Author: Haar, Selma van der
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CHAPTER 3

Towards a contextualized model of team learning processes and outcomes[4]

Abstract

Existing review studies on team learning present integrated models, suggesting general applicability to any team. However, such models neglect the influence of the team type and its developmental stages. These context-specific characteristics may create variety in team learning processes and outcomes among teams. In this theoretical contribution, we revisit the most recent generic team learning model developed by Decuyper, Dochy, and Van den Bossche (2010). Taking this model as a starting point, we present a context-specific model for ad hoc multidisciplinary emergency management teams. The developed model can fuel future research on team learning in teams with comparable characteristics. It supports the development of tools to evaluate them and offers the rationale for training programs aiming to increase the quality of their interventions.

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1. Introduction

In the past years, a vast amount of studies have aimed to offer insights into team learning (e.g. Decuyper, Dochy, & Van den Bossche, 2010; Edmondson, Dillon, & Roloff, 2007; Ellis, Hollenbeck, Ilgen, Porter, West, & Moon, 2003; Jehn, & Rupert, 2007; Knapp, 2010; Kozlowski & Ilgen, 2006; London, Polzer, & Omoregie, 2005; Wilson, Goodman, & Cronin, 2007). The number of publications on team learning has expanded since 1990 (1990-1999: 178 references, 2000-2007: 214 references; Decuyper, et al., 2010). In general, team learning is defined as “a compilation of team-level processes that circularly generate change or improvement for teams, team members, organizations, etc.” (Decuyper, et al., 2010, p. 128). It is a dynamic behavioral process of interaction and exchange among team members (Kozlowski & Ilgen, 2006). Through these processes individuals acquire, share, and combine knowledge in order to adapt and improve (Edmondson, 1999). As a compilation, team learning consists of changing combinations of different types of processes. Working circularly means that these processes lead to certain outcomes which in turn influence these processes. Team learning differs from individual learning in that the ability to acquire knowledge and skills is collectively shared by team members and the team learning outcome is collectively available and used (Ellis, et al., 2003; Jehn & Rupert, 2007).

Team learning is distinct from teamwork, which is a set of interrelated thoughts, actions and feelings of each individual team member that are needed if the team is to really function as a team (Salas, Sims, & Burke, 2005). Teamwork is about cooperative interactions that facilitate dealing with task objectives and realizing coordinated, adaptive performance. During this cooperation, team members use knowledge. It is a resource that helps to understand how team members are able to combine their (individual) knowledge to improve team effectiveness (Kozlowski & Ilgen, 2006). One could say that team learning refers to teams as a learning unit while teamwork refers to teams as a working unit (Decuyper, et al., 2010). A team can be defined as “a collection of individuals who are interdependent in their tasks, who share responsibility for outcomes, who see themselves and who are seen by others as an intact social entity embedded in one or more larger social systems” (Cohen & Bailey, 1997, p. 241). Teams interact dynamically, interdependently and adaptively and have a specific role or function to perform and a limited life span of membership (Salas, Dickinson, Converse, & Tannenbaum, 1992).

Different review studies integrated the team learning research findings by combining various perspectives on the phenomenon into a coherent whole (e.g. Edmondson, et al., 2007; Knapp, 2010; Wilson, et al., 2007). Most recently, Decuyper, Dochy, and Van den Bossche (2010) developed an integrated team learning model including team learning processes, their antecedents and their outcomes (Figure 1). In their search for variables that are central to team learning, they thoroughly reviewed relevant team learning studies conducted within different disciplines and addressing different team types and settings, except virtual teams. This interdisciplinary integration of research findings is highly valuable, since the increasing specialization, the split into innumerable disciplines and sub-disciplines and the consequent diversity in the study of team learning raises questions about the extent to which we are truly executing scientific research that builds up a cumulative body of knowledge.

At the same time, however, the question arises whether it is possible to describe team learning in a generic way for a wide variety of teams. Teams are complex, dynamic, and adaptive systems (McGrath, Arrow, & Berdahl, 2000) which exist in a context and perform across time (Ilgen, Hollenbeck, Johnson, & Jundt, 2005). Based on their review of team learning studies, Decuyper et al. (2010) conclude that the importance of time and the developmental stage of a team have been neglected in team learning research so far. Team learning processes may operate differently in different stages of a team's existence. Furthermore, the time pressure a team experiences may influence the appearance of team learning processes as well. Finally, future research needs to study the relation between team learning and team type, including structural elements of the team composition such as team size, team autonomy, team tenure, and team diversity. Therefore, in addition to the development of integrative models and in order to fully understand the phenomenon of team learning, research needs to develop more context-specific models that acknowledge the differences in team processes and team outcomes (Decuyper, et al., 2010; Edmondson, et al., 2007; Jehn & Rupert, 2007; Wilson, et al., 2007).

The aim of this theoretical contribution is to develop a context-specific team learning model, further developing the most recent integrative team learning model of Decuyper, et al. (2010) and using studies addressing team learning in ad hoc multidisciplinary emergency management command-and-control teams.

2. A reflection on the generic integrative systematic model for team learning

In the past 20 years, a significant number of authors from different (sub-)disciplines (e.g. organizational sciences, psychology, learning sciences), taking different theoretical perspectives (e.g. socio-cultural, cognitive, socio-cognitive), have contributed to the theoretical development of the construct of team learning. The increasing number of studies has resulted in review studies such as Mathieu, Maynard, Rapp, and Gilson (2008) and Ilgen et al. (2005). The most recent review of Decuyper and colleagues (2010) presents an integrative model of team learning (Figure 1) based on team learning studies across different disciplines.

