
# SPE 112173

# Group Mental Models in Collaborative Work Environments

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## Abstract

Individuals in Collaborative Work Environments (CWE's) have interpretations and norms towards the technology they use. We call these interpretations and norms 'mental models'. These mental models form the perceptions from which other models are interpreted, for example decision-making models. Mental models can be divided into taskwork and teamwork mental models.

This paper will focus on the group level of the (shared) mental models. Not only the use of technology is influenced by the mental models, also the success of learning will, to a large extent, depend on these mental models. So far, the emphasis has been on the development and implementation of Smart Oil Fields Technology as such. Little attention has been paid to the importance of the influence of mental models during the implementation of the new technology. This paper aims to shed some light on the subjective aspect of the implementation of Smart Oil Fields Technology within the CWE's, by providing a model of major factors of influence and outcomes of Group Mental Models in Collaborative Work Environments.

## 1. Context of Collaborative Work Environments

Most major oil companies have implemented Smart Oil Fields (Technology) in order to enhance their oil recovery and productivity. Collaborative Work Environments (CWE's) have been implemented by several major oil companies, to support the use of technology in Smart Oil Fields. Following Taylor & Fosse (1), we define a Collaborative Work Environment as "any forum, physical or virtual, formal or informal, in which parties can come together to discuss problems and scenarios and come to decisions". These environments will allow people to work collaboratively regardless of distance, making better decisions, faster, thereby enabling enhanced productivity and delivering operational performance improvements (2). The decision-making in the Collaborative Work Environments has to cope with three important aspects: (i) Multi locations (both on site and at distance, without the need for actual face-to-face interaction); (ii) Multi disciplinary (people with different educational and cultural backgrounds); (iii) Multi party (in collaboration with several service firms). Within CWE's, many models are used to simulate the 'real-life' situation. Employees are used to 'thinking in models', for example decision-making or reservoir models. Besides these models, it is important to know how employees interpret these models. We refer to these as 'mental models'.

### 1.1 Major factors of influence

The implementation of both Smart Oil Fields (Technology) and Collaborative Work Environments is not without problems. We mention two related 'people problems': (i) the need to organize collaboration between and within teams both on site and at distance over a period of a few years; (ii) the blending of employees with (a) different kind and level of skills & knowledge (3) and with (b) different kind of cultural backgrounds (4). Different ideas, interpretations and norms exist among employees with different kinds of educational and cultural backgrounds. We call these interpretations and norms 'mental models'. These mental models form the perceptions from which other models are interpreted. Over the years the E&P process has changed drastically. In the past, knowledge through craftsmanship was most essential, whereas in the future oil companies want to be able to control the E&P process through 'Closed loop control', whereas the emphasis will be on scientific knowledge. This change has implications for the mental models of employees. Not only the use of technology and decision-making is influenced by the mental models, also the success of learning will, to a large extend, depend on these mental models. So far, the emphasis has been on the development and implementation of Smart Oil Fields Technology as

such. Little attention has been paid to the importance of the influence of mental models during the implementation of the new technology. Even more, since major oil companies are global players and therefore have to cope with a large variety of mental models in different countries throughout the world.

## 2. Group Mental Models

We define 'Group Mental Models' as "shared organized knowledge structures by a selected number of people, that allow people to predict and explain behavior of the world around them, to recognize and remember relationships among components of the environment, and to construct expectations for what is likely to occur next" (see 5). Mathieu et al. mention that mental models serve three crucial purposes: They help people to describe, explain, and predict events in their environment (5). Mental models can be distinguished in different types. We will shortly discuss the following three distinctions of mental models:

- Individual and shared (6);
- Taskwork and teamwork (5,7);
- Technology/equipment, job/task, team interaction, and team (5).

**Individual and shared**

The first distinction is between individual and shared (6). We focus on shared mental models, more specifically on the group level. Organizations are divided into several groups; therefore this will be the level of research. According to Mathieu et al. (5) some authors argue that under conditions that allow team members to freely communicate with one another – to strategize - shared mental models can have a greater variety. Furthermore they add "This is because the team can discuss its next moves and does not need to rely on preexisting knowledge. However, under conditions in which communication is difficult – because of excessive workload, time pressure, or some other environmental feature – teams are not able to engage in necessary strategizing".

**Taskwork and teamwork**

Several authors (5,7) make a distinction between taskwork (or task related) and teamwork (or team related) mental models. Task procedures, task strategies and environmental constraints are examples of knowledge related to the taskwork mental model. Examples of teamwork are: roles/responsibilities, interaction patterns and communication channels. "Shared knowledge about team interactions drives how team members behave by creating expectations" (5).

