent variables in the model are uncorrelated. The CFI should be greater or equal to 0.90 to accept the model, indicating that 90 percent of the covariation in the data can be reproduced by the given model. NNFI penalizes the model for complexity, and it is not guaranteed to vary between 0 and 1. Values on the NNFI close to 1 indicate a good fit. Hu and Bentler (1999) have suggested that values below 0.95 indicate a need to re-specify the model.

It is also common to use the Satorra-Bentler scaled χ^2 to evaluate model fit. However, the problem with the χ^2 is that it is directly related to sample size; as such, almost all models are evaluated as incorrect as sample size increases (Bentler and Bonnet, 1980). Due to the large sample size in this study, χ^2 was not used to evaluate model fit.

Results

Qualitative Results

Qualitative results are summarised in Table 2, with results presented according to four categories: 1) two-day kickoff; 2) programme design and implementation; 3) personal programme commitment; and 4) safety behaviour and culture change.

Table 2

Summary of qualitative results

Two-day kickoff • General impression that the kickoff gathering was good and interesting. • High-level presentations and round table discussions occurred. • Managers were committed • The gatherings were referred to as "very professional" implemented by "professional people". • Made us more aware of the hazards involved in their work. • Created very high expectations regarding the follow-up/day-to-day implementation. • Many workers who attended the kickoff were disappointed concerning the effectiveness of the day-to-day implementation.
Programme design and implementation • Generally positive impression of programme design regarding formal safety programme meetings, group tasks, films, posters, and so on. • Analysis of the workplaces revealed that the actual implementation of the safety programme was often delayed—for instance, because of projects or reorganisations. • One problem was that department leaders often did not devote enough time to implement safety programme activities. • In general, there was a large variation as to what degree the safety programme was continuously followed up on.
Personal programme commitment • General impression that personal commitment is positively associated with safety culture change and behaviour change (which is the intention of the safety programme). • Workers programme commitments are higher in departments with a high level of programme activities. • Impression that behaviour and attitude changes are related to change in workers' programme commitment. • Attendance at the kickoff gathering was positively associated with workers' programme commitments.
Safety behaviour and culture change • The most important cultural change was that the work on the care barrier had reduced informal status hierarchies between workers, which had made it easier to intervene on behalf of other personnel if they worked in a dangerous manner. • Most workers thought that the safety programme had improved the safety culture and safety behaviour in their work place. • Many thought that implementation of the safety programme demonstrated that safety is the top priority. • The most important safety behaviour change expressed by workers were that the safety programme, including the kickoff gathering, made them more attentive to risks in their work.

Based on the qualitative results, five theoretical domains were defined as important concepts to be incorporated in a hypothetical structural model—namely: 1) participation in a two-day kickoff; 2) the degree to which workers think the programme is effectively implemented and are satisfied with programme characteristics as well as the degree to which leadership supports the implementation; 3) the degree to which workers follow up their personal programme commitment; 4) the degree to which workers believe their safety behaviour has changed following programme implementation; and 5) the degree to which workers agree that the safety programme has improved the company's safety culture.

Quantitative Results

Exploratory factorial analyses. Separate exploratory factorial analysis revealed that the theoretical domains developed could be replicated in the data [2], *thereby supporting the validity of such theoretical and measurement concepts.* Program Effectiveness is measured with a total of 10 item; 5[3] that measure satisfaction with different program interventions (1=very dissatisfied, 6=very Satisfied, 7=don't know), 4[4] that measure to what degree workers know the messages have been focused on in different situations (1=not at all, 6=very often, 7=don't know), and 1 that concerns if the nearest leader takes the message in the safety program seriously (1=to a very low degree, 6=to a very high degree). Participation on two-day kickoff is rated with one item with a two-point option (1=no, 2=yes). Personal programme commitment is measured on two items: Have you been talking with colleagues about your personal commitments? (1=yes, many times, 2=yes, a few times, 3=yes, one time, 4=no) and have you followed up your personal commitment? (1=yes, often, 2=yes, but not often, 3=Yes,

[2] It should be mentioned that effectiveness of program implementation initially was divided into three theoretical domains: leadership, satisfaction and effective implementation. However, the exploratory factorial analyses indicated that these domains should be incorporated into a broader domain—namely, the above-defined effectiveness of programme implementation.

