Training Collaboration for an Army Digital System

Martin Bink
U. S. Army Research Institute
Fort Benning, GA
Martin.Bink@us.army.mil

ABSTRACT

Command Post of the Future (CPOF) is a collaborative battlefield-visualization and decision-making tool based on the construction, display, and sharing of tactical "products" among distributed decision makers. The use of CPOF allows command and control (C2) activities to be more interactive, adaptive, and grounded by rich visualizations. Recent research indicates that CPOF collaborative skills are more perishable than other CPOF skills and that the difficulty in training collaborative skills may limit the utilization of CPOF's full capabilities. In order to successfully train the skills necessary to effectively employ CPOF, it is essential to understand the capabilities of CPOF that allow for the execution of critical collaborative tasks. A taxonomy of CPOF collaborative capabilities was created, and task-oriented models of collaboration requirements in C2 activities (e.g., battle tracking) were developed. A framework of collaboration was then applied to align CPOF collaborative capabilities with the C2 collaboration requirements. The results were used to define procedures to better utilize CPOF for collaborative activity and to identify methods to develop collaborative skills in the context of CPOF training. From these results a set of guidelines was developed to assist CPOF trainers in developing training content. These guidelines will assist trainers to further develop collaborative CPOF skills, and the end result of this training should be an increase in the utilization of CPOF functionality.

ABOUT THE AUTHORS

Dr. Martin Bink is a Senior Research Psychologist at the U.S. Army Research Institute for the Behavioral and Social Sciences – Fort Benning (ARI). Dr. Bink holds a Ph. D. in Cognitive Psychology from The University of Georgia. Dr. Bink previously was on the faculty at the University of North Texas and at Western Kentucky University. He also completed a two-year research fellowship for the National Research Council at NASA – Ames Research Center. His research interests are in human learning, memory, and cognition especially as applied to education and training, and he has published many professional articles in those areas. Dr. Bink has worked for ARI for four years with research focus on digital-skills training and adaptive training methods.

Training Collaboration for an Army Digital System

Martin Bink
U. S. Army Research Institute
Fort Benning, GA
Martin.Bink@us.army.mil

INTRODUCTION

The next generations of command digital systems (e.g., Command Post of the Future) will allow and require Soldiers to virtually collaborate on a number of operational tasks. As a consequence, staff and Leaders must not only learn to operate the systems (i.e., hardware and software) but also develop a set of skills specific to collaboration in order to optimize the use of command digital systems during combat operations. Ostensibly, command-digital-systems training and collaboration training should be integrated. The effectiveness of integrated training depends, in large part, on structuring the learning context in a way that effectively utilizes the to-be-developed skills (Bransford, Vye, Kinzer, & Risko, 1990; Brown, Collins, & Duguid, 1989). However, not enough is known about the nature of collaboration skills or how those skills can be taught in conjunction with training command digital systems to provide guidance for the needed integrated training. The purpose of the research reported here was to develop a framework to integrate training of collaboration and command-digital systems in an operationally-relevant context. This framework can then be applied to the construction of new training materials in order to optimize digital-systems training.

The command digital system chosen was Command Post of the Future (CPOF) because it is a command digital system currently used in command posts to support and execute several command and control (C2) activities at Brigade and Battalion levels. What is more, CPOF is a battlefield-visualization and decision-making tool based on the construction, display, and sharing of tactical "products" among distributed decision makers. CPOF is grounded by rich visualizations of current and archived battlespace information to better help describe and make decisions about a complex and dynamic operational environment. Even though the use of CPOF allows C2 activities to be more interactive and adaptive, the skills required to collaborate with CPOF are more complex and are more difficult for new users to retain than other functional CPOF skills (Bink, Wampler, & Cage, 2011; Catrambone, Wampler, & Bink, 2009). In addition, the CPOF classroom typically includes the range of individuals across C2 activities. That is, a CPOF classroom can be composed of individuals with varying levels of technical expertise and military expertise from the Specialist, whose job it is to operate CPOF, to the Non-commissioned Officer or the Battle Captain, whose job it is to track the battle or to produce a battle update brief or commander's update brief to the Brigade or Battalion commander, whose job it is to use CPOF in decision making. As a result of all of these CPOF characteristics, it appears that, in order to successfully train the skills necessary to effectively employ CPOF, it is essential to understand how CPOF functional teams collaborate among individuals with varying levels of expertise and in the context of executing critical C2 activities.