**Technology/equipment, job/task, team interaction and team**

Mathieu et al. (5) describe the two major content domains taskwork and teamwork, and they further subdivide these two domains into four types. Based on the distinction of Mathieu et al. (5), we discuss the following types of shared mental models: (i) Technology/equipment; (ii) Job/task; (iii) Team interaction and; (iv) Team.

**(i) Technology/equipment**: team members must understand the technology or equipment with which they are interacting (5). This particular type of shared mental model seems essential, whereas (as earlier argued) most major oil companies have implemented Smart Oil Fields Technology;
**(ii) Job/task:** teams must hold shared job or task models (5). The blending of employees with different kind and level of skills & knowledge will create difficulties;
**(iii) Team interaction:** team members must hold shared conceptions of how the team interacts (5). Team interaction emphasis on perceptions of the collaboration between the team members;
**(iv) Team:** this model contains information that is specific to the member's teammates – their knowledge, skills, attitudes, preferences, strengths, weaknesses, tendencies, and so forth (5). Important aspects of each others characteristics are part of the element of 'Team'.

To be able to describe, explain and predict behavior on the one hand and to recognize and remember relationships on the other hand, groups will form norms and interpretations to put this into practice. We start by discussing interpretations, followed by norms.

### 2.1 Interpretations

Employees can have interpretations about both the elements of Taskwork and Teamwork. Since the implementation of Smart Oil Fields, new technology is a current issue within the petroleum industry, we focus on the interpretations of employees (specifically engineers) towards (new) technology. Following Orlikowski (8), we define 'interpretations' as "shared internal beliefs, attitudes, and intentions about the technology they use".

Specific aspects which influence the use of technology are needed. That way, concrete insights can be gained about the interpretations towards the actual use of Smart Oil Fields Technology. Davis (9) mentions two determinants which influence the use of technology: (i) perceived usefulness and; (ii) perceived ease of use.
Davis defines perceived usefulness as "the degree to which a person believes that using a particular system would enhance his or her job performance" (9). The interpretations of employees whether they could benefit from the new technology influence their job performance. If employees perceive their benefits as low, motivation for using the new technology will be low as well.
Perceived ease of use is defined as "the degree to which a person believes that using a particular system would be free of effort" (9). Difficult technology can form a barrier for the actual use of this technology.

### 2.2 Norms

Norms can be distinguished in several different ways. Important to note is the difference between 'social norms' and 'group norms'. According to Forsyth (10) "social norms structure actions in a wide variety of contexts and cultures, whereas group norms are specific to a particular group". Following Forsyth we define 'group norms' as "a consensual and often implicit standard that describes what behaviors should and should not be performed in a given context". In the literature, many types of group norms exist. Forsyth distinguishes:

- Prescriptive norms: A consensual standard that identifies preferable, positively sanctioned behaviors (10). Behavior according to the prescriptive norms will be rewarded by the group;
- Proscriptive norms: A consensual standard that identifies prohibited, negatively sanctioned behaviors (10). Behavior according to the proscriptive norms will be punished by the group.

So far, we have discussed:
**(i) Major factors of influence on group mental models:**
(a) (Technical) disciplinary background;
(b) Cultural background;
**(ii) Group mental models (group norms & interpretations towards):**
(a) Taskwork (consisting of Technology/equipment *and* Job/task);
(b) Teamwork (consisting of Team interaction *and* Team).

Figure 1 provides an overview of the mentioned elements above.

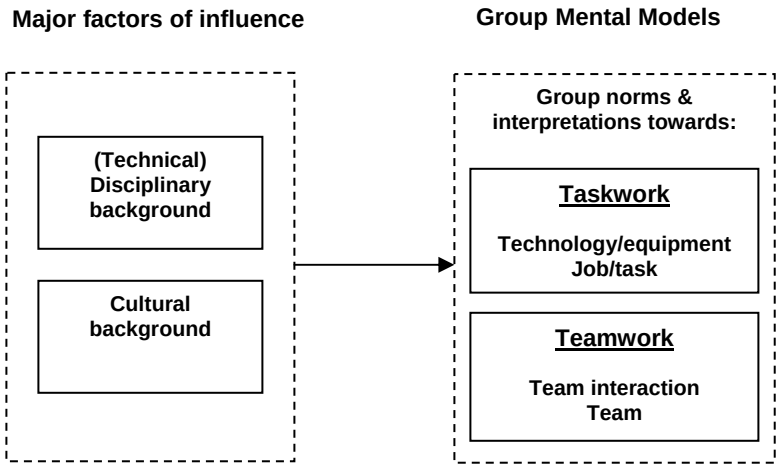


**Figure 1 – Overview of major factors of influence and Group Mental Models**

After discussing the major factors of influence and the group mental models, we will continue by discussing the outcomes of group mental models.