[3] These items were introduced with the following sentence: *How satisfied are you with the following aspects of the safety program?*

[4] These items were introduced with the following sentence: *I am aware that the messages of the safety program are focused on in the following situations?*

but seldom, 4=no, never). Safety behaviour change is measured using 9[5] items (1=worsened after safety program, 6=improved after safety program). Safety culture change is measured with 9[6] items (1=totally disagree, 6=totally agree).

Confirmatory factorial analyses. Confirmatory factorial analyses were conducted to further validate the five measurement concepts developed with exploratory factorial analyses. In the measurement model, these concepts are hypothesised as latent factors explaining the variances in their associated manifest variables (see Appendix 1 for an overview of the scale items included in the model). Widely used goodness-of-fit indices indicated that the measurement model fitted the data: RMSEA=0.067, NNFI=0.976, CFI=0.979. In addition, factorial loadings were above .50 and satisfactory. Taken together, the results indicate satisfactory evidence of and support for the association between the latent and manifest variables.

Descriptive statistics and internal consistency reliability. As part of the scale development, mean, standard deviation, and Cronbach's alpha were computed for all measurement concepts (see Table 3). The reliability coefficients ranged from .62 to .89., which are acceptable levels. The lowest alpha (.62) must be considered in relation to the fact that personal commitment is measured using two items; the number of items is a very important statistical parameter that influences the estimation of the alpha score (Schmidt, 1996). The high alpha scores for three of the items indicate a very precise measurement (DeVillis, 2003) and can be interpreted to indicate that some of the items are redundant. However, no items were removed because they were believed to measure distinct parts of the theoretical domains. In order for the concepts to capture variances in the phenomena

[5] These items were introduced with the following sentence: *How du you consider your own safety behaviour after the safety program was initiated?*
[6] These items were introduced with the following sentence: *How du you consider your own safety behaviour after the safety program was initiated?*

measured, all concepts must have some degree of variance; all in all, standard deviations and means reflect balanced measurements for the constructs.

Table 3

Descriptive statistics and internal consistency of measurement concepts

Construct	Scale (min-max)	Mean	SD	Cronbach's alpha
Participation two day kickoff	1-2	1,87	0,34	-
Program commitment	1-4	2,59	0,75	.62
Effectiveness of programme implementation	1-6	4,14	0,85	.89
Safety behaviour change	1-6	4,47	0,62	.93
Safety culture change	1-6	4,16	0,86	.85

In order for the concepts to capture variance in the phenomena measured, it is necessary that all concepts have some degree of variance. All in all standard deviations and means reflect balanced measurements for the constructs.

Development of hypothesised structural model. The development of a hypothesised structural model was based on results from the interviews, programme characteristics, and previous research. The intervention programme is regarded as an environmental factor that could facilitate change in employees' work behaviour and the organisations' safety culture. It is assumed that personnel have to attend programme activities and perceive these activities to be effective and meaningful. The degree to which the safety programme is effectively implemented is assumed to influence the degree of workers' commitment to the programme, which subsequently influences changes in safety culture and safety behaviour. It is also expected that cultures are more resistant to change (DeJoy, 2005); therefore, such change in safety culture depends on systematic measures implemented over a longer period of time—namely, as an ongoing process. It is commonly believed that participant characteristics may mediate or moderate the effect of interventions (Lipsey and Cordray, 2000); therefore, some

effects of interventions are expected to be mediated through personal programme commitment. As suggested by Cameron and Quinn (1999), change in culture partly depends on change in workers' behaviour. Based on social learning theory and a reciprocal principle of influence between the individual and the environment (Bandura, 1986; Cooper, 2000; Geller, 2001), it is further expected that the relation between safety behaviour change and safety culture change will be reciprocal.