2.1 Summary of the model

Decuyper, Dochy and Van den Bossche (2010) consider team learning to be systematic because teams are composed of interdependent members and are part of a bigger system at the same time. Teams use input, for instance information, habits, and rules, from different subsystems, such as the unit and the organization a team belongs to. Their team learning model presents team learning as a compilation of team-level processes and outcomes that generate change or improvement for teams in terms of knowledge or behavior, which is shared by the team members and becomes part of the repertoire of the team. Team learning makes team members think and act in a different way than they did before.

In previous research, different behaviors and processes that evoke team learning are mentioned (see Table 1). Decuyper and colleagues (2010) conclude in their review that all the communicative actions that are mentioned can be summarized in the three basic processes of sharing information, co-construction of meaning, and constructive conflict. These processes can be facilitated by team activity, boundary crossing, team reflexivity, and storage and retrieval. For a definition of these team learning processes, we refer to Table 2.

Table 1. Team learning behaviors and processes

Authors	Team learning behaviors and processes
Argote, Gruenfeld, and Naquin (1999)	Acquiring, sharing, refining, or combining task-relevant knowledge through interaction
Argote (1999)	Collective acquisition, combination, creation, and sharing of knowledge by teams
Edmondson (1999)	Reflection and action, characterized by asking questions, seeking feedback, experimenting, reflecting on results, and discussing errors or unexpected outcomes of actions
Ellis, Hollenbeck, Ilgen, Porter, West, & Moon (2003)	The ability to collectively share that knowledge
Gibson & Vermeulen (2003)	Experimentation, the combination of insights through reflective communication, and the explication and specification of what has been learned through codification
Gruenfeld, Martorana, & Fan (2003)	The acquisition, persistence, diffusion, and depreciation of group knowledge
Wilson, Goodman, & Cronin (2007)	Sharing, storage, and retrieval of group knowledge, routines, or behavior

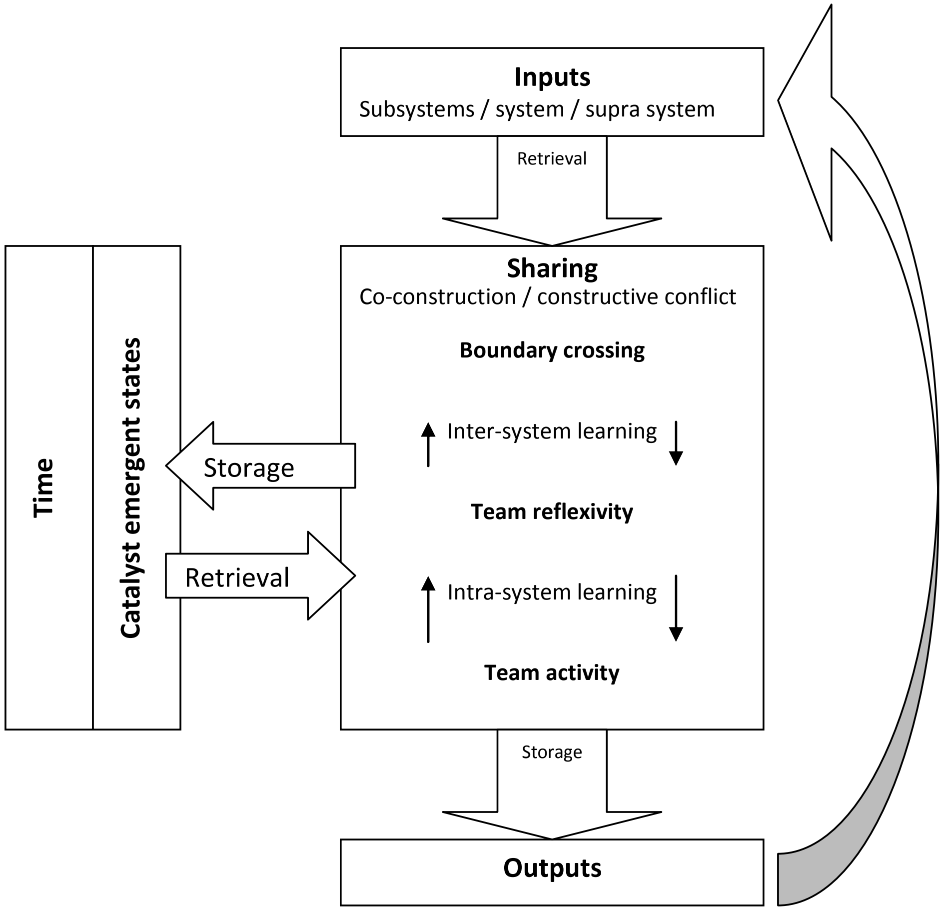
Table 2. Team learning processes as defined by Decuyper, Dochy, & Van den Bossche (2010)

Team learning processes	Definition
Sharing	'The process of communicating knowledge, competencies, opinions or creative thoughts of one team member to the other team members, who were not previously aware that these were present in the team'.
Co-construction	'The mutual process of developing shared knowledge and building shared meaning by refining, building on, or modifying an original offer in some way' (…) 'leading to shared knowledge and new meaning that was not previously available to the team'.
Constructive conflict	'The process of negotiation or dialogue in the team that uncovers diversity in identity, opinion, etc. within the team' (…) 'for example exploring different perspectives, error analysis, ad error communication' (…) 'to integrate differences in viewpoints'.
Team activity	'The process of team members working together, mobilizing physical and psychological means required for goal attainment.' (…) 'Learning by doing'.
Boundary crossing	Crossing the boundaries of separate units, groups, or organizations, being stake holders of the learning process, to share information.
Team reflexivity	'the process of co-constructing, de-constructing, and re-constructing shared mental models about current reality, and about team goals and methods.' (…) 'Single loop learning: questioning to what extend the goal is achieved; double loop learning: questioning the goals, the rules of the game and the underlying steering variables'.
Storage and retrieval	'By means of storage and retrieval, shared knowledge, developed procedures, shared ideas, plans, habits etc. that result from basic and facilitative team learning processes are saved in the software and/or hardware of the team, in such a manner that that they can serve for later use or subsequent inspection'.

