The Effect of a GPS on Learning with Regards to Performance and Communication in Municipal Crisis Response

Helena Granlund[1,2], Rego Granlund[1], and Nils Dahlbäck[3]

[1] Santa Anna IT Research Institute, Linköping, Sweden
[2] Swedish Defence Research Agency, Linköping, Sweden
[3] Linköpings Universitet, Linköping, Sweden
rego.granlund@santaanna.se, helena.granlund@santaanna.se, nilda@ida.liu.se

Abstract. This paper describes the basic learning aspects of crises management training in a computer simulated environment. A total of 108 professionals, 18 teams, contributed to the study where the impact of a GPS on C2 work was investigated. A comparison between professional groups on performance and learning show that the GPS has an impact that differed depending on the teams professional composition.

Keywords: Experiential learning, Microworld, Simulation.

1 Introduction

This paper present how a computer based simulation can be used to analyze the impact of a global position system (GPS) on command and control teams in terms of effects on performance. 18 Swedish municipal crisis management teams, a total of 108 professionals, participated in the project (Granlund et al, 2010). The key motive for the study was to gain knowledge on how teams differ depending on if they have GPS or if they have regular paper maps in their command post. The study was not designed to explore or optimize training, and had a passive attitude to perform training; meaning that training could be accomplished by the participating members themselves. The paper presents the learning approach, the training procedure, its underlying educational thoughts and a comparison between rescue service and municipal personnel's performance and communication.

1.1 Study Context

In Sweden the municipal organizations are accountable for crisis response within the borders of the municipality. The response preparedness has many aspects, including investments in technical support and training for the local crisis management organization.

The municipalities invest in information and communication systems, in order to gain performance and control in their work. Systems such as GPS support for

C. Stephanidis (Ed.): Universal Access in HCI, Part IV, HCII 2011, LNCS 6768, pp. 215–224, 2011.

command and control applications are often integrated with other technologies like multimodal communications and geographical information systems. They have real-time sensors for the units' position and state. They present their information unfiltered, without human intervention, strait in to the management level. Researchers in for instance computer supported cooperative work (Schmidt & Bannon, 1992) distributed cognition (Hutchins, 1995) and cognitive systems engineering (Hollnagel & Woods, 2005) emphasize the importance of evaluating the effect of new systems in practice. It is essential when organizations invest in support systems for command and control to take into account what the overall system, commanders, support and environment, does and performs (Hollnagel & Woods, 2005).

Lessons learned from empirical evaluations in practice can be feed back into the total command and control system during preparedness training. To empirically evaluate events and human experience in situations where geographically distributed commanders use technological systems under heavy workload is however difficult. Real crisis response operations are rarely reviewed in sufficient detail to gain insight for preparedness purposes. Simulations are one possible way to confront and analyze these situations and systems. The simulations that are relevant in this context are scenario-based simulations executed in real-time, and where the development of the tasks can be described as dynamic (Brehmer, 2005).

1.2 The Simulation Environment

The C3Fire simulation environment, used for the study, is designed for evaluation of command and control systems and can be understood as a micro world. Microworlds have complex, dynamic and opaque characteristics that represent the environments people encounter in real-life systems. In microworlds the system designer isolates chosen characteristics from the real world in order to study their effects on teams in a controlled manner (Brehmer, 2005; Brehmer and Dörner, 1993; Granlund, 2001). The system allows controlled studies of collaboration, decision-making, cultural differences in teamwork and effects concerning work processes and information communication tools in command and control (Artman and Wearn, 1999; Granlund et al., 2010; Johansson et al., 2010; Lindgren & Smith, 2006).

In this study C3Fire generated a dynamic forest fire fighting. Six management members needed to collaborate in a team. Their goal was to manage and extinguish forest fires and to protect homes and valuable areas. In order to handle the response the team needed to prioritize between different objectives and identify critical areas. They needed to create a plan and implement operations. All work was distributed, which means that the participants needed to exchange information within the group to execute the task although some participants were separately located. Organization, communication structure, resources, the participants' information systems and simulation environment are examples of properties that were configured in C3Fire to create appropriate learning and research scenarios.