Based on results from the interviews, the kickoff gathering is expected to have direct, long-term effects on personal programme commitment and safety behaviour change. The interview data also indicated that employees were often disappointed with the effectiveness of the follow-up based on the high expectations developed during the two-day kickoff. Therefore, the two-day kickoff is expected to contribute to a direct negative influence on effectiveness of programme implementation. The aim of the programme activities is to commit employees to safety goals and influence safety behaviour and safety culture. As such, it was hypothesised that an effective implementation of programme activities has a positive impact on personal programme commitment, safety behaviour change, and safety culture change.

The hypothesised structural model in Figure 1 includes one exogenous variable and four endogenous latent variables with both direct and indirect effects.

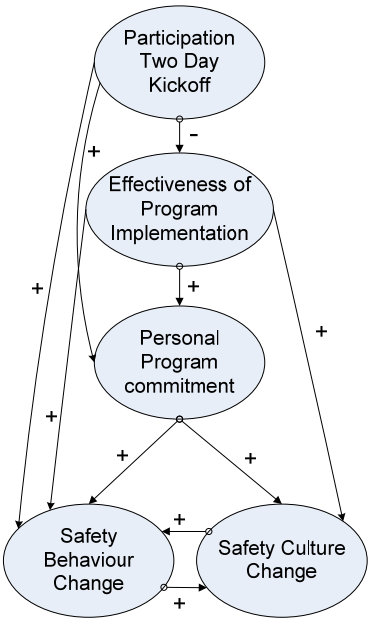

Figure 1. Hypothesized structural model displaying linear relationships between constructs. Observable variables are excluded from the model in order to simplify the presentation.

Testing of structural relationships. CFA and SEM goodness-of-fit statistics indicated that the suggested structural model fitted the data (RMSA=0,066, NNFI=0.977, CFI=0.979). The tested model had effective explanatory power (see Figure 2) and explained most variances in safety culture change (62.1) and safety behaviour change (47.1), followed by personal programme commitment (11.9) and effectiveness of programme implementation (1.4).

Two of the ten hypothesised relations demonstrated no significant effects; personal programme commitment had no significant effects on safety culture change or safety behaviour change. Participation in the two-day kickoff had a negative influence on programme effectiveness, as hypothesised. The rest of the relations were significantly supported[7].

[7] Using an ad hoc hypothesis, we also tested to see if participation in the two-day kickoff had a direct influence on safety culture change; this relation was not significant.

