

TOWARDS A FRAMEWORK FOR DESIGNING A SOCIO-TECHNICAL INTERVENTION TO MEDIATE ORGANISATIONAL LEARNING

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ABSTRACT

The history of socio-technical interventions is intertwined with reports that interventions are successful in the short to medium term but over time organisations revert back to their previous practices. It is often reported that changes in senior management or politics result in an undermining of the legitimacy of the systemic principles used in the intervention and as a result the organisation reorganises the situation according to conventional (Taylorist) principles. This paper works toward the development of a framework to design interventions that mediate organisational learning so that the sustainability of a socio-technical intervention is no longer dependent upon on the presence of specific members of management or the political environment but becomes engrained into the cognition and practices of the organisation.

Keywords

Organisational Learning; Distributed Sensemaking; Problematic Situations

1. INTRODUCTION

Very early on in the history of socio-technical systems thinking it became evident that interventions in work organisations based on principles different to those of conventional bureaucratic organisation were not likely to survive unless the whole organisation changed in a new direction [1]. Typically interventions would be sustained in the short term but would not go on to influence the behaviour or cognition of the organisation in the long-term due to a range of factors including sociopolitical factors [1, 2]. In response to this there has been an increasing interest in performing interventions that incorporate organisational learning (OL) so as to make interventions sustainable and enable organisations to learn alternative principles to those of conventional bureaucracy [3].

In this paper, we present our work towards creating a framework that guides the design of enquiries to troubleshoot problematic enterprise-scale socio-technical situations and the design of interventions that mediate OL. This framework contributes towards two key research challenges when enquiring and intervening in problematic socio-technical situations of an enterprise-scale. The first challenge arises from the scale and diversity of an enterprise-scale socio-technical situation and may be framed in terms of: 'how do we structure an investigation to understand a situation that may be influenced by interactions between technical and non-technical elements where each individual has a partial view of the situation'. The second challenge comprises 'how do we design an intervention that will be sustainable in the sense that it becomes ingrained in the cognition and practices of the organisation'.

The approach we present uses insights from distributed sensemaking [4] to provide practical guidance as to how one may structure an investigation in order to manage trade-offs between approaches to sensemaking. The approach also uses the 4I model of barriers to organisational learning [5] to guide the design of investigations and interventions by creating awareness of recognised pitfalls to OL so that practitioners can avoid, manage or at least be realistic about the sustainability of an intervention in a given situation.

To illustrate the use of the framework we describe how it was used to guide the design of an investigation to troubleshoot a problematic enterprise document management system within a multinational engineering firm and how our planned intervention was designed to encourage OL. We conclude that our framework provides a practical means of guiding the design of an investigation to troubleshoot a problematic enterprise-scale socio-technical situation as well as providing a practical means to guide the design of an intervention to mediate OL. We recommend further research in validating and extending the approach and we outline the implications for

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future research in socio-technical systems engineering.

2. BACKGROUND

With the adoption and use of enterprise information technologies such as ERP systems increasingly large numbers of people with differing needs and worldviews are becoming coupled [6-8]. It is not uncommon for these systems to become problematic during construction or implementation due to socio-technical issues [9]. When these enterprise technologies are perceived to be problematic the resultant is a problematic enterprise-scale socio-technical situation.

2.1 Problematic Enterprise-scale Socio-technical Situations

Problematic situations are situations where the existence, nature and extent of a problem is observer dependent such that there is not one objective view of the situation but a plurality of views that may be considered legitimate [10, 11]. Due to the scale and nature of these situations stakeholders have partial views and may be unaware of the intricacies of the whole. Due to the close coupling of these technologies with organisational work (such as them being incorporated into multiple stakeholders' business processes or workflows) socio-technical issues can be a significant component of the situation and therefore special attention is required to understand the interactions between social and technical components of the situation [9, 12].

To troubleshoot these situations investigations typically assist by constructing one, or perhaps more, representations that aim to outstrip the partial images that any single individual in the situation holds. Designing an investigation to elicit and integrate partial views into a representation poses a methodological challenge that involves making a number of design decisions that can impact the overall findings of the enquiry and may even influence the legitimacy of the intervention and thus outcome of the OL.