2 Training Method

Members of the municipal crisis management organizations need training to handle a variety of costly, risky and often rare crises. Computer simulations is a means for the

training. They offer opportunities to repeat the training process, which in itself is a prerequisite for learning when learning is seen as a continuous process (Kolb, 1984).

2.1 Experiential Learning for Team Training

Kolbs (1984) generally accepted model of experiential learning can be adapted for research and team training performed with computer-based simulations (Granlund, 2008). The two main components of the model are the four step learning cycle (Figure 1) and the idea of learning as a continuous process.

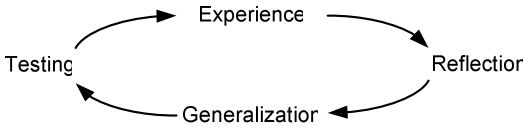

Fig. 1. Kolb's basic model of experiential learning

According to Granlund (2008) having an *experience* initiates the learning. For computer-based simulations, the instructor tries to direct the participant's experience towards the objectives of the education. The participants will have different experiences during the simulation depending on their previous knowledge and experience. During the *reflection* all participants communicate their own experiences from the simulation as well as listen to the other participants' in a shared reflection. The *generalization* takes place when thoughts from the experience and the reflection are linked to the participant's initial knowledge and is performed within the participant. The participants will not do the same generalization, as their knowledge and experience differs, but their shared reflection increases the ability to generalize in the same direction. *Testing* is the last step of the experiential learning cycle. The ideas from the generalization are validated. If the ideas hold they might be included in the participant's knowledge.

By repeating this process the continuous learning of each individual participant in the group will evolve a joint knowledge as they will influence each other during their shared activities throughout the cycles.

2.2 The Study's Utilization of the Four Step Learning Cycle

The study was designed to meet the conditions for experiential learning and the idea that learning is a continuous process. During the training day the participants goes through different levels of learning. To support these levels in the C3Fire environment a training day is performed by a sequence of simulation sessions (Figure 2).

Each of the 5 cycles consist of; a 20 minutes C3Fire simulation trial, 5 minutes of individual questionnaires and then 15 minutes after action review were the whole group is active. The total experiment last for about five hours.

During the simulation trial the participants made experiences thru the team work in the simulated emergency response task. While performing the individual questionnaires the participants had possibility to do personal reflections on the

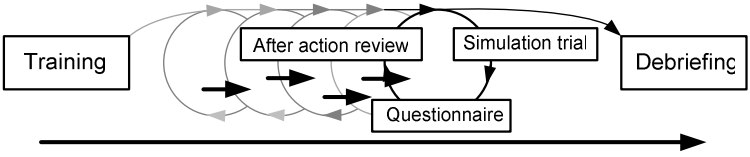

Fig. 2. The experiment procedure with 5 simulation sessions

experience. During the after action review the participants' saw a fast played recording of their latest trial. They performed a shared reflection where they discussed their performance together and made tactical plans for the next session trial. This phase is very intense and takes at least 15 minutes, which can be compared to a simulation trial that takes 20 minutes (Figure 2).

2.3 The Study's Utilization of Learning as a Continuous Process

There are several issues that continuously can be learned during a simulation based team task in C3Fire. Offerman and Spiros (2001) listed eleven common problems team developers deal with regarding team training. Most of which are general for team training and liable also for preparedness training. With the above described cyclic procedure these issues can be learned by the team or the individual in different modes of control; Scrambled, Opportunistic, Tactical (unattended or attended) or strategic. The scrambled mode is defined by no planning, no reflection and actions are ad hoc. In the opportunistic mode behavior is reactive due to lack of understanding and time. The tactical mode is more organized and driven by known rules and procedures and planning is proactive. In the strategic mode actions are not only proactive they also approach higher level goals in an effective manner (Hollnagel & Woods 2005).

Three levels of learning will occur while using the C3Fire environment; individual level, organizational level and task level.