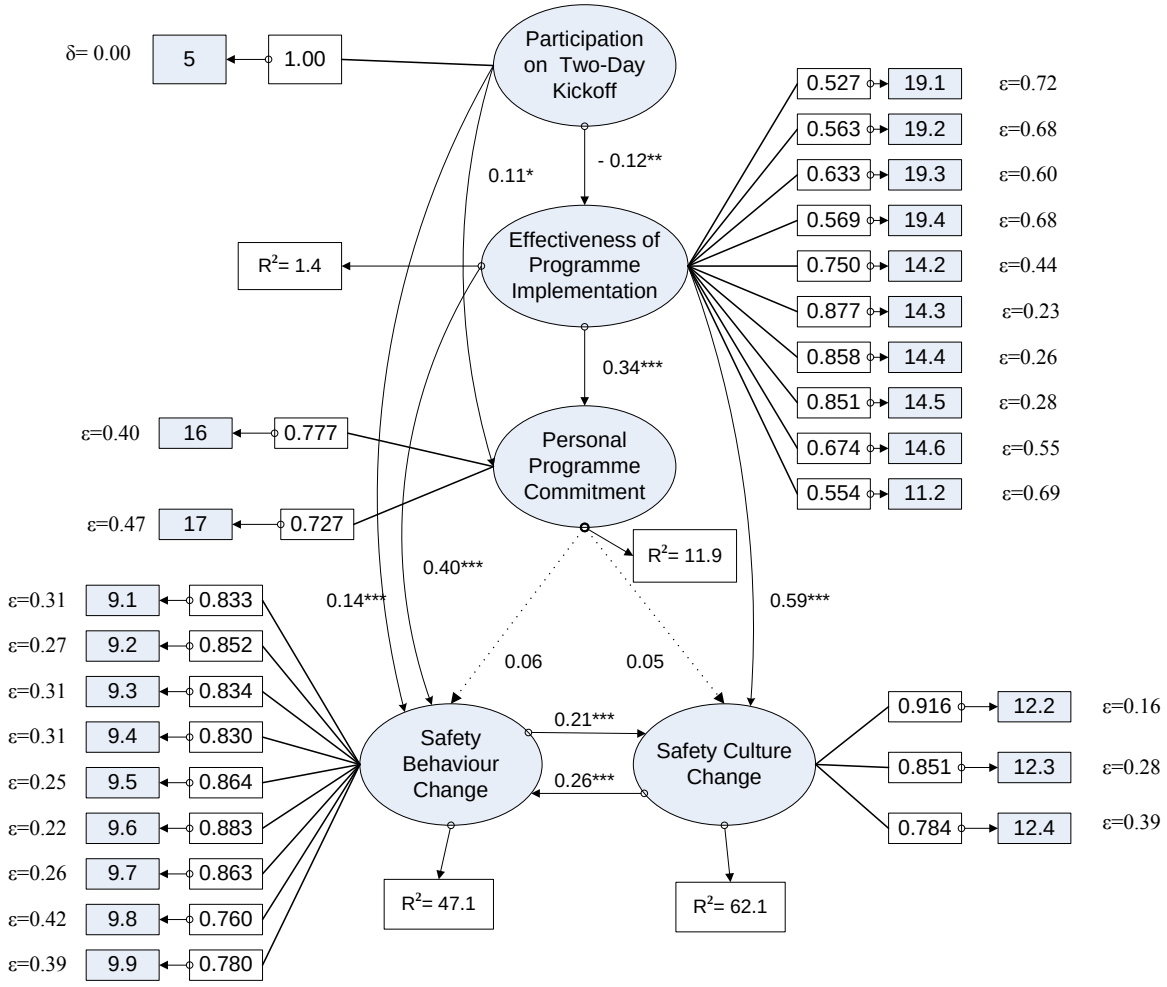

Figure 2. Structural linear model with standardised path coefficients. Broken lines indicate non-significant influence. * $p < .05$, ** $p < .01$, *** $p < .001$

Model modification. The rationale behind model modification is simple: Are there any changes that can be made to improve the model? While tempting, model modifications shall always be based on (solid) arguments that can be grounded on residual statistics, modification indices, or with the aim to increase the model parsimony (Diamantopoulos and Siguaw, 2000). Because of satisfactory fit, the estimated model (see Figure 2) did not reveal a need for modification based on residual statistics or modification indices. Although, based on the qualitative data, some concerns emerged about the parsimony; the estimated model contrasted

with the qualitative data because personal programme commitment had no significant influence, indicating a lack of concurrent validity for this measurement concept. Undoubtedly, interviews revealed that workers' commitment to the programme was important and associated with change. As such, the model was modified so that personal programme commitment was an antecedent, instead of an outcome, of effectiveness of programme commitment. The result after the modification is illustrated in Figure 3. Generally, the fit indices were satisfactory (RMSA=0.087, NNFI=0.960, CFI=0.964), and all hypothesised influences were supported in the modified model.