In order to build a framework of integrated training for CPOF, a socio-technical system explanation is offered for the integration of collaboration skills and CPOF digital-system skills. Socio-technical systems are defined as the complex interactions among individuals using technology in order to build and share knowledge (Bink & Beyerlein, 2007). The use of command digital systems to execute C2 activities can be defined as a socio-technical system. The term, "socio-technical" is hyphenated to emphasize the interdependence of the intellectual and social systems with the technology that facilitates the activity or the interactions. The social and technical systems are interdependent insofar as the extent to which collaborations achieve intellectual goals depends on the efficacy of technical skills. The goal of a socio-technical system is to leverage technology to create a network that allows open sharing, creative synthesis, consensus decision making, and social constructions of learning practices (Yang & Chen, 2008). C2 activities such as the military decision making process (MDMP) require individuals who may be spatially distributed to share information and build consensus through the technologies of command digital systems. As a consequence, the ability to execute MDMP depends on the ability to master digital skills and to collaborate. CPOF socio-technical skills represent the degree to which collaboration procedures (e.g., Cloning and Mirroring) and collaborative technology (e.g., voice-over-internet communication,

Share Tree, etc.) are leveraged for interaction during C2 activities such as MDMP.
Socio-technical systems must rely on information technology to interact because people are spatially and/or temporally dispersed. The ways in which information technology is used to achieve collaborative interaction define the socio-technical environment by providing the "physical" support for collaboration and by structuring the possible interactions (e.g., (Blackburn, Furst, & Rosen, 2003). Information technology provides the social-intellectual environment not only by serving as the communication environment but also by serving as a mechanism to enhance both social and intellectual processes (Bink & Beyerlein, 2007; Jermann, Soller, & Lesgold, 2004). Ways in which the technological environment can enhance social and intellectual processes include supporting the understanding of trust among group members, supporting implicit knowledge of the group, and facilitating informal interactions (Bink & Beyerlein, 2007). Most importantly, the technology must be seamless in the interactions within the group in order to maintain focus on collaboration and not the technology. People in a socio-technical system will consider the constraints of the technology and structure interactions to match those constraints (see Kirschner, 2005, for a partial review) and will build necessary interactions using the affordances of the technology (e.g, Dwyer and Suthers, 2006). As a result, it appears that effective socio-technical interactions are defined by the degree to which a group utilizes the affordances of the available information technology to (a) build relationships, (b) share understanding, and (c) coordinate action (Beyerlein, et al. 2008; Dwyer & Suthers, 2006; Nemiro, 2007; Salas & Cannon-Bowers, 2000).

Socio-technical Skills

Build Relationships. Relationship building allows communication and information exchange and promotes the organizational development of the socio-technical system (Beyerlein, et al., 2001). Individuals must be able to confidently rely on the interpersonal and technical competencies of others in the socio-technical system to produce the desired outcomes. Organizational and interpersonal trust builds cohesion in the socio-technical system.

Share Understanding. In order to optimize the intellectual input of all individuals, the socio-technical system must integrate knowledge and skills into a co-generated solution. Shared understanding in socio-technical systems encompasses a continual cycle of knowledge transfer, knowledge integration and feedback and becomes new knowledge and understanding (Salas & Cannon-Bowers, 2000). Individuals in the socio-technical system need to seek feedback and to give feedback about the level of shared understanding.

Coordinate Action. The distributed nature of activities in socio-technical systems requires that decisions be made about who will execute a given task, that information and resources are provided to the appropriate person, and that evaluations are made about the execution of tasks (Bearman, et al., 2010). Socio-technical systems must also develop methods to clarify ambiguity and to co-reference information in order to coordinate action (Barron, 2000).

In addition to these interpersonal skills that give rise to socio-technical interactions, socio-technical systems must use technology to manage the types of interactions. As previously mentioned, interactions in socio-technical systems occur across space and time (i.e., same place and same time, same place and different times, different places and same time, and different places and different times). This means that socio-technical interactions are both synchronous and asynchronous. Synchronous interaction requires additional coordination of timing and organization (e.g., scheduling around time zones and work hours), the simultaneous and effective application of information technologies, and an increased awareness of the limitations of information technology for interaction. Even though socio-technical interaction can primarily be asynchronous, there is less investment in social processes with asynchronous interaction (Mansour-Cole, 2001). Asynchronous interaction is most effectively used as a supplement to synchronous interaction, especially as a means of sharing specific information. Socio-technical must foresee the most appropriate interaction method (i.e., synchronous or asynchronous) for the type of task and must execute the task using the planned interaction method.