Decuyper and colleagues (2010) categorize team learning outcomes by stating that they can be adaptations to the environment, the generation of new knowledge, or the application of new ideas concerning the main team activity, its procedures and its goals. A possible output could be a project plan for organizational changes or a work scheme. Furthermore, they state that a team develops catalyst emergent states, such as shared mental models, psychological safety, shared habits or routines as a team learning output. Since team learning is considered a cyclical phenomenon in this model (Figure 1), all learning outcomes are fed back into the team as learning inputs.

The theoretical model of team learning by Decuyper and colleagues (2010) is an important step in integrating research from different disciplines. At the same time, it indicates interesting paths for future research. More precisely, even though in the general model (Figure 1) the role of time is mentioned, it does not reveal how this factor influences team learning processes and outcomes. In the next section we will elaborate on the importance of the time aspect for understanding team learning.

Figure 1. Integrative systematic model for team learning (Decuyper, Dochy, & Van den Bossche, 2010).



2.2 Reflections on the model from a temporal perspective

First, each team has a dynamic nature of its own, due to lively interactions in and outside the team, changes in its task description, changes in the team itself such as a new composition, and changes in the environment over time (Arrow, 1997; Cronin, Weingart, & Todorova, 2011; Ilgen, et al., 2005; Kozlowski & Klein, 2000; Marks, Mathieu, & Zaccaro, 2001). The dynamics and frequency of such changes vary among different team types. Imagine for instance the differences between a team operating in physical closeness in a small emergency unit at the scene of an incident communicating face-to-face and facing high time pressure, and a dispersed team of technicians scattered around the globe developing new technology, merely communicating via e-mail and internet and having ample time to finish a project.

Second, due to the dynamics and the frequency of the changes that a team faces, team learning processes and outcomes evolve over time. In this respect, Marks and colleagues (2001) suggest in their repeating cycle model for team development that teams alternate between action and transition phases during their lifetime. During action phases, teams are engaged in acts that contribute directly to task and goal accomplishment. During transition phases, however, teams focus primarily on evaluation and/or planning activities to structure and guide their accomplishment of the team goal. It is to be expected that in each phase different team learning processes and outcomes play a role depending on the team type, its situation and environment, and its task and goal. Therefore, we argue that team learning should be considered to be a dynamic and context-specific phenomenon.

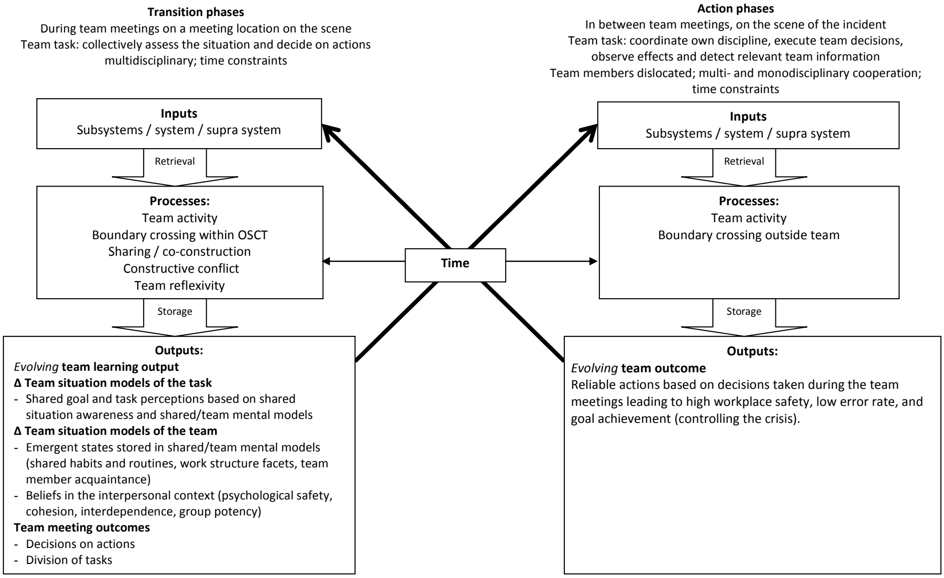
Third, time could also influence the storage of knowledge in teams. Teams store the results of team learning processes in, for instance, manuscripts or databases, as well as in the minds of the team members. We argue that, due to the role time plays, understanding the process of storage requires a dynamic approach. Team learning processes lead to the development of team cognition: the manner in which knowledge important to team functioning is mentally organized, represented, and distributed in a team, and allows team members to anticipate and execute actions (Kozlowski & Ilgen, 2006). Team cognition develops within teams over time (DeChurch & Mesmer-Magnus, 2010). It is an emergent team state that is dynamic in nature and varies as a function of team context, inputs, processes, and outcomes over time and thus, the team type (Kozlowski & Ilgen, 2006; Marks, et al., 2001; Mohammed, Ferzandi, & Hamilton, 2010).