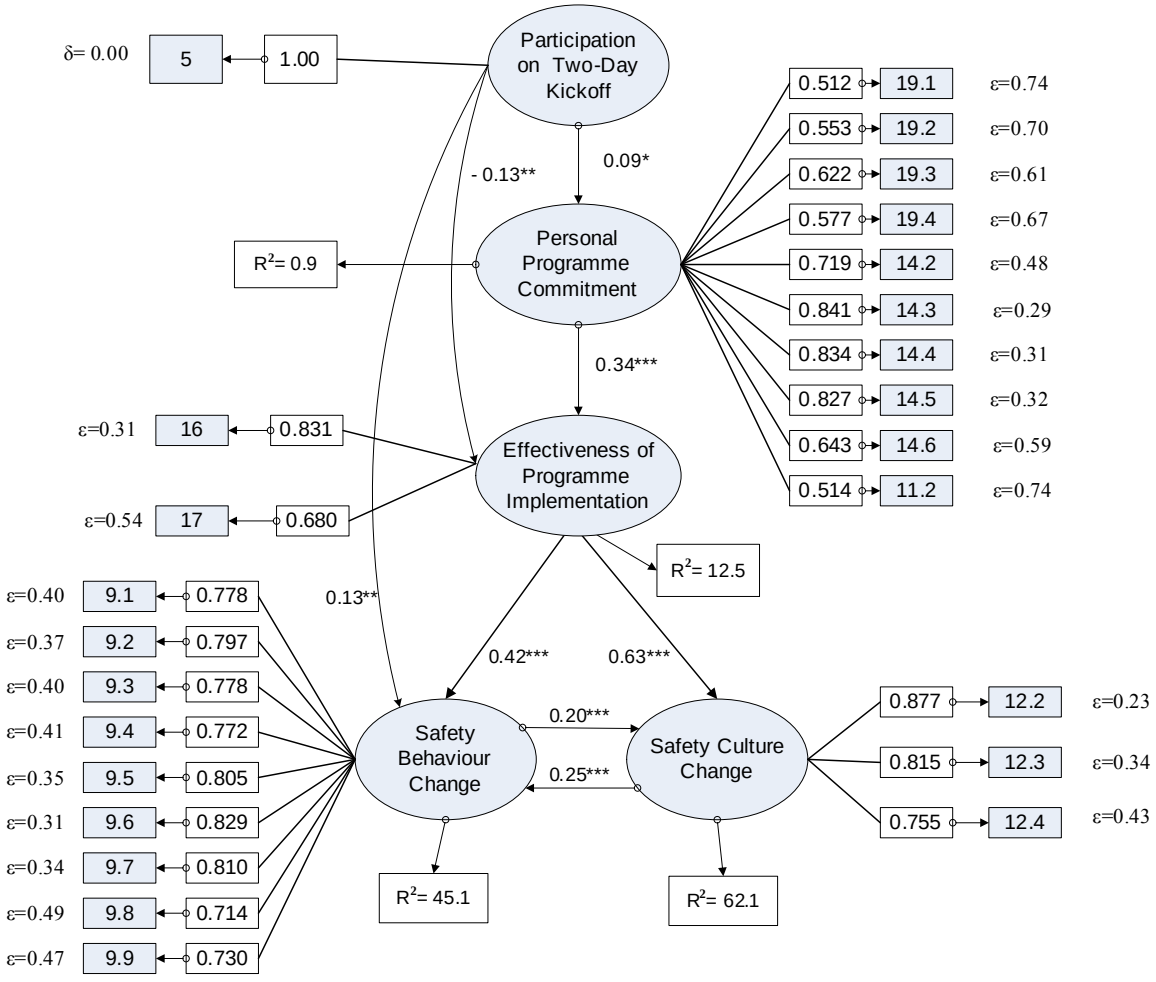

Figure 3. Modified structural linear model with standardised path coefficients.

* $p < .05$, ** $p < .01$, *** $p < .001$

Discussion

The present study sought to address two aims—namely, to gain insight into important factors that influence and mediate the effects of a safety programme and to develop and test a hypothetical structural model that illustrates important effects of the safety programme. The results of the study demonstrated that a combined quantitative and qualitative approach is beneficial when it comes to understanding safety programmes. Qualitative and quantitative methods emphasise different aspects of scientific knowledge that can be overlapping of throw light on different facets of a phenomenon (Tashakkori and Teddlie, 1998). The qualitative approach is inductive and emphasises individual experience and understanding; however, because qualitative interviews are time consuming this normally leads to smaller samples that reduce the possibility to generalise across organisational units and levels, which is associated with the strengths of the quantitative approach that contribute with statistically generalisable predictions. Weaknesses of the qualitative approach are compensated for by SEM, which is designed for the analyses of relationships between latent variables by estimating standardised path coefficients that allow for the comparison of the magnitude of influence for the different latent variables (Nachtigall et al., 2003).