Research Goals

Again, the goal of the present research was to identify CPOF socio-technical skills in order to guide the development of integrated training of digital skill and collaboration skill. The first step to accomplish this goal was to define CPOF socio-technical skills by producing a taxonomy of CPOF collaborative capabilities based on relevant virtual-collaboration skill (i.e., build relationships, share understanding, and coordinate action). The second step was to map the socio-technical skills defined in the first step to an operationally-relevant C2 activity in order to define a training context. In this case, MDMP was used as the C2 activity. MDMP provides a rich and multiperspective context in which to develop training content, which is important for integrated training (Bransford, et al., 1990). MDMP involves timely inputs from multiple individuals. Even though the inputs are mostly structured, the contexts in which MDMP are applied and additional interactions among decision makers to verify information and to coordinate action makes the process dynamic and varied. This mapping produced an outline for possible training scenario development.

CPOF SOCIO-TECHNICAL SKILLS

Method

The identification of specific CPOF socio-technical skills utilized an existing taxonomy of CPOF collaborative skills (Catrambone, et al., 2009) to identify ways in which CPOF is leveraged to facilitate interaction during C2 activities. In addition to this existing taxonomy, CPOF collaborative capabilities were identified by technical-document analyses. Observations of CPOF use and interviews with expert CPOF users were then used to validate and supplement some of the identified collaboration capabilities. Once the CPOF collaboration capabilities were identified, they were mapped to the general socio-technical skills (i.e., build relationships, share understanding, and coordinate action) to define CPOF socio-technical skills.

The document analyses reviewed the U. S. Army Field Manual for the Operations Process (FM 5 – 0; Department of the Army, 2010), unit CPOF standard operating procedure document for a mechanized infantry brigade, and classroom training materials from a Battle Command Training Center CPOF course in order to provide a preliminary understanding of specific CPOF features that could be used for collaboration. From these analyses and the existing CPOF taxonomy (i.e., Catrambone, et al., 2009), a preliminary list of CPOF collaboration capabilities was produced. Observations and user interviews were then conducted during a field training exercise for a battlefield surveillance brigade. The semi-structured interviews were conducted with five individuals who had at least 12 months experience with operating CPOF (maximum 36 months). The CPOF users ranged in rank from Specialist to Captain. The interview questions sought (a) to identify situations in which CPOF can be used for collaboration, (b) to identify additional collaboration features of CPOF, and (c) prioritize the list of CPOF collaboration skills. Finally, observations of CPOF use during the field training exercise were used to identify additional collaboration capabilities and to estimate the frequency of various capabilities.

Research Product

After the observations and interviews, a final list of critical CPOF collaboration capabilities was derived. This final list of capabilities was then organized according to the socio-technical skill categories to produce a set of CPOF socio-technical skills. The skills were also identified as being either synchronous or asynchronous. In total, 89 specific CPOF socio-technical skills were identified. Table 1 provides an example of the CPOF socio-technical skills across each skill category.

MDMP TRAINING CONTEXT

In order to define a context to develop integrated CPOF training exercises, an analysis of the collaborative aspects of MDMP was required. The goal was to define the collaborative aspects of MDMP as a means of identifying the types of CPOF socio-technical skills that could be trained in a MDMP context. Once these skills were identified, it was possible to develop CPOF training scenarios based on MDMP.

Method

Even though the MDMP is well-defined and well-documented, an initial task analysis was conducted on the MDMP in order to specify collaborative processes for which CPOF could be used. Two subject-matter experts with C2-analysis experience and familiarity with CPOF systematically reviewed MDMP doctrine in FM 5 – 0 Appendix B (Department of the Army, 2010). Each task in the MDMP that required some form of collaboration was noted, and then each task was aligned with a general socio-technical skill (i.e., build relationships, share understanding, and coordinate action).