Team cognition is stored in more structures than only the shared mental model as suggested in the model of Decuyper et al. (2010). Shared or team mental models refer to collectively owned long-term knowledge which team members have developed during earlier team training, team experiences and team discussions (Mohammed, et al., 2010). Which shared or team mental models a team has is thus related to its history and life span. In the case of ad hoc composed teams for instance, members only cooperate for a short period of time. They will bring individual mental models into the team and the extent to which these are similar will appear during cooperation (Canon-Bowers, Salas, & Blickensderfer, 1999; Cooke, Salas, Cannon-Bowers, & Stout, 2000; Cooke, Kiekel, & Helm, 2001). In addition, team members assess the current situation. In this respect, Endsley (1988, p. 97) refers to situation awareness as “the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future". While sharing their individual situation assessments, they may develop shared situation awareness (Cooke, Stout, & Salas, 1997; Cooke, Stout, & Salas, 2001). Both shared or team mental models and shared situation awareness are ingredients for the production of a dynamic and continuously changing shared understanding of the momentary situation, which is reflected in the team situation model (Cooke, et al., 1997; Cooke, et al., 2001). This team situation model (TSM) is defined as “the mental representation associated with a dynamic understanding of the current situation (i.e. environment, task, team) that is developed by team members moment by moment" (Rico, Sanchez-Manzanares, Gil, & Gibson, 2008, p. 167; Cooke, et al., 2000). The TSM is a product and collectively shared interpretation of the available information from both the shared or team mental models and the shared situation awareness. It develops moment-by-moment while a team is engaged in a task (Canon-Bowers, et al., 1999; Cooke, et al., 2000).

A team may have several TSMs of which each contains knowledge of a specific subject. According to Mathieu, Heffner, Goodwin, Salas, and Cannon-Bowers (2000) this could be task-related cognition: the understanding of the team's work goals, performance requirements, task, equipment, and resources, in other words the TSM of the task. The TSM can also contain teamwork cognition, which in turn refers to the understanding of team interaction requirements and skills and team member interdependency (DeChurch & Mesmer-Magnus, 2010; Mathieu, et al., 2008; Mohammed, et al., 2010): the TSM of the team. TSMs have a dynamic nature and vary as a function of the team context, inputs, processes, and outcomes (Kasl, Marsick, & Dechant, 1997; Kozlowski & Ilgen, 2006; Marks, et al., 2001; Mohammed, et al., 2010). The appearance of TSMs changes over time due to their dialectic relation with team learning processes (Edmondson, 2003; Edmondson, et al., 2007; Cooke, Gorman, Duran, & Taylor, 2007; Decuyper, et al., 2010; Van den Bossche, Gijselaers, Segers, & Kirschner, 2006; Van den Bossche, Gijselaers, Segers, Woltjer, & Kirschner, 2011; Wilson, et al., 2007). In sum, the TSM, as an output of team learning, varying in content across team types and evolving over time, is an important variable within a theoretical model of team learning (see Figure 2).

In the next section, based on the aforementioned reflections, we revisit the generic team learning model (Decuyper, et al., 2010) by analyzing its components in the context of emergency management teams and illustrating our arguments in the specific setting of on-scene-command-teams (OSCT).

Figure 2. Context-specific model for team learning in the on-scene-command-team (OSCT)



3. Revisiting the generic team learning model: Emergency management command-and-control teams

3.1 Emergency management command and control teams: The on-scene-command-team

In case of an emergency situation, for instance a car accident on a highway involving a truck containing flammable gas, different assistance units (e.g. the police, the medical assistance unit and the fire department) cooperate at the scene of the incident to reach the shared goal of saving lives, prevent damage, clear the scene, and control the crisis situation. Together they are a multi-team system, defined as “two or more teams that interface directly and interdependently in response to environmental contingencies toward the accomplishment of collective goals” (Marks, et al., 2001, p. 290). The different assistance units incorporate different expertise and experience and are capable of conducting different types of tasks. A typical multidisciplinary emergency management command-and-control team has the responsibility to organize and manage these resources (Salas, Burke, & Samman, 2001) and coordinate the multidisciplinary cooperation at the scene: the on-scene-command-team (OSCT). This requires intra-crisis team learning, “learning that seeks to improve response during a single crisis episode” (Moynihan, 2009, p. 189). In table 3 we summarize the features of this team type.

Thorstensson, Axelsson, Morin, and Jenvald (2001) summarize the structured work process the OSCT needs under these circumstances in four steps: detect – assess – decide – act. During action phases, each OSCT member coordinates the own unit for goal achievement (*acts*), and *detects* available information about what is going on and needs to be discussed during the next meeting. During their meetings, the transition phases, the team collectively shares and *assesses* this information to create a shared interpretation of what is going on, draws up possible future consequences, makes *decisions* and defines the actions needed to give instructions to the units in the field, and monitors the developments at the scene, using the standard agenda for OSCT meetings (Helsloot, Martens, & Scholtens, 2010). During both the action and transition phases, the team continuously monitors and evaluates the effect of actions on the present situation and possible future scenarios (Rasker, Post, & Schraagen, 2000; Schraagen & Van de Ven, 2008; Thorstensson, et al., 2001).