According to the original model, personal programme commitment is expected to be an outcome of effectiveness of programme implementation; in the modified model, it is regarded as an antecedent. The general impression is that the modified model is more robust, especially since all hypothesised relations were significantly supported and combined with satisfactory fit indices. This result is consistent with both previous research (Stanton, 1996) and the qualitative results of this study, which found that workers' commitment to the programme is essential for successful implementation as well as an important premise for positive outcomes of programme activities.

In both the original and the modified estimations of the structural model, effectiveness of programme implementation demonstrated the highest influences; solid influences were demonstrated in personal programme commitment in the original model estimation and in safety culture change and safety behaviour change in both the original and modified estimations. These results are in accordance with earlier studies (DePasquale and Geller, 1999), which suggest that effective operational implementation is essential for the success of safety programmes. In addition, the qualitative results are in accordance with the findings that departments with a low level of implementation were associated with small or no changes while units with a high level of implementation were associated with larger changes and enthusiasm. The qualitative results revealed that the implementation to a very high degree was influenced and potentially hampered by other phenomena—e.g., organisational changes or a high activity level in general. Organisations will always have the potential for differentiation and conflict (Cameron & Quinn, 1999; Martin, 2002); therefore, the potential lack of workforce incongruence towards programme implementation must be seriously considered.

The effect of the safety programme in general must logically also depend on a correct programme design (Lyer et al., 2005). Without a satisfactory design of the safety programme, it is probable that the substantial influence of programme effectiveness would not have been estimated in the model. The qualitative results also reflect that the programme design was to a high degree successful. It is, however, challenging to develop a programme aimed at so many subgroups within a large organisation.

According to the qualitative data, a low degree of programme activities was often associated with dissatisfaction concerning programme characteristics and low leadership support of programme activities. Thus, it is reasonable to define the wider theoretical domain—effectiveness of programme implementation—which includes these issues. In accordance with earlier studies (Cox et al., 2004), interview data in this study pointed to

several pitfalls and contextual factors that could possibly hinder the implementation of programme activities. Typically, high work pressure in departments was often associated with a low priority of programme activities from both leaders and employees, which in turn hampered programme effectiveness and resulted in low satisfaction with programme activities. Another important result from the interviews was that general challenges—e.g., those related to technical or organisational problems—could disturb and reduce the degree of programme activities. Sometimes such factors clearly impaired interpersonal trust and reduced employees' safety motivation, which are considered important factors related to safety interventions (DePasquale and Geller, 1999; Griffin and Neal, 2000). Breaks from the recommended programme activities could often be used as a "weapon"; employees considered such breaks as a symbol reflecting that safety does not take priority over production.

In general, the quantitative results are in accordance with the results from the interviews; most workers had the impression that programme implementations resulted in various changes—especially change in care among workers. Ineffective implementations in units were also associated with a weak establishment of colleague groups. This was, again, typically related to a low and dysfunctional follow-up of programme activities that, in turn, contributed to lower satisfaction with these activities. These problems were often perceived in combination with low leadership dedication within departments. Interviewees often complained that, when programme activities were not followed up, they often associated it with disappointment concerning outcomes related to behavioural and cultural changes.

The results of this study also favour Lund and Aarø's (2004) conclusion. These researchers suggest that the use of a combination of preventive measures is probably more effective than interventions affecting individuals only. Follow-up activities in the developed programme consist of various measures—e.g., tasks solved by groups and individuals in

addition to movies and meetings on a continuous basis. Interventions require the participation of leaders at all levels, and employees are highly involved in discussions and tasks implemented during the programme period. This combination of preventive measures has been important. Interview data also give an additional understanding of the expected negative influences on effectiveness of programme implementation from participation in the two-day kickoff. Indeed, the introductory two-day kickoff was so successful that employees often created unrealistic expectations concerning the follow-up of the programme activities. In general workers still recalled the kickoff several years later, often spontaneously referring to happenings during the kickoff gathering during the interviews. Participants considered the kickoff to be very professional, and the stories presented were not forgotten. This explains the positive influences of participation on the two-day kickoff on personal programme commitment and safety behaviour change.