Research Product

Table 2 presents an example of how MDMP tasks (i.e., Receipt of Mission) was aligned with socio-technical skills (i.e., Build Relationship). The matrix in Table 2 helps identify the specific CPOF capabilities needed to execute the MDMP task. To do so, the cross reference between the socio-technical skill in Table 2 and the CPOF capability in the documentation of CPOF socio-technical skills (e.g., Table 1) can be made. For example, in Table 2, the subtask for Conduct Initial Assessment involves the socio-technical skill for "Develop shared awareness of team member roles, culture, and tasks." By cross-referencing this skill in Table 1, one could determine that using Ventrilo, Group browsers, User preferences, and User profiles in CPOF would allow for this MDMP subtask to be executed.

Table 1. Example CPOF Socio-Technical Skills

Skill Category	CPoF Capability	Socio-technical Skill
Build Relationships	Ventrilo	Develop Trust (engage in more personal communication such as voice rather than text during
Build Relationships	Presence in Ventrilo, Channel Membership	Use "speaking" status indicators and channel
Build Relationships	Ventrilo, Group browser, User preferences, User profiles	Develop shared awareness of team member roles, culture, and tasks
Share Understanding	Ventrilo; Flashlight and static annotation tools	Guide attention during communication
Share Understanding	Archive, Shared Products, Static Annotations	Save communications
Share Understanding	Shared Products, Mirrors, Clones	Share Collection
Coordinate Action	Group browser	Form group hierchies, assign members, remove members, view groups
Coordinate Action	Chat comments, Shared Products, Ventrilo, SOP	Anticipation of team member information needs
Coordinate Action	Ventrilo, Group browser, User preferences, User profiles	Determine knowledge, skills, responsibility, authority, and boundary spanners

Table 2. Example Socio-Technical Skills in MDMP

	Build Relationships Socio-Technical Skill				
MDMP Task	Develop shared awareness of team member roles, culture, and tasks.	Engage in personal communications	Acknowledging Others	Reliability in presence during interaction	Maintain awareness of security levels
STEP 1: Receipt of Mission					
1. Alert the staff and key participants		X	X	X	X
2. Gather tools (e.g., graphics, map, FMs, current estimates)					
3. Update estimates including the status of friendly units and resources					
4. Conduct initial assessment	X				
5. Issue Commander Initial Guidance	X				
6. Issue initial WARNO & log subordinate/supporting unit acknowledgement				X	X

TRAINING CPOF SOCIO-TECHNICAL SKILLS

Using the MDMP context, scenarios for training CPOF were developed. At the outset of this paper, the challenge was established to find ways to integrate training for virtual collaboration skills with training on command digital systems. Other methods of training collaborative skills, for example observational learning, scripted problem solving (Rummel & Spada, 2005), social interventions (Saab, Van Joolingen, & Van Hout-Wolters, 2007), and mentoring (Day, et al., 2007), do not readily provide for the integration skills training. Hence, the MDMP context was developed on which to base problem-based practical exercises. While most problem-based approaches to training are effective for training critical thinking skills (Bransford et al., 1990) and even collaboration skills (Hmelo-Silver, 2004), a more structured approach may be required for digital-skills training (Bink, et al., 2011). As a result, the approach offered here attempts to prescribe a method that can leverage the contextual effects of problem-based training while maintaining the structured skill progression required by digital-skill training.

The key to developing effective problem-based-training scenarios for CPOF socio-technical skills is to build multiple exercises that utilize a progression of digital skills in a collaborative context (i.e., MDMP). The following four steps identify one way to create effective training scenarios based on MDMP. The scenarios require students to role-play entities in the MDMP process (e.g., Battle Captain or Battalion S-4) and to build on basic CPOF skills as the socio-technical skills are exercised. Even though development of training scenarios is presented as a series of steps, the actual process is iterative as reconsideration of each step is needed as the scenario is developed.

Step 1. Determine the Types of Skills to be Trained.

Because the training of CPOF socio-technical skills should be based on a progression and because training socio-technical skills will require the execution of other CPOF skills, selecting the correct group of skills to train in a given scenario is important. By following a skill progression, increasingly complex skills or skills that are more susceptible to forgetting can be trained in the context of "easier" skills. The specific skills introduced at each step of the sequence can be determined not only by the procedural commonality with already-learned skills but also by the operational relevance of the skill (i.e., the application to MDMP). An appropriate progression for CPOF skills is given in Bink et al. (2011) and can be applied to the socio-technical skills identified in this paper. For example, Setting User Privileges was part of the socio-technical skill of "Develop shared awareness of team member roles, culture, and tasks." From the information provided by Bink et al. (2011), one could determine that this socio-technical skill was easily retained and should precede training "Anticipation of team members needs."

