Computers in Human Behavior 27 (2011) 1103–1113

Contents lists available at ScienceDirect

Computers in Human Behavior

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

Mediating team effectiveness in the context of collaborative learning: The importance of team and task awareness

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ARTICLE INFO

Article history:
Available online 11 June 2010

Keywords:
Collaborative learning
Higher education
Awareness
Team effectiveness
Learning team

ABSTRACT

Learning teams in higher education executing a collaborative assignment are not always effective. To remedy this, there is a need to determine and understand the variables that influence team effectiveness. This study aimed at developing a conceptual framework, based on research in various contexts on team effectiveness and specifically team and task awareness. Core aspects of the framework were tested to establish its value for future experiments on influencing team effectiveness. Results confirmed the importance of shared mental models, and to some extent mutual performance monitoring for learning teams to become effective, but also of interpersonal trust as being conditional for building adequate shared mental models. Apart from the importance of team and task awareness for team effectiveness it showed that learning teams in higher education tend to be pragmatic by focusing primarily on task aspects of performance and not team aspects. Further steps have to be taken to validate this conceptual framework on team effectiveness.

1. Introduction

The use of collaborative learning is often based upon the social-constructivist paradigm that students should become involved in a process of knowledge construction through discussion, debate, or argumentation, which will result in deep learning, deep understanding, and ultimately conceptual change (Bereiter, 2002; Bruffee, 1993; Geelan, 1997; Smith, 2002). Within this paradigm, learners working with conceptual artifacts on the basis of an open assignment with built-in interdependency is considered conditional for meaningful participation in knowledge construction activities (Blumenfeld, Marx, Soloway, & Krajcik, 1996). The use of technology for implementing collaborative learning practices is widespread and when learning teams partly or exclusively communicate and discuss with each other online (either synchronously or asynchronously), collaborative learning is defined as computer-supported collaborative learning (CSCL). Learning teams that collaborate with the shared intention of achieving deep learning and conceptual change are considered to be effective learning teams (Salomon & Globerson, 1989). Team effectiveness is not only expressed by the quality of team outcomes, but also includes the quality of the team's performance, as well as the perceived satisfaction of the needs of individual team members (Hackman, 1990).

However, team effectiveness not only depends on task characteristics and shared intentions, but also by factors, such as team formation, team members' abilities and characteristics, role assignment within a team, decision making strategies of teams, team leadership, and interdependency. *Team formation* based on learner characteristics such as their learning strategies has proved either to be ineffective (Tongdeelert, 2004; Webb & Palincsar, 1996), or only partly effective when specific aspects of learning strategies and/or when students collaborate in pairs are considered (Alfonseca, Carro, Martín, Ortigosa, & Paredes, 2006; Paredes & Rodriquez, 2006). The fact that learning strategies are defined and operationalized in many different ways complicates the process of grouping learners for collaborative learning practices (Sadler-Smith, 1997). *Cognitive ability* of team members appears to positively affect team learning (Ellis et al., 2003), but learning teams usually are not composed on the basis of differences in the cognitive ability of the students. The assignment of *functional roles* to team members tends to increase the effectiveness of learning teams (Strijbos, Martens, Jochems, & Broers, 2004) for assigned teams, at-random formed teams and student-led formed teams (Wang & Lin, 2007). Team effectiveness can partly be predicted by the team members' *social skills* and *personality characteristics* (Baldwin, Bedell, & Johnson, 1997; Ellis et al., 2003; Halfhill, Sundstrom, Lahner, Calderone, & Nielsen, 2005; Morgeson, Reider, & Campion, 2005). Teams are also

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doi:10.1016/j.chb.2010.05.017

more effective if team members show *commitment* toward the team (i.e., the process) and towards the task (i.e., the product) (Hirokawa, Cathcart, Samovar, & Henman, 2003). The role of *leadership* in learning teams or problem-solving teams is unclear. Some researchers have found negative effects of leadership on team performance if learning and/or problem solving is the goal (Alper, Tjosvold, & Law, 1998; Cummings & Cross, 2003; Durham, Knight, & Locke, 1997; Johnson, Suriya, Won Yoon, Berrett, & La Fleur, 2002; Kayes, 2004) while others report positive effects on team efficiency in teams having appointed a leader or coordinator/planner (Henry & Stevens, 1999; Sivasubramaniam, Murry, Avolio, & Jung, 2002; Strijbos et al., 2004). Finally, team effectiveness was found to be enhanced when *positive interdependence* is strong (Gully, Incalcaterra, Joshi, & Beaubien, 2002; Katz-Navon & Erez, 2005; Shea & Guzzo, 1987).

Although learning-team effectiveness is influenced by many of these factors in both contiguous (i.e., face-to-face) collaborative learning as well as in CSCL, effects vary greatly according to contextual characteristics of a learning practice. There is a need for insight in the underlying factors that influence team effectiveness and how these factors are related to each other; regardless of the context of the learning practices. Establishing what these factors are offers opportunities to train learning teams on effectiveness before starting or during the start-up phase of a learning practice. As a result, effectiveness might improve both quantitatively and qualitatively. Existing frameworks on team effectiveness developed in the context of work teams in organizations are therefore not fully applicable for learning teams. A conceptual framework for learning teams collaborating in either a face-to-face or online way, based on those work team-effectiveness models, must be developed. This article describes the exploration of factors influencing team effectiveness of learning teams leading to a framework, as well as a test of this framework.

2. Constructing the conceptual framework

There is much research on teamwork and team effectiveness, though mostly related to production teams or work groups in organizations (Hackman, 1990; Halfhill et al., 2005; Shea & Guzzo, 1987; Stewart & Barrick, 2000). A problem here is that this research focuses on long-term teamwork, task-specific teamwork, aspects of leadership within teamwork, relations between teams and the organizations in which they are embedded, and effects of characteristics of work environments on team effectiveness of production teams, crisis teams or critical teams; aspects which are often not fully relevant in learning teams. Studies on effectiveness of learning teams often focus on one or more of these aspects and their possible effects on learning team performance, and often define team effectiveness differently (Barron, 2003; Fleming & Monda-Amaya, 2001; Henry & Stevens, 1999; Rulke & Galaskiewics, 2000; Salomon & Globerson, 1989). Definitions of effective learning teams by these researchers range from 'establishing a joint problem-space as a team' to 'goal attainment with respect to quality standards of the organization and satisfaction of team member's needs'. In other words, there appears to be no shared framework on what learning-team effectiveness is.