As an ad hoc hypothesis, the possible direct influence of participation in the two-day kickoff on safety culture change was also tested; this relation was not significant. This supports the basic assumption that changes in culture are due to more systematic measures implemented over a longer period of time. However, it is important to emphasise that participation in the two-day kickoff had indirect effects on safety culture change through the other measurement concepts in the model, which suggests the possibility of a more rapid culture change boosted by the two-day kickoff. Nevertheless, the influence of participation in the two-day kickoff is generally weaker than the influence of effectiveness of programme implementation.

Finally, based on social learning theory, it was expected that safety behaviour change influenced safety culture change and vice versa. This expectation was supported, confirming the fundamental principle of reciprocity between the person and the environment (culture) emphasised in social learning theory (Bandura, 1986).

Conclusion

The benefits of combining quantitative and qualitative methods have been illustrated in this study; the qualitative approach gave much insight into different characteristics of the safety programme activities and indicated that variations in programme implementations were associated with variations in outcomes related to changes in culture and behaviour. The quantitative approach gave further understanding of structural relations that could not have been illustrated using only a qualitative study. Thus, the benefits of combining methods have been demonstrated.

This study examined the largest safety programme probably implemented by any organisation in Norway, making it especially important for analysing and understanding the effects of the safety interventions implemented. Future research should try to replicate the modified model of this study to investigate whether the model can be replicated on the basis of other safety programmes in other contexts. In order to do so, it may be necessary to incorporate several minor adaptations to the measurement instrument used to ensure that all items are relevant.

One obvious limitation of the current study is that the structural models estimated were tested on cross-sectional data, meaning estimated coefficients have not been proven over time. However, this limitation has been compensated for in several ways. First, the theoretical constructs developed were based on characteristics of the safety programme. Second, the measurement model was tested by conventional validity techniques using exploratory and confirmatory factorial analyses and reliability measures. Finally, the development and interpretation of the hypothesised structural models tested were based on actual safety interventions, qualitative interviews, fieldworks, and previous research.

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Appendix 1: Scale items included in the structural equation model. Denotations in Figure 2 and 3 are indicated in the table.

Eta Exogenous variables	
Effectiveness of Programme Implementation	
λy 1 1	14 2 First general meeting after kickoff
λy 2 1	14 3 Development of measures in order to remove obstacles that hinder caring among employees
λy 3 1	14 4 Use of brochures and posters
λy 4 1	14 5 Task in order to increase caring
λy 5 1	14 6 Movies
λy 6 1	19 1 In group work
λy 7 1	19 2 In meetings
λy 8 1	19 3 In work situations
λy 9 1	19 4 Between leaders
λy 10 1	11 2 My experience is that my nearest leader takes the message in the safety programmes seriously
Personal Programme Commitment	
λy 11 2	16 Have you been talking with colleagues about your personal commitments?
λy 12 2	17 Have you followed up your personal commitment?
Safety Behaviour Change	
λy 13 3	9 1 Attention to risks in the job
λy 14 3	9 2 That I care about colleagues
λy 15 3	9 3 Consciousness to carry out running risk assessment
λy 16 3	9 4 Compliance to procedures
λy 17 3	9 5 Have an open dialogue about risks
λy 18 3	9 6 Prioritising safety
λy 19 3	9 7 Take my own initiative to improve safety
λy 20 3	9 8 Take safety initiatives on safety meetings
λy 21 3	9 9 Take initiative if others don't work safe
Safety Culture Change	
λy 22 4	12 2 The colleague programme has improved safety were I work
λy 23 4	12 3 The safety programme has reduced unwanted incidents in my department
λy 24 4	12 4 The safety programme has improved the safety culture within the company
KSI Endogenous variable	
Participation on Two-Day Kickoff	
λx 1 1	5 Did you attend the gathering at Clarion Hotel with the colleague programme?