Step 2. Determine the Type of Scenario to be Used.

The training scenarios should trigger the use of the desired CPOF socio-technical skills. Once a set of skills is identified for training, those skills can be referenced to MDMP task (see Table 2) to identify the types of interactions that should be used in the scenario. Scenarios should also have several characteristics aid skill progression and retention:

- Scenarios should build from an existing situation. While the trigger of the scenario will introduce a change, this change should build on an established general situation.
- The scenario should introduce a recognizable but unforeseen or unexpected event or situation. The scenario should introduce information that would cause the student to perform actions with minimal prompting from the trainer.
- The scenario event or information should generate the need for assessment or reassessment of aspects of the current situation. The event should cause the socio-technical system to update estimates, to modify guidance, to make or revisit decisions, and to make timely dissemination to others within the system.
- The scenario information should stress unit capabilities or require external resources to resolve.

It is also important that the scenario utilize the complete MDMP process and that the trainer assure the interaction of individuals in the team.

Step 3. Assign Roles and Execute the Scenario.

In the MDMP, the lack of familiarity with basic roles and relationships of a staff can quickly become an impediment. Once required roles in a vignette are determined, basic orientation to staff duties and relationships may be required. However, training major staff functions and processes is beyond the scope of CPOF basic skills and should be avoided. Based on the knowledge and experience of the individuals, students may be grouped to role-play staff elements or units. Possible players/roles will be identified in Step 2, but for expediency, not all potential player roles may be included in a scenario. Due to complexity of actions or decisions the trainer may play some roles, for example commanders or decision makers. Trainers may find it useful to group students using their strengths in some situations or require less-experienced students to perform roles they are less familiar with in other situations to enhance collaboration and developing proficiency with some CPOF skills.

Trainers should follow the sequence of actions and predictable behaviors for the event developed or derived from Step 2 as a guide. This guide will assist trainers in monitoring the flow of information and communications. Trainers can use both electronic means and "over the shoulder" monitoring techniques to assess student actions. The skill level of the students, both with CPOF and with their player role, will likely necessitate some scaffolding to encourage correct processes and behaviors. In addition, limited intervention and corrections might be needed if errors are made or students do not perform correct action.

Step 4. Provide Performance Feedback.

All training must be evaluated. Soldiers should receive feedback on their performance, receive feedback of actions performed well and determine how to sustain them, as well as understand mistakes and errors, determine the lessons learned, and determine corrective actions. An *after action review* can be used for this purpose in which the trainer and other team members provide feedback to each individual. Care should be taken to give specific feedback on the use of CPOF skills and on the socio-technical skills.

Sample Scenario

Using the guidance in the scenario-development steps, a CPOF training scenario for "unexpected severe weather" was developed. Figure 1 presents the scenario trigger message. Figure 2 presents the anticipated actions for the scenario. This scenario requires that the roles of S2, S3, S4, and two subordinate units be used. In addition, the trainer must provide the following information as Shared Products (PASS):

- A weather report
- Intelligence Estimate
- Operations Estimate
- Logistics Estimate
- Schedule of Logistics Support
- Current Operations Plan
- Map with current Operations Graphic
- Map with Terrain Analysis

```
* A THUNDER STORM AND FLASH
FLOOD WARNING FOR OUR AREA OF
OPERATIONS HAS BEEN ISSUED BY
THE U.S. AIR FORCE AIR WEATHER
SERVICE UNTIL 02:00 LOCAL
TOMORROW MORNING.

* AT 12:30 HRS LOCAL, DOPPLER
RADAR INDICATED A LINE OF SEVERE
THUNDERSTORMS CAPABLE OF
PRODUCING DAMAGING WINDS IN
EXCESS OF 45 MPH AND DEPOSITING
6 TO 10 INCHES OF RAIN IN A 12
HOUR PERIOD.  THE STORM IS
MOVING TO THE SOUTHEAST AT 25
MPH.

* PRECAUTIONARY/PREPAREDNESS
ACTIONS...
THIS IS A DANGEROUS STORM. IF
YOU ARE IN ITS PATH...PREPARE
IMMEDIATELY FOR DAMAGING
WINDS...DEADLY CLOUD TO GROUND
LIGHTNING ... AND FLOODING/FLASH
FLOODING IN LOW LYING AREAS AND
NEAR STREAMS AND RIVERS.
```