Given its characteristics (Table 3), this team type is relevant to describe the role of time and therefore of TSM in team learning. Given the OSCT is an exemplar of emergency-management command-and-control teams we will illustrate our arguments in this specific context. In the next section, based on empirical and theoretical literature on emergency management teams, we develop a context-specific team learning model for emergency management command-and-control teams, and more specifically the OSCT, by arguing how team learning processes play a role during action and transition phases and to what team (learning) outcomes they lead in this context. We illustrate this model in Figure 2.

3.2 Developing a contextualized team learning model: Team learning processes and outcomes in the On-Scene-Command-Team

The characteristics of the OSCT (Table 3) show that this team has a dynamic nature and works in a dynamic environment, requiring a dynamic perspective on team learning. Therefore, revisiting the generic team learning model (Decuyper, et al., 2010), we discern action and transition phases and consider the role of the dynamic team situation model (TSM). Figure 2 illustrates the team learning model for the OSCT that we will develop in this section. It is divided in two components: the left component describes team learning during transition phases (meetings with all team members present) and the right component during action phases (team members operating separately at the scene with the people of their own assistance unit). In this context, the division between transition and action phases (Marks, et al., 2001) is based on the presence or lack of physical closeness of the OSCT members. The input from (sub / supra) systems (upper box in Figure 1 and 2) refers to the input the OSCT gets from the different teams and units that participate in the emergency management process during the action phases. We first explore the team learning outcomes in both action and transition phases. We then describe the team learning processes that are relevant in both phases. We acknowledge how OSCT features influence the team processes and outcomes.

3.3 Team learning outcomes in action and transition phases

During action phases, the team members execute the decisions made during team meetings. These actions should contribute to the eventual goal of controlling the situation, and prevent (more) death and damage. Therefore, the actions need to be reliable. The final goal, after all, is to achieve control of the crisis, while showcasing low error rates and a high workplace safety (Baker, et al., 2006; Wilson, et al., 2005; see the box “Outputs, evolving team outcome” under “Action phases” in Figure 2).

During transition phases, two types of outputs can be discerned: the team meeting output and the team learning output. The team members develop concrete team meeting outputs in terms of decisions on actions to be taken and a division of tasks (see the box “Outputs, team learning output” under “Transition phases” in Figure 2). These outputs are input for the actions the team members will execute at the scene. They are based on the team situation model (TSM) of the task and the TSM of the team which the team members develop during transition phases. These TSMs are the team learning output.

Since each emergency situation is unique and unpredictable (e.g. the location, the timing and nature of critical events, the availability of new information, and sudden failures of equipment) each time an OSCT has to operate, it needs to develop new task knowledge (Dunn, Lewandowski, & Kirsner, 2002; Edmondson, et al., 2007) about what is going on (shared situation awareness) and about what needs to be done (shared goal and task perceptions) (see Figure 2). This knowledge needs to be stored in a TSM of the task. The importance of this TSM is argued by different authors in the field of emergency-management teams. Comfort (2007) states that emergency management teams are served by developing a TSM of the task, i.e. a shared idea of the situation and its risks, a shared idea of the team goal that follows from this situation, and a shared idea of how to act towards this goal together in an efficient way. It is a resource and starting point for decision-making on the actions that are needed (Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995; Mohammed, et al., 2010; Helsloot, et al., 2010). Previous research has evidenced that shared situation awareness is positively related to team effectiveness (Cooke, et al., 2001; Mohammed, et al., 2010). Cooke, Kiekel, and Helm (2001) have shown that the TSM of the task predicts team performance in teams dealing with time pressure. The best performing teams have collectively shared knowledge; teams with members that understand the task from other perspectives, too, outperform the others. Team members were queried by experimenters about the task during and after task completion.

Table 3. Features of the emergency management command and control team

Feature	Definition	References
Environment		
Structural complexity and dynamic uncertainty	The work environment is hazardous, the area of operation is typically large, available sources are limited, and in many situations there exist competing goals.	Becerra-Fernandez, Xia, Gudi, & Rocha, 2008; Salas, Wilson, Murphy, King, & Salisbury, 2008; Thorstensson, Axelsson, Morin, & Jenvald, 2001
Task		
Non-routine decision-making task	The goal of the OSCT is to interpret a unique situation in a very short time leading to coordinating decisions on actions that are adequate and trustworthy.	Uhr, Johansson, & Fredholm, 2008
Intellectual task	The task requires extensive acquisition and integration of information.	Devine, 2002
High risks and time pressure	Wrong decisions or decisions not made on time can lead to a deteriorating situation or even escalation.	Klein, Ziegert, Knight, & Xiao, 2006; Rasker, Post, & Schraagen, 2000
High reliability	Reliability refers to goal achievement (crisis control) while having low error rates and a high workplace safety.	Baker, Day, & Salas, 2006; Wilson, Burke, Priest, & Salas, 2005
Team		
Different team member roles	Members: officers coordinate the different assistance units at the scene (fire department, police, medical assistance unit), a chairman, an information manager, and an a person responsible for media communication.	Helsloot, Martens, & Scholtens, 2010
Multidisciplinary, expertise diversity	The team members have differences in knowledge and skill domains in which they are specialized as a result of their work experience and education. They have different sources of information and different materials and methods to use.	Baker, et al., 2006; Edmondson, 2003; Helsloot, et al., 2010; Klein, et al., 2006; Salas, Burke, & Samman, 2001; Thorstensson, et al., 2001; Van der Vegt & Bunderson, 2005
Interdependency	The different discipline-related tasks and expertise may be needed on a scene which leads to interdependency.	Gully, Incalcaterra, Joshi, & Beaubien, 2002; Klein, et al., 2006
Short life time	The team exists for the duration of an incident or disaster (max. 8 hours); in case managing the incident takes more time, the team is replaced.	Helsloot, et al., 2010
Ad hoc composition, low familiarity	Each team is composed ad hoc, of whoever is on call; team members work in a new team composition with possibly unfamiliar team members.	Baker, et al., 2006