## 3. Outcomes of Group Mental Models

### 3.1 Effective use of technology

As mentioned earlier, the perceived usefulness and perceived ease of use are two important determinants of the actual use of technology. Insights into the perceived usefulness and perceived ease of use are important for the effective use of Smart Oil Fields Technology. If perceived usefulness and/or perceived ease of use have negative impact on the actual use of the technology, concrete interventions can be made by the organization.

### 3.2 Effective decision-making

Decision-making is one of the most important elements in the Exploration & Production (E&P) process of oil companies. Before groups make decisions, they go through two phases: (i) Orientation phase; defining the problem and planning the process; (ii) Discussion phase; remembering, exchanging and processing information (10). To illustrate the decision-making process within the petroleum industry, we use a simple figure (see Figure 2 below) with two axes: x-axis consists of 'Time' (*Days* to *Years*) and y-axis consists of 'Level of decision-making' (*Concrete* to *Abstract*). Three stages in the decision-making of the E&P process can be distinguished:

(i) Production operations, where day-to-day decisions about the production are being made;
(ii) Production optimization, decisions about optimizing the production on a weekly to monthly base;
(iii) Field development, decisions about if and how to develop the oil & gas field further. This takes places over a longer period of time; months till years.

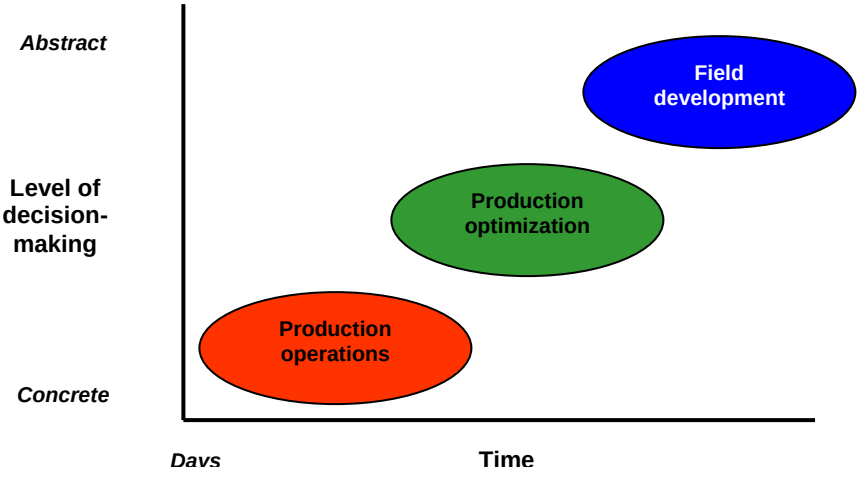


**Figure 2 – Illustration of stages of production and decision-making**

For the petroleum industry, day-to-day decision-making (production operations) calls for a tighter shared mental model, than decision-making over a longer period of time (field development). Little time can be spent on the orientation phase (defining the problem and planning the process) within the day-to-day decision-making of production operations. Therefore individuals who collaborate closely will need to have a tight shared mental model. Even though tasks will be more routine on a day-to-day basis and decisions will be more concrete, than in field development, it is important that the team members adopt the same conceptualization of their tasks, goals, and procedures (see 10). Group (or team) members in field development decision-making have more time to define the problem and planning the process.

### 3.3 Effective learning

In the literature important distinctions of learning are between: (i) operational and conceptual learning (6,11) and; (ii) individual and organizational learning (6,11,12).

**Operational & conceptual learning**

Learning has two aspects: (i) operational learning (or know-how): the capability of bringing about a desired situation; (ii) conceptual learning (or know-why): the understanding of experience, or insight (11). The two levels of learning – operational and conceptual – can be related to two parts of mental models (6). Operational learning represents learning at the

procedural level, where one learns the steps in order to complete a particular task (6). Important to note is that this know-how is captured as routines (see 6). Operational learning is associated with 'observing' and 'implementing' (11).
Conceptual learning "has to do with the thinking about why things are done in the first place, sometimes challenging the very nature or existence of prevailing conditions, procedures, or conceptions and leading to new frameworks in the mental model" (6). Conceptual learning is associated with 'design' and 'assess' (11).