2.2 Designing an Investigation

It is well known that the way an investigation is structured affects the cognitive behaviour (and particularly the sensemaking) of actors participating in an enquiry. Sensemaking is the process by which humans comprehend, understand, explain, attribute, extrapolate or predict a situation [13]. It occurs when a situation is turned into thoughts, discussions, representations or salient categories and serves to understand past experiences and shape future action [14]. Distributed sensemaking comprises the integration of partial images of a complicated situation to form a representation that outstrips the capacity of any single individual in the situation [4].

There are three forms of sensemaking: reciprocal; pooled; and sequential. Reciprocal sensemaking is sensemaking that is coordinated by mutual adjustment. An exemplar comprises a group session where participants share their views and adjust their views in accordance with the information provided by others. The situation is called reciprocal as each of the participants can revise their views multiple times on the basis of others' contributions thus creating what may be viewed as a feedback loop. It is known that reciprocal sensemaking can be more effective at identifying anomalies than either sequential sensemaking or pooled sensemaking [4]. This suggests that facilitated group sessions should be selected for enquiring into problematic situations because this enables participants to perform reciprocal sensemaking. However, in practice a trade-off is made by opting for group sessions as they can suffer from unproductive group processes that result in problems such as group-think, legitimate views not wanting to be expressed in front of others, or views being marginalised or emphasised more strongly due to power and politics [15-17]. The affect of group processes can be minimised through the use of group elicitation techniques however more subtle issues can still go unnoticed [17]. For example, the participants' views may be limited by their lack of specialist skills and/or time to devote to rigorously collecting data and thoroughly analysing the situation. This can result in biases/limitations in the output of group sessions.

An alternative to reciprocal sensemaking is pooled sensemaking. Pooled sensemaking is where each individual participant makes sense of a situation on their own and their view of the situation is collected and contributes to a pool of views that is then integrated by an investigator. An example of pooled sensemaking is where partial viewpoints are elicited in a one-to-one manner during an interview process and no effort is made during the interview to influence the views of one participant with the views of another. This approach has the advantage that group processes are limited since participants engage with the enquirer in a one-to-one manner and the enquirer can rigorously collect, transcribe and analyse data for a prolonged period of time in a manner that is impractical during a group facilitated session. The disadvantage of this approach is that pooled

sensemaking is reported to be the least sensitive sensemaking approach with respect to anomaly detection as participants reports tend to normalise deviant characteristics and as a result they go undetected by the enquirer [4]. Another disadvantage is that participants are not given the opportunity to listen to and directly share with others their views as the investigation unfolds and therefore they may not have the same sense of ownership over the outcome of the investigation.

Another alternative to reciprocal sensemaking is sequential sensemaking. This is where each individual participant makes sense of a situation on their own but the participant has access to previous participants' views such that participants can influence each other in sequence. An example of this approach is where partial viewpoints are elicited in a one-to-one interview but the interviewer brings up viewpoints of previous participants where relevant in order to trigger sequential sensemaking.

This approach may be seen as a hybrid of the two previous approaches as it has the advantage of sharing information, albeit sequentially, amongst participants thus increasing anomaly detection whilst avoiding group processes that are often observed in facilitated group sessions. The advantage of this approach is that the investigator can record, transcribe and reflect upon the collected data for a prolonged period of time in a manner that is impractical during a group facilitated session and that group processes are limited since participants engage with an investigator in a one-to-one manner. The disadvantage is that a trade-off is made with respect to the extent each participant can influence the others' sensemaking due to a lack of reciprocal relations that limits debate and negotiation amongst stakeholders during data collection.

2.3 Sustaining an Intervention via Organisational Learning

OL comprises “a change in the organization’s knowledge that occurs as a function of experience”[18]. This definition acknowledges that learning can manifest in both changes in cognition and behaviour such that an organisation can be considered as both a social system of interacting members and a body of structures and rules that regulate members’ behaviours [5]. For socio-technical interventions to become sustainable they must incorporate OL. This means interventions must be designed to influence organisational cognition or behaviour in a manner such that their viability is not dependent upon specific individuals or a certain political climate. This means that the intervention itself, or the principles behind it, must be embedded in organisational systems, tools, or processes [19].