Another problem is that in most work team-effectiveness models, the teamwork itself is not specified, but only those factors that might promote effective teamwork or detract from it are explored (Brannick, Salas, & Prince, 1997; Gully et al., 2002). Furthermore, some researchers explore the dynamics of a specific kind of learning teams, for instance virtual learning teams, which makes it difficult to generalize the findings to learning teams operating in a face-to-face or in a blended context (Martins, Gilson, & Maynard, 2004; Warkentin & Beranek, 1999; Yoon, 2006).

Complicating the situation further is the fact that research on the influences on learning-team effectiveness is not always aimed at variables that can be controlled, but also on conditions or team inputs that cannot (Martins et al., 2004). Conditions or team inputs are for instance: team composition, member characteristics, team size, diversity, team potency, team efficacy, time constraints, and task characteristics. Those conditions are either fixed or can only partly be influenced as a result of institutional regulations and/or the type of students enrolled in a given program. In this study we focus on controllable variables influencing team effectiveness in the process of team collaboration. These variables will be explored in the next section.

2.1. Variables mediating team performance and effectiveness

Salas, Sims, and Burke (2005) developed a framework with the most important variables influencing teamwork. They called it 'The Big Five in teamwork', introducing five key factors influencing team effectiveness and three mechanisms that support and coordinate this. The five key factors are team leadership, team orientation, mutual performance monitoring, back-up behavior and adaptability. The supporting and coordinating mechanisms are shared mental models, mutual trust, and closed-loop communication. All variables and mechanisms are important for a work team to be successful, and probably actually develop during the timespan that a team executes a task, instead of 'being there' when a team starts. Salas et al. state that the Big Five are important only if the task a team has to carry out requires the commitment and participation of all members. In other words: team members must be highly interdependent (Wageman, 1995). In a true collaborative task, interdependence is implicit, as the task can only be completed successfully if team members can and must depend on each other. In this section we explore the five key factors and the three supporting and coordinating mechanisms within the perspective of their significance for learning teams.

The effects of *team leadership* on team effectiveness are widely studied in the research on teamwork in different settings and contexts, but the importance of *leadership* in learning teams is questionable (Johnson et al., 2002; Kayes, 2004). Effective learning in learning teams, especially in virtual learning teams, tends to benefit more from shared leadership than individual leadership. Learning teams relying too much on directive leadership tend to learn less because strong leadership leads to limited discussion. The effect of team leadership may also depend on the type of team and task at hand. Long-term work teams consisting of members with specific expertise to execute subtasks within the overall task obviously need directive leadership, especially if the task implies execution of specific subtasks in a strict order and/or addresses critical or life-threatening situations. This type of leadership might be defined as directive, and in cases of crisis teams or critical teams as 'commander-type' of leadership. In contrast, learning teams usually have a short lifecycle and can be characterized as democratic as a consequence of the expertise being distributed more equally within a team. Leadership in learning teams, if at all needed, will likely be of the coordinator-type, implying someone supervising the process. All team members are expected to participate equally in the process of knowledge construction through discourse and negotiation, so that leadership in terms of combining and synchronizing individual contributions, and ensuring that members understand their interdependence, is not crucial. Leadership will probably evolve as collective leadership, resulting in a team appointing some sort of coordinator, independent of whether it is face-to-face (Sivasubramaniam et al., 2002) or within the context of CSCL (Johnson et al., 2002). It is therefore hypothesized that team leadership is not critical for the effectiveness of learning

teams, except when critical moments appear (e.g., in the case of fast-approaching deadlines).

Team orientation is attitudinal in nature. It implies both a preference for working with others as well as a tendency to enhance individual performance through coordination and evaluation, and the utilization of task inputs from other members while performing group tasks. Teams could be characterized to the extent that team members value teamwork as enriching and necessary for the development of solutions to complex problems (Kasl, Marsick, & Dechant, 1997). Related terms are *collective orientation*, but this is usually focused on culture instead of context and implies the preference for accomplishing group goals rather than individual goals (Wagner, 1995), and *team cohesion*, which refers to the desire to work with a particular team, rather than to work in team settings. Team orientation is said to facilitate team performance through better decision making, resulting in increased cooperation and coordination among team members (Eby & Dobbins, 1997). As a result, team performance is facilitated through increased task involvement, information sharing, strategizing, and goal setting. The fact that team orientation is attitudinal makes it more difficult to influence and it probably is a result of team members' individual attitudes towards teamwork, and therefore depends on the team's composition. It is a condition that is difficult to control in the educational context, since students usually have no say in team formation and/or choice of assignments, and is therefore not a variable that could/should be influenced.

Communication is relevant in all stages of teamwork, not in the least for providing feedback on individual performance and task execution to regulate the teamwork and for deciding on resource allocation (DeShon, Kozlowski, Schmidt, Milner, & Wiechmann, 2004). This *mutual performance monitoring* implies being aware of and keeping track of one's fellow team members' work while carrying out one's own work to ensure that everything is running as expected and procedures are followed correctly. The more complex a task, which means the greater the number of elements and the higher the degree of interactivity between those elements (Sweller, 1994), the more important mutual performance monitoring will be, up to the point where complexity demands overall coordination of complex subtasks executed by sub-teams. If a task is stressful as a consequence of time constraints, mutual performance monitoring is conditional for the team's performance. However, in stressful situations with a team executing a complex task, mutual performance monitoring might not be enough and the need for team leadership probably becomes apparent.