While cooperating face-to-face during transition phases and despite the time pressure, the members of the OSCT not only learn about the task, but also learn about each other. In addition to the TSM of the task, the TSM of the team is also a team learning outcome. OSCT members often do not know each other before cooperation and consequently have a low familiarity. Because they participated in different OSCT compositions during training exercises they do have certain expectations stored in an individual mental model, which may or may not be similar among team members, about the way the members will cooperate and communicate during both type of phases. They probably import trust "swiftly" from previous experiences and invoked by similarities in the current situation with that of the past (Meyerson, Weick, & Kramer, 1996). During their cooperation they discover who has what particular knowledge and experience, how the team communicates and cooperates, and with what effects. This way, the OSCT develops emergent states (Decuyper, et al., 2010; Jehn, Rispens, & Thatcher, 2010; Meyerson, et al., 1996) such as shared habits and routines (who is sitting where at the meeting table?), work structure facets (what is the best time frame for our meetings during this specific incident?), and also team member acquaintance.

In addition, the team develops beliefs about the interpersonal context (Van den Bossche, et al., 2006), concerning psychological safety ("a shared belief that the team is safe for interpersonal risk taking", Edmondson, 1999, p. 354), cohesion ("the shared commitment among members to achieve a goal that requires the collective efforts of the group", Van den Bossche, et al., 2006, p. 499), interdependence ("the extent to which team members' outcome depend on their personal or team performance", De Dreu, 2007, p. 628), and group potency (a general collective belief that the group can be effective, Van den Bossche, et al., 2006).

These emergent states and interpersonal beliefs are part of the TSM of the team and evolve during cooperation. They are among the factors that are the most discussed in relation with team learning and have a significant effect on team learning (Decuyper, et al., 2010). Former research has shown that the TSM of the team has a positive predictive value for team performance (i.e. Mathieu, et al., 2000; Mohammed, et al., 2010; Rentsch & Klimoski, 2001; Smith & Dowell, 2000).

3.4 Team learning processes in action phases: Team activity and boundary crossing

In between team meetings, the members execute discipline-specific actions that follow from team decisions in cooperation with their own assistance units and not together. They do need to take the actions of the other disciplines and OSCT members into consideration. If necessary, they can consult an OSCT member individually; they do not have to wait to share important information until the next team meeting. During the action phases, each team member observes the effects of the activities at the scene. This yields information to share collectively in the team during the meetings as input for the collective discussion about what needs to be done next. So these individual actions during action phases are a result of team decisions and facilitate the team process. Even stronger, they are required for further cooperation. Although executed individually or in cooperation with members of assistance units at the scene, these activities are part of the OSCT approach. These characteristics of the work done by team members in between the meetings make us consider it the team learning process of *team activity* (Figure 2).

In between team meetings the team members use the team learning process of *crossing the boundaries* (Figure 2) of the team when they cooperate with the members of the own assistance unit and observe those of other units. Crossing the boundaries is necessary in multi-team systems that have to interface directly and interdependently in response to an emergency situation to accomplish the shared goals of workplace safety, reduction of errors, and crisis control (Marks, et al., 2001). Boundary crossing enables individual team members to gain more insight into what expertise is available, increase their level of awareness of what matters for other disciplines and units, and their awareness of how to contribute to the tasks of others (Moynihan, 2009). We assume this individual learning effect adds to the development of shared situation awareness as an ingredient of the task-TSM. Boundary crossing is related to boundary spanning, defined as the teams' efforts to establish external linkages within an organization or across organizational boundaries in favor of information transfer, knowledge creation, and innovation (Marrone, 2010). Boundary spanning is forced by the multidisciplinary composition of the OSCT, but needs to be created at the scene. We approach boundary crossing here as one type of effort to improve the boundary spanning by collecting and sharing information outside the OSCT.

3.5 Team learning processes in transition phases: Sharing, co-construction, constructive conflict, team reflexivity, storage and retrieval

During the team meetings (transition phases), the OSCT uses different team learning processes making the TSM of the task and the TSM of the team evolve (Figure 2). *Team activity* during transition phases consists of the members collectively participating in team meetings. Since these meetings are multidisciplinary, the members experience *boundary crossing.* During the meetings they use the team learning processes of sharing information, co-construction of meaning, constructive conflict, and team reflexivity, each of which we will elaborate on below.

Because the incident evolves over time, the collective assessment of the acquired information requires an ongoing process of *sharing* information and *co-construction* of meaning during each team meeting,. The process is important for aligning the different disciplines and organizations contributing to the emergency management process at the scene (Schraagen & Van de Ven, 2008). However, evaluation reports of large emergency management incidents, such as the Enschede fire work disaster[5] (Commission Research Firework Disaster, 2001), indicate that the processes of sharing information and (co-) construction of meaning are often under pressure (Schraagen & Van de Ven, 2008). This is caused by the specific features of the OSCT.