There are numerous models of OL [20-22] however we opt for the 4I model [23] as it has a number of qualities that are useful to guide systemic investigations and interventions. The 4I model was selected as it articulates sub-processes that compose OL in a way that brings together individual, group and organisational levels of analysis as well as notions of power and politics that play important roles in the (lack of) sustainability of interventions [1].

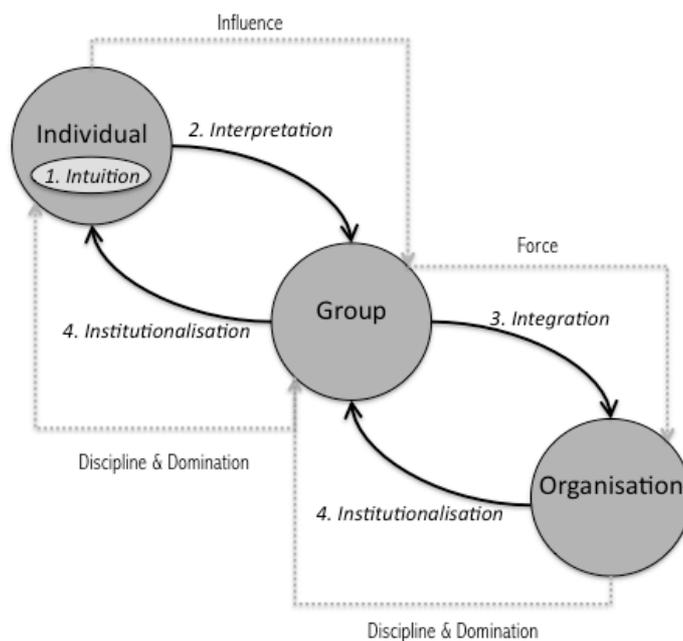


Figure 1 - The social psychological and political processes of organisational learning (Lawrence et al. 2005)

The 4I model postulates four processes by which different levels of OL are connected (See Figure 1).

1. *Intuiting* is the process of developing new insights and ideas.
2. *Interpreting* is the process by which an individual explains their insight to others so it may be integrated within the group's mindset.
3. *Integrating* is a process that occurs at a group level where shared understanding among groups is achieved, which allows for coherent, collective action within the organisation
4. *Institutionalising* is where the shared understanding is implemented as a system, procedure, rules or strategies thereby becoming independent of the individual or group origins and shapes organisation cognition or behaviour.

The 4I model provides guidance on how-to structure and implement an investigation and an intervention. The investigation phase may be viewed as consisting of intuiting (generating a new representation of the problematic situation) and interpreting (sharing this with the group sponsoring the investigation so it becomes a shared mental model of the situation). The intervention may be viewed as integrating (sharing the sponsoring group's shared mental model of the problematic situation with other groups) and institutionalising (making changes to the organisation's systems, structures, procedures, rules or strategies to ameliorate the problematic situation in accordance to the new shared mental model).

These four stages are complemented by the introduction of four socio-political processes called *influence*, *force*, *dominance* and *discipline* [24] (See Figure 1). These socio-political processes may be viewed as things to monitor or influence when designing an investigation or an intervention as they are important levers for enabling the organisation to change its behaviour and cognition. Influence involves a wide range of political tactics such as persuasion, negotiation, and ingratiation. It comprises influencing the perceived cost and benefits that other organisational members associate with an idea. The process of force is characterised by creating circumstances that restrict the choices available to organisational members by using formal authority during the integration process. The process of dominance occurs during the institutionalisation of change. Dominance comprises restricting the range of technologies such as production machines, the physical layout of the workplace and providing predetermined decision paths or restricting access to data sources. The process of discipline implies altering perceptions of the costs and benefits associated with actions available to organisational members. It involves practices such as training, rewarding or punishing behaviour and enculturation.

The 4I mode has been extended by [5] who supply a comprehensive set of barriers to OL that we believe can provide guidance in designing an investigation and an intervention that mediates OL. At the stage of intuiting (generating a new representation of the problematic situation) Schilling et al. (2009) identify barriers in terms of bounded rationality and limited knowledge, the implicitness of knowledge, role constrained learning and psychological safety (See Table 1).