To this end, mutual performance monitoring requires *awareness* of task and team aspects and therefore a shared understanding of both task and team responsibilities. Only then can it be expected that team members understand what other members are supposed to be doing. It also requires a dynamic type of awareness similar to the concept of situation awareness, which refers to acquisition and interpretation of information from the environment in order to update and monitor team performance (Endsley, 1995; Leinonen, Järvelä, & Häkkinen, 2005; Salas, Prince, Baker, & Shrestha, 1995). In that sense situation awareness is not only a prerequisite for mutual performance monitoring, it also guarantees its effectiveness. Additionally, without a shared understanding, feedback becomes inconsequential and monitoring becomes ineffective, which in turn results in low performance (Bolstad & Endsley, 1999; Stout, Cannon-Bowers, Salas, & Milanovich, 1999). Also, mutual performance monitoring implies 'participation awareness' and information about team members' activities to be exchanged within the team (Janssen, Erkens, Kanselaar, & Jaspers, 2007; Kreijns, Kirschner, & Jochems, 2003). Another important prerequisite is the existence of trust in a team because only in a climate of trust will members positively and constructively react to the feedback and/or critique of other team members. The concepts of shared understanding and trust will be explored later in this section. Since mutual performance monitoring is important for team performance and team effectiveness, it is hypothesized that mutual performance monitoring is also critical for team effectiveness of learning teams.

Back-up behavior is the ability to anticipate other team members' needs through accurate knowledge about their responsibilities, and includes the ability to shift the workload among members to achieve balance during periods of high workload or pressure (Salas et al., 2005). Adequately shifting the workload between members not only requires knowledge about who is supposed to do what, but also activity awareness (i.e., knowledge about who is doing what) which emphasizes the importance of activity context factors such as planning and coordination (Carroll, Neale, Isenhour, Rosson, & McCrickard, 2003). There are three ways of providing back-up (Marks, Mathieu, & Zaccaro, 2001): providing feedback and coaching to improve performance, assisting a teammate in performing a task, and completing a subtask for a team member when work-overload is detected. In this sense, back-up behavior has a direct influence on team performance. In a learning team, inadequate reasons for back-up behavior may appear that do not lead to increased team performance or increased team orientation. When someone takes over a subtask of a team member for reasons of a more personal character and not related to team goals, it may lead to fault-lines within the team and the forming of subgroups, especially when conflicts arise and team communication decreases (Molleman, 2005). In learning teams carrying out a collaborative task, back-up behavior is important, especially when interdependence is high. Team mates must back each other up to accomplish common goals. However, back-up behavior only becomes an issue during the productive phase of teamwork and is also difficult to influence given the fact that it is linked to team orientation and team members' individual attitudes. It is therefore hypothesized that back-up behavior can only be partly influenced in later stages of teamwork and for that reason it is less critical for teams to become effective in an early stage of teamwork.

Adaptability is the ability to adjust strategies based on information gathered from the environment through the use of back-up behavior and reallocation of intra-team resources, or altering a course of action or team repertoire in response to changing internal and external conditions (Salas et al., 2005). It is a team process that moves the team more effectively toward its objectives. This is different from simple flexibility since adaptation should focus on awareness of and assessing changes in the team's task or in the environment to determine if current strategies will be effective in reaching team objectives (i.e., both situation awareness and activity awareness). This implies that team members should have a shared understanding of the team objectives and of the most effective strategies for reaching them. They should also monitor the team's performance, as well as the performance of its members, to determine if the process is effective or whether adaptations are necessary. Adaptability is important to many types of teams in many situations, but defining the quality of the adaptation in a specific situation is difficult. Adaptability is important when learning teams carry out a collaborative task, especially when the task is complex and a team can choose between strategies to reach the objectives. However, since task characteristics are usually clear from the start of a learning practice and are not likely to change during the process of teamwork, adaptability will be less needed. Also, it is not very likely that changes in the environment will occur, except when authentic tasks are executed in real professional contexts in the perspective of an internship. The most likely changes that can be expected are changes in team composition and/or team members having problems in carrying out their subtasks. When this is the case, back-up behavior alone should be an adequate solution. It is therefore hypothesized that adaptability is not crit-

ical for team effectiveness of learning teams in early stages of team collaboration.

2.2. Supporting and coordinating mechanisms

Building *shared mental models* is considered a supporting and coordinating mechanism during teamwork (Salas et al., 2005). A number of studies have investigated the importance of building shared mental models in teams. Shared mental models are considered to be conditional for setting team goals, deciding on team strategies, allocating subtasks to team members, adequate monitoring of the team processes, and effective communication (Klimoski & Mohammed, 1994; Van den Bossche, Gijselaers, Segers, Woltjer, & Kirschner, 2010). Different concepts are used by different researchers with respect to shared understanding, for instance *team mental models* (Mohammed & Dumville, 2001), *shared mental models* (Stout et al., 1999), *common ground* (Beers, Boshuizen, Kirschner, & Gijselaers, 2006), or *synergistic knowledge* (Mu & Gnyawali, 2003). These concepts mainly refer to shared understanding on team level and could be defined as the awareness of team and task aspects in order to become effective as a team. This team and task awareness should be distinguished from 'knowledge awareness' which relates to the knowledge that team members have to offer and therefore to the individual, situational and team-related parts of shared understanding (Engelmann, Dehler, Bodemer, & Buder, 2009). To this end, a distinction can be made between team-related and task-related mental models and both types have been discussed in relation to work team performance (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000). In *team-related mental models*, the focus is on the awareness of team functioning and on the expected behaviors of both the team as a whole and the team members individually and in relation to each other. Knowledge awareness is considered to be an aspect of team-related shared mental models and conditional for effective coordination and communication, which in turn results in increased learning team performance (Engelmann et al., 2009). The focus in *task-related mental models* is on information regarding the materials and strategies needed to successfully carry out the task. Shared team-related and task-related mental models, or team and task awareness, facilitate task execution by creating a framework that promotes common understanding and action. This does not imply that all team members should have exactly the same understanding, because reaching that level of shared understanding would be very time-consuming and could lead to a reduction of those alternative perspectives and understanding needed to find new solutions to problems and new ways of executing a task (i.e., *groupthink*, Johnson & Weaver Ii, 1992; Jones & Roelofsma, 2000; Paulus, 1998). Each team member must have a mental model regarding task and team aspects similar to the other team members in order to effectively carry out the collaborative task as a team, and these mental models should be negotiated within a team. A sufficient level of dissimilarity is needed within a team regarding the cognitive domain in which the task is situated to improve the team's decision quality and team learning as a result of the input from different perspectives (Kellermanns, Floyd, Pearson, & Spencer, 2008; Van den Bossche et al., 2010). Being aware of differences between individual mental models, defined as knowledge awareness, positively effects team performance (Engelmann et al., 2009). Similarity and dissimilarity of mental models should be balanced during teamwork and the nature of this balance will probably be different in various stages of teamwork. Also, team members will update their shared mental models continuously during the process of teamwork. Being aware of team and task aspects and having a shared mental model becomes increasingly important as situations become more stressful, not in the least because communication tends to decrease in those situations. Findings suggest that teams engaged in high-quality planning in early stages of teamwork form better shared mental models during teamwork and perform better, especially when time is running out and situations become stressful (Stout et al., 1999). It is therefore hypothesized that generating shared mental models in early stages of teamwork is critical for the effectiveness of learning teams.