First, due to expertise diversity the OSCT members' knowledge and skill domains vary, which could hinder sharing of information and co-construction of knowledge (Van der Vegt & Bunderson, 2005). For example, research has shown information held by only one person in a team is omitted from discussion (Mesmer-Magnus & DeChurch, 2009; Stasser, Taylor, & Hanna, 1989). Second, typical for OSCTs is their low team member familiarity as the teams are ad hoc composed of the officers on call. In this respect, research has shown that command-and-control teams with experience in working together show better performance than teams with less mutual experience (Cooke, et al., 2007). In general, teams with unfamiliar members only have a better team performance if information is fully shared, while teams with familiar members have a better result when some of the critical information remains unshared (Gruenfeld, Mannix, Williams, & Neale, 1996).

Apparently a high level of expertise diversity and a low level of familiarity threaten the team learning processes sharing and co-construction. However, mutual recognition of expertise and responsibility for specific domains of information (Stasser, Steward, & Wittenbaum, 1995) and team identification (Van der Vegt & Bunderson, 2005) support teams in making use of each other's expertise. De Dreu (2007) showed outcome interdependence ("the extent to which team members' outcome depend on their personal or team performance", p. 628) relates to more information sharing, to learning, and to higher levels of team effectiveness. For the OSCT having high expertise diversity and low familiarity, this implies that the negative effect on sharing and co-construction could be reduced by mutual recognition of expertise, team identification, and outcome interdependence as facets of the TSM of the team.

Third, we suppose sharing and co-construction is influenced by the fact that the OSCT has to deal with time pressure in most cases, especially at the start of the cooperation and when something unforeseen happens, for instance, an unexpected explosion (Moynihan, 2009). This pressure, combined with the level of complexity and dynamic uncertainty of an incident, leads to a certain level of stress, risk and responsibility which influence the work and can lead to time constraints (Gonzales, 2004) when there is a difference in time available and time needed to resolve a task. Time constraints can cause the need for cognitive closure (Kruglanski, 1989) with the effect that the team will take less time than needed for information sharing and co-construction because of the perceived costs.

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[5] On May 13, 2000, the storage facility of the company S.E. Fireworks, Enschede, the Netherlands, caught fire. The disaster caused 23 deaths, among who 4 fire fighters, and injured a further 950 people. 200 houses were completely destroyed.

The consequence may be a confirmation bias indicating team members are overemphasizing information that confirms the original interpretation of an ambiguous situation, while discounting information inconsistent with it (Perrin, Barnett, Walrath, & Grossman, 2001), or groupthink. Groupthink refers to the rationalized conformity of thoughts that seeks to diminish conflict within the group by rejecting behavior that is divergent from the team culture, team identity, team norms and/or shared opinions (Decuyper, et al., 2010; Ellis, et al., 2003; Janis, 1972). Furthermore, the OSCT has to deal with the information order bias indicating that experts are significantly influenced by the order in which they receive information (Adelman, Tolcott, & Bresnick, 1991; Perrin, et al., 2001). Therefore, time constraints and cognitive closure can result in a less than desired team learning outcome. That way, the reliability of the team outcome is threatened.

To prevent these threats, a fifth team learning process is required: *constructive conflict*. It means that the team members are critical regarding each other's contribution, there is enough consideration of each other's ideas and comments, and the team members address differences in opinions and feel free to speak up (Edmondson, 2003; Van den Bossche, et al., 2011). Discussing opposite perspectives through constructive conflict is crucial and needed to prevent the aforementioned information order bias, confirmation bias and groupthink. It is needed to develop mutual understanding and agreement about the situation and the best way to respond to it (Van den Bossche, et al., 2011). Detecting relevant information, sharing it, co-constructing meaning and critically questioning the information and its meaning, supports the development of TSMs.

Here again, familiarity plays a role. Gruenfeld and colleagues (1996) showed familiar teams were more comfortable disagreeing with each other than teams whose members were unacquainted: the greater the member familiarity, the greater the comfort with expressing disagreement, the greater the openness to learning from each other, the greater the enjoyment of working together, and the greater the satisfaction with the outcomes. Therefore, we propose that the level of familiarity relates to the extent to which the OSCT uses constructive conflict and thus influences the risk the team runs to develop groupthink or suffer from confirmation or information order bias.

A sixth team learning process plays a role during transition phases. While sharing information and co-construction of meaning are used by the OSCT to define the emergency situation and approach, *team reflexivity* is especially used to discuss the OSCT's work and adds to the TSM of the team. Team reflexivity implies the team discusses the way it works using a team dialogue and asking themselves whether they are doing the right things in the right way. For instance, the dialogue could be about what subjects need to be on the agenda, the time used for discussion, or the division of roles during a team meeting. This reflexivity leads to the de-construction and re-construction of the TSM of the team. Single loop learning occurs when reflexivity is limited to questioning to what extend the goal is achieved; in the case of double loop learning the goals, the "rules of the game" and the underlying steering variables are questioned (Decuyper, et al., 2010). However, the OSCT generally lacks the time needed for thorough reflection during the emergency management process (Moynihan, 2009). Therefore we expect single loop learning to occur, but double loop learning to be rare.

As suggested above, it is important for the team to save the output of sharing, co-construction, constructive conflict, and team reflexivity. The knowledge stored in TSMs can be combined and used in later stages of incident management if necessary. This requires the seventh team learning process of *storage and retrieval*: the competence of a team to encode, store, and retrieve information on the group level.