Table 1 - **Barriers to Intuiting (Schilling et al. 2009)**

Barriers to Intuiting	Description
Bounded rationality and limited knowledge	<ol style="list-style-type: none"> 1. Confirmatory bias. 2. Lack of know-how to identify and understand causes of problems. 3. Superstitious learning creating overconfidence in current practices. 4. Monolithic cultures restricting range of skills and ideas. 5. Lack of systems/techniques to identify/detect gaps between actual and desired behaviour.
Implicitness of knowledge	<ol style="list-style-type: none"> 1. The situation or the knowledge derived from the situation in implicit/vague/ambiguous and is thus difficult to articulate and share.
Role constrained learning	<ol style="list-style-type: none"> 1. Division of labour rewards accomplishment of primary activity and not identifying/improving upon/fixing problems. 2. "First order problem solving" – workers 'work around' problems thus hiding the symptoms and underlying causes of problems. 3. Workers do not have the freedom to experiment / change

	work activity or processes so there is experiential knowledge of the interconnections between processes and outcomes.
Psychological safety	1. Workers do not want to be associated with problems or failures so defensive psychological routines are employed that have a tendency to suppress failure.

At the stage of interpreting (sharing a new representation of the situation with the group sponsoring the investigation so it becomes a shared mental model of the situation) Schilling et al. (2009) identify barriers in terms of worker motivation, skills, relations, status, working conditions, importance to group tasks, collective identity and group norms (See Table 2).

Table 2 – **Barriers to interpretation (Schilling et al. 2009)**

Barriers to Interpreting	Description
Motivation & skills	<ol style="list-style-type: none"> 1. Worker does not share insights due to psychological safety concerns such as insight being inadequate, unimpressive, fear of loss of ownership of insight, loss of individual advantage. 2. Worker does not have the socio-political skills such as ingratiation, persuasion, negotiation influence co-workers mental models or 'sell' the costs and benefits of implementing a change.
Relations & status	<ol style="list-style-type: none"> 1. Worker has insufficient status or reputation for insight to be considered as worthy of consideration. 2. Worker has problematic relationships with others making it difficult for the insight to be communicated and legitimately considered.
Group tasks & working conditions	<ol style="list-style-type: none"> 1. In high workload contexts insights must be coupled with important 'instrumental objectives' to be considered as making an important contribution. 'Instrumental objectives' comprise things like sales targets, errors of large financial cost or similar objectives that are considered instrumental to the success of the group. 2. The absorptive and retentive capacities of groups determine the extent and nature of insights that can be learnt, retained and put into practice.
Collective identity & norms	<ol style="list-style-type: none"> 1. Insights that undermine group identity are often ignored. 2. Insights tend not to be absorbed and retained in groups with diverse objectives or hidden agendas. 3. Insights tend not to be absorbed and retained in groups where the norm is failure avoidance or denial of bad news.

At the stage of integrating (sharing the sponsoring group's shared mental model of the problematic situation with other groups) Schilling et al. (2009) identify barriers in terms of group motivation to share, lack of trust, lack of top management support, managerial conservatism and resistance from other groups (See Table 3).

Table 3 - **Barriers to integration (Schilling et al. 2009)**

Barriers to Integrating	Description
Motivation of group or sponsor	1. Teams may not share insights if they fear punishment, disadvantages or do not expect recognition for doing so. This is especially the case in situations where groups are competing for resources.
Lack of trust	1. Inadequate direct communication between groups or lack of trust resulting in suspicion when insights are shared.