Figure 1. Trigger Message for CPOF Training Scenario

- Phase 1
  - S2 makes mirror of weather situation
  - Posts updated weather forecast chart in shared area and spotlights weather warning
  - Notifies other staff sections by ventrilo
  - Modifies the current Intel Estimate, highlights comments, and requests concurrence of assessment from higher headquarters
  - Modifies privileges
- Phase 2.
  - Other staff members (S3, S4, ENGR, __) access shared posting.
  - Make clone of S2 assessment for use on their own system.
  - S2 provides modified graphic terrain analysis of low-lying areas and stream crossings on map/3D map. Notify others of update
  - Staffs conduct own analysis and re-post in shared area.
  - S3 accesses other staff inputs and develops revised operational plan based on impacts
  - S3 iteratively shares with S4 to ensure new plan is supportable.
  - S4 confers with support element to revised expected logistics delivery schedules (inbound and to subordinate)
- Phase 3
  - S2, 3, 4 and ENGR bookmarks changes and shares with Commander
  - Subordinate requests modification of mission based on expected winds and degraded trafficability
  - Elements confer with Commander to gain approval of changes
- Phase 4
  - Commander provides approval
  - S4 revises resupply plan and supply routes based on update shared by S3.
  - Units and staff create clone of revised plan and develop own revised implementation plans.
- Phase 5
  - S3 shares approved plan with units and staff
  - S4 posts revised log and distribution plan
  - Subordinate units share revised plans and conduct synchronous rehearsal.
  - Staffs inform counterparts at high headquarter of detailed changes.

Figure 2. Anticipated Actions for CPOF Training Scenario.

CONCLUSION

The goal the research reported in this paper was to develop a research-based method to integrate training of command-digital-system skills and collaboration skills. In order to accomplish this goal, a socio-technical-systems conceptualization was developed for the integration of digital-systems skills and collaboration skills. The specific socio-technical skills for CPOF were developed and applied to a relevant training context (i.e., MDMP). By aligning CPOF socio-technical skills and the tasks of MDMP, problem-based-training scenarios can be developed to support the progression of CPOF skill development.

The socio-technical-system approach represents a way to leverage a conceptual construct for actual training outcomes. That is the socio-technical approach allowed diverse skills to be defined as a solitary skills set. Incorporating a single skill set into training should be easier than training skills sets separately. Of course, successful integration of skill training heavily depends on providing the appropriate context. In the case of CPOF skills, MDMP provide a relevant and flexible context to build training scenarios. This approach to integrated skills training can be applied to other types of digital skills (e.g., Joint Battle Command Platform).

The extent to which scenarios developed with this process will lead to effective training is yet to be empirically determined. While plans exist to develop, implement, and validate training scenarios, no data has yet been gathered about the effectiveness of the scenarios. This training development step certainly needs to be addressed. However, the use of the socio-technical approach improves upon current training approaches that only train individual skills.

Finally, virtual collaborations are becoming standard operating procedure for the military. As a result, the quality of socio-technical interactions impacts the individual, the product, the organization in which it occurs, and the technology used. Thus, the appropriate approach for understanding the nature of socio-technical systems is vital to the success of many tasks and missions. The socio-technical system approach provides a framework of integrated skills development that can be used to prescribe training. A socio-technical system is distinguished by the intention and investment of each individual to contribute and to learn, by the goal of the interaction being accomplished by creating shared understanding among participants, and by the shared understanding changing future interactions and products. Also, an understanding of virtual collaboration through the socio-technical-system approach may also help guide the development of technologies used for virtual collaboration and help optimize critical collaborations in both training and operational applications.

ACKNOWLEDGEMENTS

The author wishes to acknowledge Evelyn Cage for her contributions to the data analysis and to the production of this report. The author also acknowledges Roger Chapman and Dawn Riddle for their expert data collection and analysis. Finally, the author acknowledges Norm Blankenbeckler and Rich Wampler for their contributions to the development of training materials.

REFERENCES

Barron, B. (2000). Achieving coordination in collaborative problem-solving groups. *Journal of the Learning Sciences, 9*, 403 – 436.