The importance of *mutual trust* for a team to become effective has been studied in a variety of contexts and types of teamwork (Castleton_Partners/TCO, 2007). Without sufficient mutual trust, team members spend too much time and energy protecting, checking, and inspecting each other and each others' behaviors, and too little time constructively collaborating. Mutual trust implies the shared perception that individuals in the team will perform particular actions important to its members and will recognize and protect the rights and interests of all team members. In situations of mutual trust, team members are willing to share information freely and feel safe to do so (Nelson & Cooprider, 1996). For that reason mutual trust is probably also conditional for building shared mental models since it requires team members sharing information without reservation. If team members work interdependently, they have to accept a certain amount of risk accompanying relying on each other to meet deadlines, contributing to the task, and cooperating without subversive intentions. It is hypothesized that mutual trust is a critical condition for team effectiveness in all stages of teamwork, and especially from early stages on.

The final supporting and coordinating mechanism for work team performance and work team effectiveness is communication (Salas et al., 2005) which should be of a closed-loop character. *Closed-loop communication* defined as the exchange of information between a sender and a receiver, irrespective of the medium, involves the sender initiating the message, the receiver receiving the message and acknowledging its receipt, and the sender verifying that the receipt-message was received and that the content and meaning was understood as intended. This communication facilitates updating the team's shared mental models, and therefore the awareness of team and task aspects. When the environment increases in complexity, communication becomes more important. In such situations closed-loop communication ensures that sent communications are correctly understood.

Communication refers not only to the quality of communication in the perspective of collaborative learning outcomes and/or task execution, but also to the modes of communication. Several studies report no significant differences between computer mediated communication (CMC) and face-to-face communication regarding the outcomes of the process of collaborative learning (Fjermestad, 2004; Ocker & Yaverbaum, 1999). A review of studies on CMC revealed that the effectiveness of CMC also relies on the context and task characteristics (Luppicini, 2007), but there are no reasons to suggest that a specific mode of communication is conditional for team effectiveness. Providing relevant information and supporting awareness by using adequate awareness devices for building a shared understanding leads to the improvement of team performance and emphasizes the importance of the quality of communication in computer-supported collaborative work (Fussell et al., 1998).

The purpose of team communication is twofold, namely building both shared mental models and the interpersonal relations within a team. Research showed that the combination of both social and cognitive factors are conditional for effective team learning (Van den Bossche, Gijselaars, Segers, & Kirschner, 2006). The importance of communication, more specifically the emotional investment through social interaction on team effectiveness was also found in a study on the role of social exchange (Saavedra & Van Dyne, 1999), though some reservations should be made here, since too much emotional exchange may lead to less effective teams as a result of narrowing the range of accepted ideas (Guzzo

& Waters, 1982). Although the importance of closed-loop communication for team effectiveness is clear, measuring the occurrence of closed-loop communication during teamwork does not indicate the level of effectiveness, since only what is communicated when and for what purpose matters. In that sense the effectiveness and adequateness of closed-loop communication is mediated through the quality of shared mental models, mutual trust and mutual performance monitoring, and therefore through the quality of team and task awareness.

3. Completing and testing the conceptual framework: hypotheses

Combining the aforementioned, the conceptual framework used here can be described as follows (see also Fig. 1): shared mental models, mutual trust, and mutual performance monitoring are key variables during all stages of teamwork in learning teams, and closed-loop communication is an important underlying condition. Team orientation and team leadership are not key variables in the context of learning teams. Back-up behavior and adaptability are also not key variables, although they could become important during later stages of teamwork of learning teams.

In the proposed model, mutual trust is an intermediate variable and related to both the team and the task. At the team level (i.e., social dimension), mutual trust focuses on protecting the interests of all members and performing actions important to all members. At the task level (i.e., cognitive dimension), mutual trust is focused on sharing information and feeling free to do so. Mutual trust is conditional for adequate mutual performance monitoring and for preventing the misinterpretation of mutual performance monitoring. In learning teams lacking mutual trust, mutual performance monitoring is likely to shift from exchanging relevant information about team aspects and task aspects to spending time checking each other's performance, discussing conflicts, and protecting each other's interests. Also, in learning teams with low levels of mutual trust, members will tend to communicate more with preferred teammates and less with the team as a whole. The perception of trust at the team level is related to the concept of *psychological safety* (Edmondson, 1999), since team members must feel safe in order to freely exchange information. In that sense, all members should share the same understanding regarding the characteristics of psychological safety in the team.

Hypothesis 1: The perception of mutual trust (or psychological safety) is conditional for effective mutual performance monitoring in learning teams.

Shared mental models are also considered an intermediate variable in the proposed model. Without shared mental models of team and task characteristics, communication will not develop towards an open exchange of views leading to the emergence of solutions. Shared mental models are also conditional for adequate mutual performance monitoring, because all members' performances need to be interpreted within the same shared perspective; that is the awareness of team aspects and task aspects, requiring team members to make use of the same knowledge about the team and the task at hand.

Hypothesis 2: Shared mental models at the team level as well as at the task level are conditional for effective mutual performance monitoring in learning teams.