**Individual & organizational learning**

According to several authors (6,11) individual learning takes place by the individual repeatedly going through a learning loop described by the OADI cycle (Observe, Assess, Design, Implement). Espejo et al. (11) argue that "individual learning in effect consists of enhancements of individual mental models. From these individuals derive, in the conceptual sphere, updated frameworks within which to design improvements. In the operational sphere, they derive updated routines and procedures with which to implement such improvements".
Individual learning is necessary for organizational learning, but not sufficient (11). In addition to this argument, Espejo et al. (11) argue as follows "Mental models must be shared. A critical factor in designing processes whereby such sharing takes place is that individual models must to a certain degree be made explicit. When they are made explicit, learning within the organization becomes less dependent on the individual".
Figure 3 provides an overview of the relation between the OADI-cycle (operational & conceptual learning) and (individual) mental models.

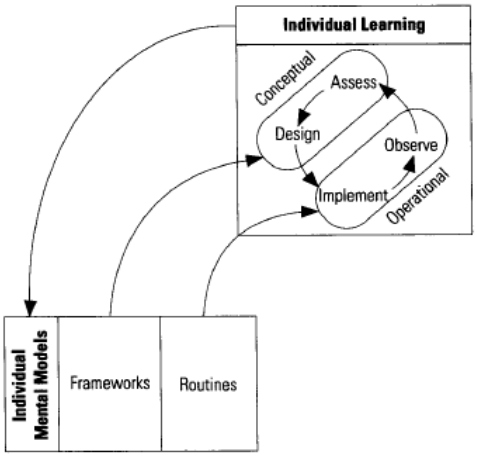


**Figure 3 - OADI-Individual Mental Models (IMM) Cycle (6)**

We focus on the level of group learning, since this level can be directly related to the level of group mental models. According to Mohammed & Dumville (13) "group learning plays a significant role in the development, modification, and reinforcement of mental models and can be viewed as a sub-set of the broader concept of team mental models". Important to mention is that in order to achieve a high level of team effectiveness, there is some knowledge that will need to be collectively learned by all team members, some knowledge that will need to overlap among dyads or triads, and distributed among team members for maximum team performance (13).

## 4. Overview of Major factors of influence and Outcomes of Group Mental Models

The blending of employees with (a) different kind and level of skills & knowledge and with (b) different kind of cultural backgrounds can be related to the distinction of taskwork and teamwork. Different kinds of (technical) disciplinary backgrounds demand for a different kind and level of skills & knowledge. For example the execution of exploration tasks requires other skills & knowledge than production tasks. Based on these differences in skills & knowledge, each (technical) discipline will entail its own 'group mental model' on how tasks should be executed (see Figure 4). We see the different kind and level of skills & knowledge as the primary factor of influence on the element of taskwork within the 'group mental model'. As a secondary factor of influence, we see the relation from 'disciplinary background' to 'teamwork'. We assume that the way engineers from different disciplines will collaborate with each other will not differ so much, compared to the way of executing their tasks. We see the different kind of cultural backgrounds as the primary factor of influence on 'teamwork'. Different expectations about the hierarchy and openness within the group will be mainly based on cultural differences. For example, "every group member is allowed to say whatever he or she likes, even though if this could result in conflicts". Engineers from more individualistic (national) cultures would rather agree with such a statement, whereas engineers from more collectivistic cultures would rather disagree.

As for the outcomes of Group Mental Models, many important organizational elements are affected by Group Mental Models, for example 'Effective use of technology', 'Effective decision-making' and 'Effective learning'. Also the process and performance of these organizational elements affects the Group Mental Models.