Top management support	<ol style="list-style-type: none"> 1. The process of force based on formal authority is important to spreading learning among groups. Lack of appropriate formal authority on the part of champions, supporters and originators of learning can inhibit it spread among groups. 2. The learning must be brought to the attention of senior management by authoritative individuals to secure support
Top management conservatism	<ol style="list-style-type: none"> 1. Rigid or outdated core beliefs, values and assumptions held by senior managers can result in them acting as inhibitors of learning e.g. do not want to change a winning team. 2. Existing competences may want to be exploited at the expense of exploratory innovative practices, processes, products and structures.
Resistance from other groups	<ol style="list-style-type: none"> 1. 'Not invented here syndrome' causing inhibition of learning. 2. Learning is inconsistent with organisational assumptions or typical 'industrial recipes'. 3. Long time lag between implementing the learning and the benefits resulting in rejection of learning 4. Learning that challenges existing structures and powers will be resisted by those disadvantaged by the learning 5. Cultural norms based on stability rather than learning can inhibit learning

At the stage of institutionalising (making changes to the organisation's systems, structures, procedures, rules or strategies to ameliorate the problematic situation in accordance to the new shared mental model) Schilling et al. (2009) identify barriers in terms of (See Table 4) lack of trust in proposed change, lack of skills and resources to implement change on the part of workers or management, and structural issues such as departments having parochial views and the organisational structure making control of the change difficult.

Table 4 - Barriers to institutionalisation (Schilling et al. 2009)

Barriers to Institutionalising	Description
Lack of trust in change	<ol style="list-style-type: none"> 1. Change is perceived to be irrelevant to future purposes or goals of the organisation. For example rapid environmental changes resulting in obsolescence. 2. Competition with other ideas or management fads. 3. Need to keep up with emerging trends from external consultants rather than internal ideas.
Lack of skills/resources on part of workers to implement change	<ol style="list-style-type: none"> 1. Lack of time, physical space, resources to support the change process. 2. Inappropriate training or communication of change. 3. High employee turnover resulting in loss of organisational memory of change.
Lack of skills/resources on part of management to manage the change	<ol style="list-style-type: none"> 1. Change is incompatible between current policies or practices and management are not willing to change these. 2. Laissez faire management style resulting in a lack of pressure to commit to making changes. 3. Inadequate middle or lower management as indicated by low trust in employees, reduced change expectations.
Structural issues	<ol style="list-style-type: none"> 1. Departmental structures focus attention on parochial problems rather than organisational wide problems.

	<ol style="list-style-type: none"> 2. Decentralised organisational control over changes resulting in limited change. E.g. Lack of individual responsibility or diffusion of responsibility. 3. Group aspirations incompatible with proposed change 4. Negative attitude towards change or organisational cynicism. 5. Absence of measures to evaluate progress.
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3. DESIGNING AN INVESTIGATION AND INTERVENTION USING DISTRIBUTED SENSEMAKING AND THE 4I MODEL

3.1 The Problematic Situation

The distributed sensemaking and 4I model was used to guide our investigation and intervention into a problematic enterprise document management (EDM) system at a multinational systems engineering company. The company, which we will call 'Company A', specialises in the design, manufacture and maintenance of specialist electro-optical components and systems. The organisation is divided into a number of functional groups that come together under a project structure to produce customer deliverables e.g. components, systems and documents. The design of components and systems is a collaborative activity and the sharing of documents is considered to be an important aspect of this activity by those involved.

'Company A' deployed an EDM system in the early 2000s as it was perceived by the IT director that an EDM system would be more advantageous than using shared folders on a file server to exchange documents. There was a perception that the introduction of the system would bring about greater visibility and awareness of work rather than having different teams and functions working in information silos. Within projects it was envisioned that EDM would be an up-to-date repository of all project documentation. Teams would store their documents in personal working areas and upload them to locations in standardised EDM project file structures.

When we visited the organisation in 2010 the EDM was perceived by engineering management to be problematic due to "socio-technical factors". The use of the system was mandatory so all projects had an EDM project area but the extent that documents were being uploaded from working areas to the EDM project areas varied between teams. In addition to this the use of the EDM file structure varied between teams, as did the location of files within the file structure. As our investigation unfolded it became clear that engineering management perceived the system to be problematic because teams did not use it in a "common way". Following our enquiry it emerged that the reason why this was the case was due to range of interactions between the technical systems and social systems within the organisation – for more information see [25].

3.2 A Systemic approach for Designing Interventions to Mediate Organisational Learning

We utilised the following systemic approach for designing our investigation and intervention (See Figure 2). The approach encapsulates the notion that a group within an organisation perceives the existence of a problematic situation and wants to perform an investigation to elicit a representation of the situation that could be used to ameliorate it.