Finally, mutual performance monitoring is seen as an intermediate variable. To adequately monitor the performance of one's team members, information must be freely shared within the team and team members must be aware of contextual conditions and changes in the environment, task aspects and goals, distribution of subtasks and roles within the team, and possible time constraints. As a consequence, mutual performance monitoring should result in effective task execution in relatively stable situations, provided that changes in environmental demands as well as workload distribution problems do not occur.

Hypothesis 3: Mutual performance monitoring is a predictor of learning-team effectiveness in cases when changes in environmental demands and workload distribution problems do not occur.

The outcome, and thus the dependent variable in the proposed model is team effectiveness. To this end, Hackman's definition of group effectiveness (1990) is used, which distinguishes between group performance, satisfaction of group members, and the ability of a group to exist over time. Although the latter is not particularly relevant in the educational context (i.e., learning teams usually exist over short, fixed periods of time and new teams with different

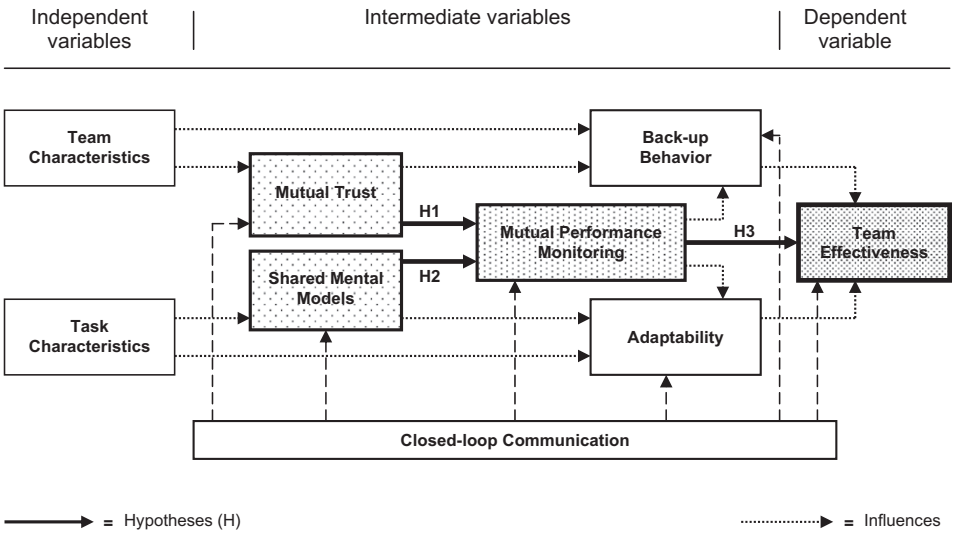

Fig. 1. Independent and intermediate variables, dependent variable, influences and hypotheses.

composition are usually formed for new assignments) expressing a willingness to collaborate again within the same team can be seen as a measure of how the team members perceive the effectiveness of the team. Team effectiveness includes the quality of the team's performance as well as the perceived satisfaction of individual needs of team members. This definition addresses team effectiveness at the team level (i.e., performance) and at the individual level (i.e., team member satisfaction), emphasizing that in teamwork, team goals and individual goals should merge, or at least should be well balanced, if a team is to be effective (Kasl et al., 1997). At the team level, effectiveness is expressed through the quality of performance, which in itself includes quality of the product and of the process. *Product quality* in the educational context is usually expressed through grading and often refers to the quality of the product and whether a preset deadline has been met. *Process quality* refers to the balance between time and materials invested versus the outcomes achieved as a result of that balance (i.e., efficiency). It also refers to the quality of the collaboration, which is the effective use of a team's expertise and capacity, along with smooth processes of negotiation, decision making and performance monitoring in the team.

Connections between the independent variables, intermediate variables, and dependent variable are shown in Fig. 1. Matching hypotheses are added with corresponding numbering.

To establish the validity of this model an experiment was carried out.

4. Method

4.1. Participants

Students (N = 116) from the Initial Teacher Training Program of a large Dutch university working on a computer-supported collaborative exercise in their fourth and final study year participated in this study. The learning task was called '*Schools Are Made by People*' in which teams had to design a new primary school for which they will be the staff. In this way they experience what it means to be a member of a school organization. Being a team, they develop the school's organizational and pedagogical policy and during this process are confronted with problems that schools normally have to deal with. The exercise takes 10 weeks to finish and is concluded by producing a written policy paper and a website, followed by an oral presentation to an educational inspector. The teams communicated face-to-face and online, and a virtual learning environment (*Mensen Maken Scholen*), specifically designed for this assignment, was used for exchanging work-in-progress, peer feedback, and publication of results (Vreugdenhil, Moors, & Van der Neut, 2004).

The 116 students were divided over 9 teams ranging from 8 to 16 members each, strongly resembling real team sizes of school teams in smaller primary schools in the Netherlands. Every student operated as a member of this team, but collaborated more intensely in smaller sub-teams in committees determining specific parts of the school's policy. The teams had not worked in the same composition before, although every student had previously collaborated with one or more of the other team members on assignments in preceding years. This means that in order to function effectively all teams needed to develop both team skills and task skills. Eight teams were composed exclusively of students coming from either the full-time program or the part-time program, and one team contained a mixture of students from both programs. Students were informed about the research project and all agreed to cooperate.

4.2. Instrumentation

A questionnaire containing 20 items formulated as statements on a 7-point Likert scale (ranging from 'completely disagree' to 'completely agree') was developed for determining the degree of mutual trust, shared mental models, mutual performance monitoring, and team effectiveness. Three items were reversed, and almost every item stems from instruments used and validated in other studies, but slightly adapted to fit the specific context of this study. The questionnaire can be found in Appendix A.

Since no direct measure was found for perception of mutual trust, some items from the 'Psychological Safety' scale in the 'Team Survey Questionnaire' (Edmondson, 1999) were used, augmented with two items derived from the criteria on swift trust/deeper trust in the Scoping Study Report from the Emergency Capacity Building Project (Castleton_Partners/TCO, 2007). Mutual trust is assumed to be related to the concept of 'psychological safety' in the sense that psychological safety is more or less conditional for mutual trust to emerge in a team. The internal consistency was acceptable (Cronbach's α = .68).