Bearman, C., Paletz, S.B.F., Orasanu, J., & Thomas, M.J. (2010).The breakdown of coordinated decision making in distributed systems. *Human Factors*, *52*, 173-188. doi:10.1177/0018720810372104.

Beyerlein, M. M., Johnson, D. A., & Beyerlein, S. T. (Eds.) (2001). *Virtual teams*. Amsterdam: Elsevier Science/JAI Press.

Beyerlein, M. M., Bradley, L. Nemiro, J., & Beyerlein, S. (2008). Collaboration in the real world: Virtual team key take-away principles that work. In J. Nemiro, M. Beyerlein, L. Bradley, & S. Beyerlein (Eds.), *The handbook of high-performance virtual teams: A toolkit for collaborating across boundaries* (pp. 671-691). San Francisco, CA: Jossey-Bass.

Bink, M. L., & Beyerlein, M. M. (2007). Innovating in virtual teams. *The International Journal of Cognitive Technology, 12(2)*, 11 – 16.

Bink, M. L., Wampler, R. L., & Cage, E. A. (2011). *The retention of digital skills: Command Post of the Future.* (ARI Research Report 1937). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC No. AD A535536).

Blackburn, R., Furst, S., & Rosen, B. (2003). Building a winning virtual team: KSAs, selection, training, and evaluation. In C. B. Gibson & S. G. Cohen (Eds.), *Virtual teams that work: Creating conditions for virtual team effectiveness* (pp. 95 – 120). San Francisco: Jossey-Bass.

Bransford, J. D., Vye, N., Kinzer, C., & Risko, V. (1990). Teaching thinking and content knowledge: Toward an integrated approach. In B. F. Jones & L. Idol (Eds.), *Dimensions of thinking and cognitive instruction* (pp. 381-413). Hillsdale, NJ: Lawrence Erlbaum Associates.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32-42.

Catrambone, R., Wampler, R. L., & Bink, M. L. (2009). *Determining a critical-skill hierarchy for Command Post of the Future (CPOF)*. (ARI Research Report 1906). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (DTIC No. AD A507712).

Department of the Army (2010). The operations process (FM 5-0). Washington DC: Author.

Dwyer, N. & Suthers, D., D. (2006). Consistent practices in artifact-mediated collaboration. *International Journal of Computer-Supported Collaborative Learning, 1*, 481 – 511.

Hmelo-Silver, C. E. (2004). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review, 16,* 235 – 266.

Jermann, P., Soller, A., & Lesgold, A. (2004). Computer software support for CSCL. In J. W. Strijbos, P. A. Kirschner, & R. L. Martens (Eds.), *What we know about CSCL and implementing it in higher education* (pp. 141– 166). Dordrecht: Kluwer.

Kirschner, P. A. (2005). Learning in innovative learning environments. *Computers in Human Behavior, 21*, 547 – 554.

Mansour-Cole, D. (2001). Team identity formation in virtual teams. In M. Beyerlein, D. Johnson, & S. Beyerlein (Eds.) *Virtual teams* (pp. 41 – 58). Amsterdam: Elsevier Science/JAI Press.

Nemiro, J. (2007). The Building Blocks for Creativity in Virtual Teams. In S. P. MacGregor & T. Torres-Coronas (Eds.), *Higher creativity for virtual teams: Developing platforms for co-creation* (pp. 98 – 121). Hershey, PA: Information Science Reference/IGI Global.

Rummel, N., & Spada, H. (2005). Learning to collaborate: An instructional approach to promoting collaborative problem solving in computer mediated settings. *Journal of the Learning Sciences, 14,* 201 – 241.

Saab, N., Van Joolingen, W. R., & Van Hout-Wolters, B. H. A. M. (2007). Supporting communication in collaborative discovery learning environment: The effect of instruction. *Instructional Science, 35*, 73 – 98. doi10.1007/s11251-006-9003-4.

Salas, E., & Cannon-Bowers, J. A. (2000). The anatomy of team training. In S. Tobias & J. D. Fletcher (Eds.), *Training and retraining: A handbook for business, industry, government, and military* (pp. 359 – 370). New York: MacMillan.

Yang, S. J. H., & Chen, I. Y. L. (2008). A social network-based system for supporting interactive collaboration in knowledge sharing over peer-to-peer network. *International Journal of Human-Computer Studies, 66,* 36–50.