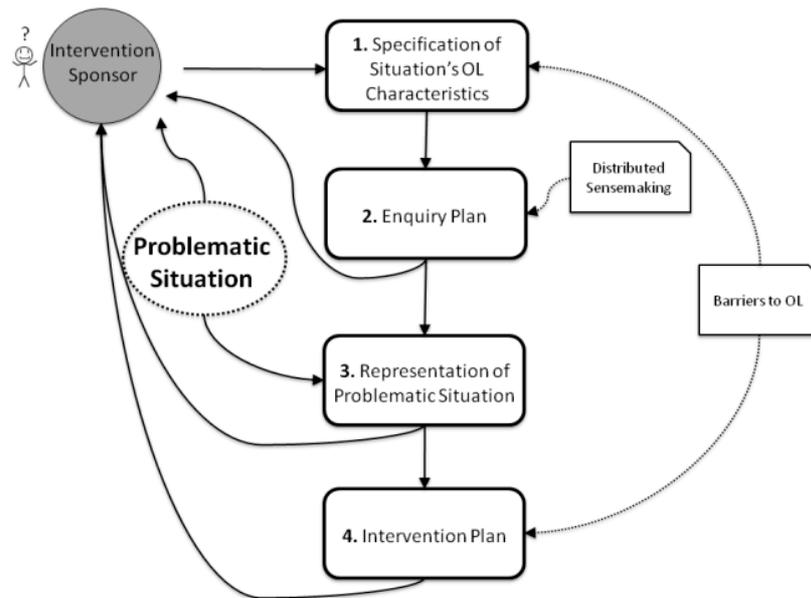


Figure 2 – A Systemic Approach for Designing Interventions to Mediate OL

The first step is to use what the sponsoring group already knows about the problematic situation to create a specification of the situations OL characteristics. The second step is to use this specification to select a sensemaking approach for the investigation and subsequently create an investigation plan. Step three is to execute the investigation plan and create a representation of the problematic situation. The fourth step is to use the representation of the problematic situation to design an intervention to ameliorate the situation. This step, as does the first step, uses the 4I model of barriers to OL to design a plan that avoids or acknowledges identified barriers to OL. In section 3.3 we describe designing the investigation (steps 1, 2 and 3) in more detail. In section 3.4 we describe designing the intervention (step 4) in more detail.

3.3 Designing the Investigation

The aim of our investigation at 'Company A' was to create a representation of the elements and interactions that were composing the problematic EDM situation and to provide the sponsoring group with a new mental model of the situation that could be used to ameliorate it. To achieve this we recognised that this involved selecting an appropriate method of sensemaking. To select our choice of sensemaking approach we created a specification of the OL characteristics of the problematic situation using the barriers to OL for guidance. This specification was based upon our first meeting with the sponsoring group to understand their broader problems and email exchanges with group members to clarify certain points prior to commencing the investigation.

3.3.1 Specifying the OL characteristics of the problematic situation

Drawing upon the barriers to intuiting (Table 1) we recognised a number of factors that needed to be taken into account in our investigation design:

- The organisation seemed to lack know-how or incentives to identify and understand the causes of the problems they were experiencing. We justified this on the basis that the initial EDM implementation had occurred in the early 2000s so the problematic situation had a history and had not been solved over that this period. This suggested a need for employing a mode of sensemaking that would enable an investigator to bring in this expertise to understand the possible interrelationships between social and technical systems in the situation.
- The situation seemed vague, ambiguous or implicit as engineering management claimed the situation suffered from socio-technical factors but were not able to articulate this in a concise manner. This suggested a need for employing a mode of sensemaking that would be sensitive to ambiguous or subtle signals.
- The organisation was strongly structured around the division of labour with multiple functional groups and specialisation within each of these functional groups so we suspected role constrained learning issues such as pluralities of perspective across functional and site boundaries. This suggested a mode of sensemaking that is sensitive to the affect of different roles on viewpoints and that can sensitively integrate potentially disparate views.