Perception of shared mental models was determined through the use of a number of items extracted from the section 'Clear Direction' of the 'Team Survey Questionnaire'(Edmondson, 1999), and from the 'Team Learning Beliefs & Behaviors – Questionnaire' (Van den Bossche et al., 2006). One item was added, derived from criteria on swift trust/deeper trust in the Scoping Study Report from the Emergency Capacity Building Project (Castleton_Partners/TCO, 2007), focusing on the team's vision on roles of members. Internal consistency was high (Cronbach's α = .81).

Since mutual performance monitoring aims at improvement of team effectiveness and the quality of results, it is related to the concept of *team learning behavior*. Perception of team learning behavior was measured by using two items from the 'Team Learning Behavior' scale of the 'Team Survey Questionnaire' (Edmondson, 1999).

Mutual performance monitoring becomes more important as interdependence increases. Teams scoring low on perceived interdependence will probably have less reason to frequently communicate on team and task aspects. Measuring perception of interdependence is necessary to corroborate the findings on the other two items on *team learning behavior*, resulting in a deeper insight in mutual performance monitoring. To this end, three items were used from the 'Team Learning Beliefs & Behaviors – Questionnaire' (Van den Bossche et al., 2006). The internal consistency of the resulting five item scale on mutual performance monitoring was sufficient (Cronbach's α = .68).

Perceived team effectiveness was measured by using three items previously used in studies on team effectiveness (Chang & Bordia, 2001), and which were also used in the 'Team Learning Beliefs & Behaviors – Questionnaire' (Van den Bossche et al., 2006). Although the existence of a team over time is not an issue in this particular context, the perception of team members of the ability of their team to exist over time might be an indication of team effectiveness, even if the team is dismantled after completing the assignment. The internal consistency was strong (Cronbach's α = .83).

A principal component analysis showed the complexity of the construct of mutual trust, resulting in deletion of one item and the shift of three items from the trust scale to the shared mental models scale and the mutual performance monitoring scale. The resulting mutual trust factor focused more on aspects of the resulting trusting behavior. Kaiser–Meyer–Olkin measurement showed acceptable results (KMO = .78) and Bartlett's test was significant (p < .001), indicating that results of the factor analysis may be interpreted (Field, 2005). Scores on original scale as well as the resulting factor of the principal component analysis will be used in the data analysis.

4.3. Procedure

The questionnaire was presented within 2 weeks of the deadline for delivering the final products. This choice of delivery mo-

ment was based on the assumption that all teams would have reached the final productive phase by that point, but that perceptions about team effectiveness would not be biased by grading and/or a premature onset of team dismantling. The questionnaire was distributed and collected during a regular meeting with the tutors, resulting in a high response rate (90%). Students were informed that anonymity would be assured and that responding would not influence their grade.

4.4. Method of analysis

Regression analyses were performed to test the hypotheses and to identify the nature of the effects of intermediate variables on team effectiveness. Intra-class correlation coefficients were calculated. However, only two of the four variables were significant (i.e., mutual performance monitoring and team effectiveness) and showed a group effect. For this reason and also due to the small number of teams multilevel analyses were not performed (Cress, 2008).

First, effects of mutual trust and shared mental models on mutual performance monitoring were analyzed in simple regression analyses. Additionally, stepwise multiple regression analyses were carried out to test influences of all intermediate variables on team effectiveness. All residuals were inspected. Regression analyses were also performed with data aggregated on team level to confirm the findings or to identify significant differences in outcomes.

Additionally the re-designed model was tested through Structural Equation Modeling using AMOS 7.0 (Arbuckle, 2006). Results from maximum likelihood estimation were used. The Chi-square statistics, as well as the values of the Root Mean squared Residual (RMR), with values <.05 indicating a good fit, the Root Mean Squared Error of Approximation (RMSEA), with values <.05 indicating an excellent fit, and the Adjusted Goodness of Fit Index (AGFI), with values >.90 indicating a good or excellent fit, were examined.

5. Results

No significant effect of mutual trust ($M = 5.27$, $SD = .90$) on mutual performance monitoring ($M = 5.36$, $SD = 1.19$) was found and as a result hypothesis 1 was rejected.

A significant effect of shared mental models ($M = 5.21$, $SD = .95$) on mutual performance monitoring was found ($\beta = .268$; $R^2 = .072$; $p < .05$) which did not change when mutual trust was added to the model. Therefore hypothesis 2 was accepted, although the effect is considered limited.

These findings are supported by results of the analysis of the effect of mutual performance monitoring on team effectiveness ($M = 5.77$, $SD = .98$), which is also limited ($\beta = .264$; $R^2 = .069$; $p < .05$). Hypothesis 3 is accepted, but the findings suggest that mutual performance monitoring contributes to team effectiveness in a limited way. A considerable effect of shared mental models on team effectiveness was found ($\beta = .622$; $R^2 = .380$; $p < .001$), suggesting that shared mental models are more important than mutual performance monitoring for a team to become effective. Since the correlation between mutual trust and shared mental models was significant ($r = .631$), an additional regression analysis was executed to explore the effect of mutual trust on shared mental models. The results showed a substantial effect ($\beta = .631$; $R^2 = .392$; $p < .001$), which emphasized that mutual trust appears to be conditional for shared mental models to emerge in a team, and supported the assumption that the effect of mutual trust on mutual performance monitoring might be mediated through shared mental models. Table 1 shows the results of the separate regression analyses.

A stepwise regression analysis exploring partial effects of intermediate variables on team effectiveness, as well as the overall effects of the intermediate variables on team effectiveness confirmed the major effect of shared mental models on team effectiveness, since the effects of mutual trust and mutual performance monitoring on team effectiveness became insignificant when shared mental models was entered in the model. The effect of mutual trust on team effectiveness is, thus, mediated through shared mental models. The effects were analyzed on the whole sample as well as at team level. Since the results were similar, further analysis of the data at team level was not carried out.