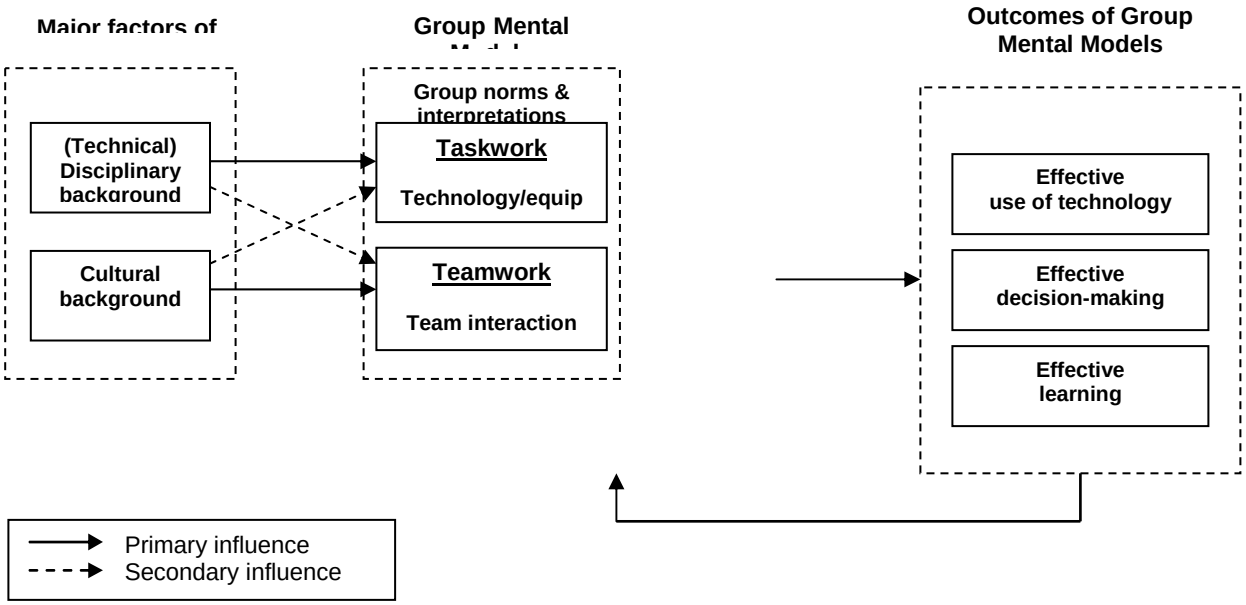


**Figure 4 – Overview of major factors of influence and outcomes of Group Mental Models**

## 5. Final thoughts

Awareness of different types of Group Mental Models (taskwork and teamwork), caused by different disciplinary and cultural backgrounds, is the first step to a shared (group) mental model. The urge to combine employees with different mental models into multi-disciplinary/multi-cultural teams is greater than before within the petroleum industry. There is a lot of implicit experience with different kinds of Group Mental Models within the E&P industry, due to the great variety of disciplinary and cultural backgrounds. Although there is a lot of implicit experience with these mental models, little attention has been paid to make them explicit and to actually work with them. A few companies of other industries are successfully working with virtual teams. Apparently, working with different mental models went well, except for making them explicit.
If these mental models are made explicit, in stead of remaining implicit, these mental models can serve as a management tool. Management can adapt their policies and practices to different settings, caused by different (explicit) mental models.
So far, within several industries there is a lot of implicit experience with dealing with different mental models (based on different disciplinary and cultural backgrounds), but little explicit experience. Future research must begin to specify which team knowledge content needs to be identical, overlapping, and distributed among team members for maximum team performance (13).
A start will be made by researching the 'Group Mental Models in Collaborative Work Environments' in Shell International Exploration & Production. Following aspects are important to consider:

**Major factors of influence**

- Which (technical) disciplines are present?
- Which (technical) disciplines need to collaborate closely with each other?
- What types of groups of cultural backgrounds are present?
- Which groups of employees with different types of cultural backgrounds need to collaborate closely with each other?

**Group Mental Models**

- What are the most important group norms and interpretations towards taskwork of each (technical) discipline?
- What are the similarities and differences between each (technical) discipline?
- What are the most important group norms and interpretations towards taskwork of groups of employees with different types of cultural backgrounds?
- What are the similarities and differences between the groups of employees with different types of cultural backgrounds?

- What are the most important group norms and interpretations towards teamwork of groups of employees with different types of cultural backgrounds?
- What are the similarities and differences between the groups of employees with different types of cultural backgrounds?
- What are the most important group norms and interpretations towards teamwork of each (technical) discipline?
- What are the similarities and differences between each (technical) discipline?

**Outcomes of Group Mental Models**

- How is the present use of technology going?
- To what extent are there differences between groups of employees?
- Can these differences be related to different disciplinary or cultural backgrounds?
- If so, what can be done to solve these in the future?
- How is the present decision-making process going?
- To what extent are there differences between groups of employees?
- Can these differences be related to different disciplinary or cultural backgrounds?
- If so, what can be done to solve these in the future?
- How is the present learning process going?
- To what extent are there differences between groups of employees?
- Can these differences be related to different disciplinary or cultural backgrounds?
- If so, what can be done to solve these in the future?

Hopefully, this paper will contribute to (1) the awareness of the importance of mental models and; (2) for petroleum companies to make them explicit and work with the different mental models among the employees.

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