- The participants involved may not want to discuss perceived failings or share insights in front of their colleagues due to psychologist safety issues. This suggests we should use a mode of sensemaking where individual can discuss issues in confidence with an investigator whom him/herself is new to situation so insights are less likely to be thought of as inadequate or unimpressive.

Drawing upon barriers to interpreting (Table 2) we recognised a number of factors that needed to be taken into account of:

- The participants may not have the socio-political skills to influence co-workers mental models or ‘sell’ costs and benefits of implementing change. This suggests a mode of sensemaking where the investigator should take on the role of group influencer of mental models and use a form of sensemaking where the individual source of insights is anonymous.
- The participants may have problematic relations with others making communication and sharing of insights difficult. The investigator should use a mode of sensemaking where he/she acts as an intermediary between parties and whether the source of insights is kept confidential.
- The participants within ‘Company A’ tend to have high workloads therefore when reporting insights it is important to indicate how their objectives or responsibilities are affected. This suggests a mode of sensemaking where participants objectives and responsibilities are collected during the investigation and findings are reported in relation to the affect that the situation has on them.
- The participants have an unknown but limited absorptive and retentive capacity and therefore the outcome of the investigation should be reported as simply as possible in-order for an effective group level learning to be performed.

3.3.2 Deciding on an appropriate sensemaking approach

The OL characteristics of the problematic situation were condensed into a specification of the investigation’s sensemaking requirements (See Table 5) and these requirements were used to select our investigation’s sensemaking approach.

Table 5 – Specification of the Investigation’s Sensemaking Requirements

#	Specification of the Investigation’s Sensemaking Requirements
1	a mode of sensemaking that would enable an investigator to bring in this expertise to understand the possible interrelationships between social and technical systems in the situation.
2	a mode of sensemaking that would be sensitive to ambiguous or subtle signals.
3	a mode of sensemaking that is sensitive to the affect of different roles on viewpoints and that can sensitively integrate potentially disparate views.
4	a mode of sensemaking where individual could discuss issues in confidence with the investigator.
5	a mode of sensemaking where the investigator should take on the role of group influencer of mental models
6	a mode of sensemaking where he/she acts as an intermediary between parties and whether the source of insights is kept confidential
7	a mode of sensemaking where participants objectives and responsibilities are collected during the investigation and findings are reported in relation to the affect that the situation has on them.
8	the outcome of the investigation should be reported as simply as possible in-order for an effective group level learning to be performed.

We selected the use of sequential sensemaking (one-to-one interviews with the investigator sharing relevant views when appropriate) to gather participants’ views of the situation. We decided on reciprocal sensemaking (group session) to share the outcome of the investigation (representation of the situation) with the sponsoring group. We selected sequential sensemaking for gathering viewpoints because of requirements 1, 2, 4, 6 (See Table 5) required an approach where investigator expertise could be brought to bear, where ambiguous or subtle signals could be detected, where issues could be discussed in confidence and sources of insights could be kept confidential. We selected reciprocal sensemaking to share the representation of situation because of

requirement 5 requiring the investigator to take on the role of group influencer because their status of being an outsider was an indicator of their impartiality and their status as an academic could be seen as an indicator of the reliability of the representation. We also selected reciprocal sensemaking to encourage discussion around the representation so that the sponsoring group could together familiarise themselves with the representation and discuss how their viewpoints mapped onto the representation. This discussion was intended to create acceptance and some form of ownership of the representation as each of member of the sponsoring group can see how their viewpoint is acknowledged but also supplemented with those of others. To satisfy requirements 3, 7 (See Table 5) we used a framework based on activity systems theory [26, 27] to understand the situation in terms of actors responsibilities, objectives and other mediators such as norms and the division of labour. To satisfy requirement 8 we presented the situation as a cognitive map and explained the situation using a narrative with examples. For more information on the investigation methodology see [25].

3.4 Designing the Intervention

The aim of our intervention was to spread the sponsoring group's shared mental model of the problematic situation with the wider organisation and spread and gain support for the sponsoring group's plan (shared mental model) to ameliorate the situation.