Regression analyses performed on the factors produced by the principal component analysis confirmed the importance of shared mental models, although its effect was partly mediated through mutual performance monitoring (Table 2).

The results of the regression analyses require a re-specification of the model, showing a change in position of mutual trust which does not directly predict effective mutual performance monitoring and team effectiveness. See Fig. 2 for the adjusted model (i.e., core aspects of the conceptual framework) and effect sizes based on the factors of the principal component analysis.

Testing this model with AMOS 5.0 confirmed the findings of the regression analyses and the likeliness of the re-designed model ($\chi^2 = 3.681$ with $p = .159$ and $\chi^2/df = 1.841$, RMR = .057, RMSEA = .090, AGFI = .914). Results from the structural equation modeling show a possible fit of the model to the data (Kelloway, 1998).

6. Conclusion and discussion

Findings in this study support the assumption that learning teams perceive themselves as more effective when shared mental

Table 1
Results of separate regression analyses.

	Shared mental models	Mutual performance monitoring	Team effectiveness
Mutual trust	$\beta = .631$; $t = 8.210$; adj. $R^2 = .392^{**}$		
Shared mental models		$\beta = .268$; $t = 2.812$; adj. $R^2 = .072^{*}$	$\beta = .622$; $t = 8.016$; adj. $R^2 = .380^{**}$
Mutual performance monitoring			$\beta = .264$; $t = 2.759$; adj. $R^2 = .069^{*}$

* $p < .05$.
** $p < .001$.

Table 2
Results of stepwise regression analysis on factors from principal component analysis.

Model (+ adjusted R^2)		Team effectiveness
1. (Adj. $R^2 = -.007$)	Mutual trust 'factor' (trusting behavior)	–
2. (Adj. $R^2 = .410$)	Mutual trust 'factor' (trusting behavior)	–
	Shared mental models 'factor'	$\beta = .690$; $t = 8.549^{**}$
3. (Adj. $R^2 = .486$)	Mutual trust 'factor' (trusting behavior)	–
	Shared mental models 'factor'	$\beta = .512$; $t = 5.859^{*}$
	Mutual performance monitoring 'factor'	$\beta = .342$; $t = 3.994^{*}$

* $p < .05$.
** $p < .001$.

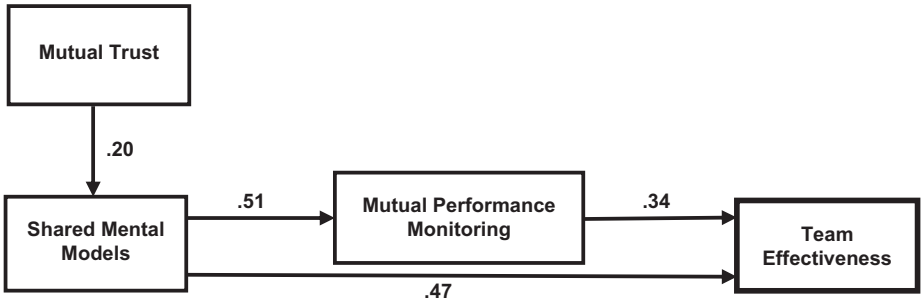

Fig. 2. Effect sizes on the basis of factors from the principal component analysis and consequences for the model regarding influences on team effectiveness.

models increase and mutual performance monitoring is adequate. In other words, learning teams need to be aware of team and task aspects in order to become effective. Although adequate mutual performance monitoring is important, the basis lies with building shared mental models and continuously updating of those models during the collaboration process. It is interesting to note that the effect of mutual trust on mutual performance monitoring and team effectiveness is not significant, though trust seems to be conditional for building shared mental models.

A noteworthy result is that psychological safety does not seem to be as similar to mutual trust as originally thought. Psychological safety might better be interpreted as conditional for the creation of mutual trust in a learning team and as such, defined as the 'initial interpersonal trust' necessary for developing shared mental models, and thus, for team maturation. The concept of 'initial interpersonal trust' is similar to the concept of 'swift trust' (Castleton_Partners/TCO, 2007) which means that the level of initial trust in teams might be measured in early stages of teamwork by investigating aspects related to swift trust. Deeper levels of trust are more likely to emerge during the team's maturation, leading to increased effectiveness. Mutual trust, in that sense, is more an aspect of an effective learning team after successfully completing a task.

The results regarding mutual trust also emphasize the complexity of trust as a construct (Watson, 2005). Trust appears to be a multidimensional construct, reflected by the abundance of research-based concepts such as calculus-based trust and identification-based trust (Lewicki & Bunker, 1996), trustworthiness and trusting behavior (Tanis & Postmes, 2005), swift trust and deeper trust (Castleton_Partners/TCO, 2007), or affect-based trust versus cognition-based trust (McAllister, 1995). Some research also suggests that trust may be context-dependent (Olekalns, Lau, & Smith, 2007), which means that operationalizing it would depend on the context in which it needs to be developed. Given this probable context-specificity of trust, our findings suggest that the effect of trust on learning-team effectiveness is negligible, and only a limited effect of swift trust can be expected. This specific type of trust could be defined as cognitive-based trust (Greenberg, Greenberg, & Antonucci, 2007). These findings are similar to findings in research on trust in virtual teams where trust was mainly based on 'perceived ability and integrity' and did not significantly influence team performance, but the existence of initial trust appeared to result in teams suffering fewer 'process losses' and in collaborating more effectively as a result (Aubert & Kelsey, 2003). Further research using a longitudinal design and an emphasis on qualitative measurements is necessary to confirm these assumptions and investigate the complexity of mutual trust in learning teams.