4. Directions for research and practice

Our team learning model for on-scene-command-teams (OSCTs) illustrates that the specific features of the OSCT influence the appearance of team learning processes (sharing information, co-construction of meaning, constructive conflict, storage and retrieval, team activity, and boundary spanning) and outcomes (team situation model (TSM) of the task and TSM of the team). Team learning appears differently during the action and transition phases that occur in the course of the team's life (Marks, et al., 2001). Although the model is based on research and theoretical argumentations in the field of emergency management teams, it needs to be validated further. Such validation studies require a longitudinal and temporal approach, observing team member behavior over time, during different action and transition phases. The eventual team outcome in terms of goal achievement (controlling the crisis situation), workplace safety, and error rate can serve as an indication of to what extent certain team learning processes and outcomes are valuable and should be included. By validating the model this way, our understanding of intra-crisis team learning (Moynihan, 2009) in the OSCT and other emergency management teams in relation to its team effectiveness could be improved. This could fuel the evaluation of emergency management and the design of training and exercises for emergency management teams, of which the OSCT is but one example.

The work structure we used for this paper, including the determination of team features and the exploration of how team learning processes and outcomes will appear in that context over time, can be used to develop context-specific models for other team types working in different professional fields (e.g. teams of teachers, air traffic controllers, managers or surgeons). If we develop these models for different team types, we will be able to make comparisons and discover similarities and differences in team learning in different team types and contexts (Decuyper, et al., 2010; Edmondson, et al., 2007; Wilson, et al., 2007). This will bring us closer to the essence of team learning: it will help uncover the main elements present in every team type and the other elements that depend on team type, task and context.

Several variables need to be included in such research. First, the level of expertise diversity and team member familiarity as well as the effect of both on the efficient use of team learning processes need attention. A team with familiar and experienced members might have different learning outcomes, might use different team learning processes and might experience less bias in information processing than a team with unfamiliar and hardly experienced members. Second, mutual recognition of expertise, outcome interdependency and team identification need to be included in the analysis as they are vital to overcome the negative effects of expertise diversity and (lack of) familiarity.

Third, research needs to explore how time constraints influence the use and effects of team learning processes (Decuyper, et al., 2010; Wilson, et al., 2007), constructive conflict in particular. Previous research (Van den Bossche, et al., 2006) has shown this process is crucial for reaching mutual agreement and preventing information processing bias and group think. However, time constraints could prevent members from being critical and from starting arguments. We need insight in the effects of constructive conflict in different team types, with different degrees of time pressure.

Fourth, the model does not specify whether all team members have to be active in the team learning processes or if it is sufficient that only some are. Obviously, which members share knowledge depends on the subject and on who knows what. However, commenting critically on what is shared and how this is interpreted and acted upon may require the participation of all members. Future research should reveal how the participation of all or just some team members influences the processes and outcomes of team learning.

Fifth, the nature of the TSM needs consideration. Former research has shown that sharedness is beneficial for team performance (Cooke, et al., 2000; Kozlowski & Ilgen, 2006; Mohammed & Dumville, 2001; Mohammed, et al., 2010; Mathieu, et al., 2000; Stanton, Chambers, & Piggott, 2001), although some studies suggest that similarity may not always be so beneficial (e.g. Cooke, Kiekel, Salas, & Stout, 2003) and could even lead to the same bias as “groupthink” (Janis, 1972) where similarity discourages critical thinking and leads to an incomplete and flawed TSM (Houghton, Simon, Aquino, & Goldberg, 2000). There is evidence that it is important not to focus on shared information only, but to actively consider the differences between the information held by different team members (Mohammed & Dumville, 2001). From this point of view, team members need to have a general overlapping understanding of what is going on and which actions are required, but need individual, discipline-specific, accurate, and detailed information of their own to be able to establish their own responsibilities in a qualitative way. This is often referred to as a distributed situation model (Stanton, Salmon, Walker, & Jenkins, 2009). Furthermore, whether the TSM is completely shared or distributed and the extent to which the TSM contains the accurate representation of the facts that is needed to have a positive impact on team performance also needs consideration (Mathieu, et al., 2000; Mathieu, et al., 2008; Mohammed, et al., 2010;

Resick, Dickson, Mitchelson, Allison, Clark, 2010). The relation between the accuracy of cognitive structures and performance is evidenced by some researchers (e.g. Cooke, et al., 2001; Edwards, Day, Arthur, & Bell, 2006; Lim & Klein, 2006; Mathieu, Heffner, Goodwin, Cannon-Bowers, & Salas, 2005), but could not be confirmed in other studies (Mohammed, et al., 2010; Webber, Chen, Payn, Marsh, Zaccaro, 2000).

Since research on TSMs during task performance is scarce (with Cooke, et al. [2001] being an exception) and validated research instruments are missing, future research of the TSM requires the development and validation of an instrument measuring the task and team TSM. This measurement should give insight in both the similarity and accuracy of the TSM as a basic starting point for research that increases the understanding of the relation between team learning processes, TSMs, and team effectiveness. Understanding what is needed in TSMs might bring more focus to the team learning processes information sharing and co-construction and could authorize the use of constructive conflict and team reflexivity.

Finally, the model presented in this article as well as the results of future validation research are relevant input for training designers developing team exercises to prepare optional OSCT and emergency management team members for actual emergency management situations. Moreover, they can fuel the evaluation of emergency management teams after real incidents or training exercises. Evaluators can use the model to structure and analyze their observations in terms of the relevant (team learning) processes for transition and action phases. While emergency management evaluation reports nowadays often state, in general terms, that communication was a problem, future evaluation will be able to be more specific. It will, for instance, be able to say that there was enough sharing and co-construction of information, but that the team suffered from constructive conflict.