3.4.1 Specifying the OL characteristics of the intervention situation

Drawing upon the barriers to integration (Table 3) we recognised a number of factors that needed to be taken into account in our intervention design:

- That establishing regular direct communication between engineering management and programme management was essential to building trust between the groups. This suggested that a member of each group should be allocated responsibility for the intervention and that these individuals would be held to account for meeting and coordinating activities.
- That top management support and formal authority would be important to sharing the mental model of the problematic situation. This suggested that a high-ranking member of both engineering management and programme management should be made responsible for the intervention and they should lobby higher powers within the organisation for support.
- That top management conservatism could be problematic therefore our plan aimed to involve top management from the onset and ensure that they endorsed the activities and understood that they were compatible with their existing beliefs and values
- That 'not invented here syndrome' could be problematic so during our investigation we involved stakeholders from all parties involved to give a sense of ownership over the representation being constructed.
- That challenging existing structures and power could be problematic so we attempted to use existing power structures where possible to champion the intervention and make sure each party understood what was in it for them.

Drawing upon the barriers to institutionalising (Table 4) we recognised a number of factors that needed to be taken into account in our intervention design:

- The problematic EDM system was due for replacement in the medium term. This suggested that our intervention should be generic enough to apply to the future system as well as the current system and therefore make it relevant to the organisation
- The skill and resource limitations of workers by setting out the development of a minimal but mandatory set of practices so as to minimise the burden of change on the workers.
- Appropriate training and communication was essential so we suggested the development of a network of champions within each group to facilitate the transition to mandatory practices. These champions use existing power hierarchies (formal or informal power) within groups to discipline groups into carrying out changes.

- Incompatibilities between current policies and practices could be problematic so these were elicited and will be brought to the attention of decision makers when the minimal set of mandatory practices is created.
- Departmental structures could divert attention from the change toward parochial problems therefore we suggested that specific high ranking individuals from each group should be made responsible for the change so as to use existing power structures to focus attention on the wider problem to be addressed
- The absence of measures could inhibit learning as progress would be difficult to track. Therefore we suggested auditing the use of the mandatory minimal principles to keep a track of their continued use within projects.

3.4.2 Deciding on an appropriate intervention approach

The OL characteristics of the intervention situation were condensed into a specification of the intervention's requirements and these requirements were used to select our intervention approach. Using the specification of the intervention requirements we developed a plan to improve the EDM situation. We designed an intervention that would make a senior figure from both engineering management and programme management responsible for the implementation of the intervention. These senior figures were tasked with gaining support from the highest level of management on their sites. We suggested the development of a minimal set of mandatory practices that were designed to encourage the use of EDM in a common way. The two members of engineering management and programme management were made responsible were tasked with creating a network of champions to promote the use of the EDM system in accordance to the minimal mandatory practices. The whole intervention process itself was generic enough to be applied to any newly introduced or problematic system such that the process could be used when the EDM replacement is introduced. Our plan suggested the auditing of the practices of each programme to ensure that mandatory practices were being followed.

It may be noted that the individual insights themselves are not particularly novel. This is to be expected as the novelty comes from the *combination* of insights that are specifically tailored to avoid barriers to OL in the problematic situation that may be inhibiting the sustainability of the intervention.

4. CONCLUSION

Our experience suggests that our approach provides a practical means of guiding the design of an investigation to troubleshoot a problematic enterprise-scale socio-technical situation as well as providing an effective means of guiding the design of an intervention to mediate OL. The guidance provided by the 4I model encourages an intervention that is sensitive to the socio-political context of the situation. It enables the verification of proposed interventions to ensure that they take account of barriers to OL present at all stages. It also enables checking that appropriate strategies are being employed during each stage of OL e.g. influence, force, dominance and discipline.

The nature of the changes proposed in our intervention mean that the approach's efficacy with respect to producing a sustainable intervention in the longer term is impossible to determine at present. To establish the efficacy of the approach a long-term research programme would be required to track the progress of multiple interventions using this approach. Our use of the approach created a new shared understanding of the problematic situation within the sponsoring group. Additionally the sponsoring group agreed on an intervention plan and it is currently in their hands as to whether it will be implemented. However we remain optimistic about the approaches efficacy as it is based on insights from the distributed sensemaking and the 4I OL model that are both grounded in empirical studies and are therefore suggestive of its efficacy.

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