The need for initial interpersonal trust, and more specifically mutual expectations about team member reliability on the task-level, supports the assumption that learning teams act pragmatically. These teams must deliver results in short periods of time, they often experience competition with other tasks that must be carried out in other courses during the same period, and they are usually dismantled after the assignment is completed. This pragmatic approach is strengthened by grading, since students tend to focus on getting good grades and preferably with minimal effort (Mao & Zakrajsek, 1993). Focusing on the task aspects of performance is by far the most efficient choice in such circumstances. This has been demonstrated in studies on short-term teams (Bradley, White, & Mennecke, 2003; Druskat & Kayes, 2000), where teams tend to redirect conflicts to the task-level, hoping that they can be easily and efficiently solved. Research on virtual teams showed that lack of trust and redirecting conflicts to the task-level resulted in an increase in 'process losses' and in teams needing more time to deliver results (Aubert & Kelsey, 2003). These interpretations were presented to the students who participated in the research in a plenary debriefing session. In that session, students stated that their shared mental models and awareness were primarily task-based, although teams also reported that knowing each other better sped up the process of building shared mental models and of reaching agreement on goals and strategies. Students admitted that this pragmatic stance, though understandable and not always effective, is not perceived by them as exceptional in practices of collaborative learning.

The finding that the effect of shared mental models was more important than mutual performance monitoring on perceived team effectiveness might be explained by the fact that teams used inadequate procedures and methods for monitoring and giving feedback. Students in the plenary debriefing session reported missing a 'quality watchdog' in their team or having not agreed on how to use the virtual learning environment for performance monitoring and feedback processes, on who delivers feedback when and in what way, and how to deal with it accordingly. Also, agreements on deadlines were not properly made or maintained. This lack of good procedures for mutual performance monitoring seemed to be partly compensated by awareness of team and task aspects in the initial stages, that is the presence of sound shared mental models, suggesting that when team members initially know what to do, how to do it, and who can do what, consultation and discussion during collaboration can be minimized. This also saves time, which is likely to be attractive since the teams have time constraints. To this end, roles within the learning team could be assigned (i.e., by the tutor or by the team itself) to facilitate and support effective mutual performance monitoring. Scripting of the monitoring procedures could enhance this even further (Gweon, Rosé, Carey, & Zaiss, 2006; Järvelä, Näykki, Laru, & Luokkanen, 2007; King, 2007). Research on assigned or acquired roles within learning teams in CSCL showed positive effects on team effectiveness (Kollar, Fischer, & Hesse, 2006; Schellens, Van Keer, & Valcke, 2005; Strijbos, Martens, Jochems, & Broers, 2007).

The limited effect of *mutual performance monitoring* on perceived team effectiveness might be the result of how mutual performance monitoring was operationalized. This was also indicated by the principal component analysis, since items loading on the factor identified as *mutual performance monitoring* differed in some respects from items in the original scale. Probably a distinction should be made between 'explicit performance monitoring' and 'implicit performance monitoring'. Explicit performance monitoring is expected as a result of shared mental models and agreements on performance monitoring on quality control, and effectuated by team communication. Implicit performance monitoring can be defined as team members taking action without concomitant communication as a result of the perception of the awareness of the current team situation at a specific stage in the process. In the latter case team members dynamically adjust their behavior as a result of anticipation and on the basis of the team's situated cognition and shared mental models, in other words the situated awareness of team and task aspects. This specific type of monitoring is also called 'implicit coordination' (Rico, Sánchez-Manzanares, Gil, & Gibson, 2008) and holds that a team is likely to show implicit coordination if all team members share a dynamic and accurate understanding of a current situation and know what has to be done. It is possible that we measured aspects of 'explicit coordination' while teams were more involved in 'implicit coordination'. The importance of situated cognition, team mental situations, and implicit coordination as described by Rico et al. (2008) in learning teams, might be worth investigating, probably also through analyzing video registrations of teams in action.

The results of this study support the existence of the intermediate variables in our conceptual framework and for their influences on perceived team effectiveness, although effect sizes and directions seem to differ from expected sizes and directions. It should be emphasized that we used perceived team effectiveness and did not measure team effectiveness directly by testing learning outcomes and/or grading by the teachers. There were two major reasons for this, both seated in the fact that the assignment was a real one in an ecologically valid educational setting. First, the researchers did not have access to the products that teams delivered and therefore analysis and assessment of learning outcomes could not be carried out. Second, there were no unequivocal assessment criteria for the learning task, and six different teachers assessed the products, with each team assessed by only the teacher assigned to the team. This made grading highly subjective and uncontrollable and was thus rejected as reliable data to determine whether perceived team effectiveness correlated with actual team effectiveness. Future research should focus on direct measurements of team effectiveness, for instance by measuring the quality of the learning outcomes of CSCL. Nevertheless, it may be assumed that investing in the creation and strengthening of interpersonal trust and shared mental models on the task-level are important for team effectiveness, as is the team's investment in adequate monitoring and feedback procedures. Shared mental models seem to be the most important variable, which means that supporting its development in early phases of teamwork is probably the most important intervention to perform in order to establish sufficient levels of team and task awareness in the early stages of teamwork in computer-supported collaborative learning.

Appendix A

Questionnaire for measuring the perceived learning-team effectiveness and conditions of the mediating variables shared mental models, mutual trust, and mutual performance monitoring, as well as the perceived interdependence.

Questionnaire for measuring learning-team effectiveness and mediating variables

Shared mental models

1 It was clear from the beginning what this team had to accomplish
2 This team spent time making sure every team member understands the team objectives
3 Group members understand what is expected of them in their respective roles
4 Shortly after the start this team had a common understanding of the task we had to handle
5 Shortly after the start this team had a common understanding of how to deal with the task

Mutual trust

6 In our team we can rely on each other to get the job done
7 Members of this team are able to bring up problems and tough issues
8 People in this team sometimes reject others being different (reversed)
9 Working with members of this team, my unique skills and talents are valued and utilized
10 It is difficult to ask other members of this team for help (reversed)
11 Group members keep information to themselves that should be shared with others (reversed)
12 No one in this team would deliberately act in a way that undermines my efforts

Mutual performance monitoring

13 We regularly take time to figure out ways to improve our team's work processes
14 In this team, someone always makes sure that we stop to reflect on the team's work process
15 My team members depend on me for information and advice
16 I depend on my team members' information and advice
17 When my team members succeed in their jobs, it works out positively for me

Team effectiveness

18 I am satisfied with the performance of my team
19 We have completed the task in a way we all agreed upon
20 I would want to work with this team in the future

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