*Individual Level***:** Initially the participants learn to operate the system and the basics of their emergency response task. It is defined by a scrambled control mode. The strength of using a microworld for this phase is that the procedure with repeated simulations assures it to be short. The participants learn to operate the system and understand the task within one trial.

*Organizational Level***:** Next, the group learns to collaborate, they allocate responsibilities and roles and they investigate the systems limits. After this phase, normally 1 or 2 trials, the group has learned the system, understands the task and is ready to act as a team. In this phase the participants should be able to use an opportunistic and in some parts an attended tactical control mode.

*Task Level***:** In the third step the group they can train or learn some specific task. In this phase the participants should be able to uses some type of attended or unattended tactical control mode in some parts of the control.

3 Method

With a series of experiments in a computer simulated crisis environment a total of 108 members from 18 municipal organizations were tested. Each team consisted of six participants, three worked as crisis managers in a command post, three worked as ground chiefs. The command post worked on an operational level, without direct access to the simulation and controlled the simulated world indirectly, through commanding the ground chiefs, who managed three fire brigades each in the simulation (Figure 3 and 4).

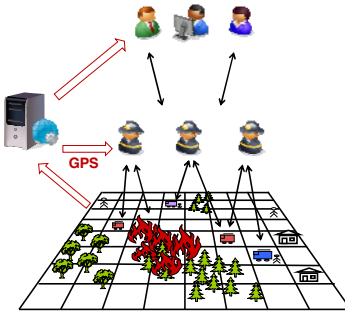

Fig. 3. The GPS condition

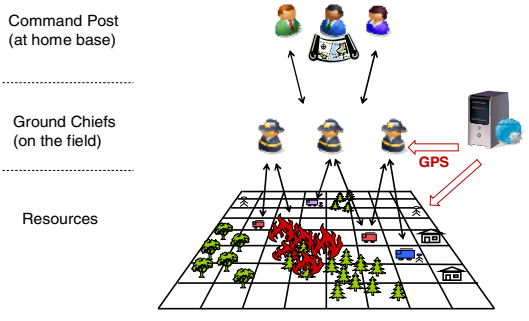

Fig. 4. The Paper Map condition

The study had a between-group design with two factors: (a) Teams with professionally homogeneous or heterogeneous command posts, and (b) Decision support in the form of GPS or paper maps. In the professionally homogeneous command posts all three participants was rescue service personnel. These teams are called RSCP, rescue service command post. In professionally heterogeneous command posts the three participants were a mixture of rescue service personnel and other municipal employee groups. These participant groups are called MCP, mixed command post.

4 Learning Effects Visible in the Results

Some of the learning effects identified in the results are related to performance, resource usage, time to first engagement and the participants own view of the perceived training.

4.1 Performance

The main task for the teams is to stop the forest fire and save houses. Normally the participants learn how to solve the task during the simulation trials and perform better at the concluding trial compared to the starting trial. The measure of the success and performance of the team, discussed here, is a measure of the total amount of burned

down area at the end of each simulation, BurnedOutArea. Figure 5 shows the average result from each of the five simulation trials. A small amount of BurnedOutArea is preferable to a large.

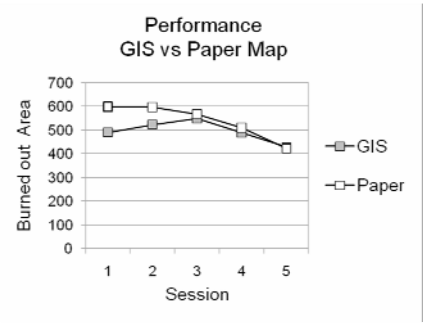

Fig. 5. Amount of burned-out area at the end of each simulation trial

The result shows that the teams with GPS perform better during the initial trials. For the concluding trials the teams with paper maps solve the task equally well as the teams with GPS. This result did not follow the expectations presumed for the study. In a previous study with students as participants the GPS supported teams performed better than the paper map teams in all the five simulation trials (Johansson et al, 2010).

4.2 Team Composition Effects on Team Learning

When the results were divided into the two team compositions, RSCP and MCP, another result appeared. The result show that the *RSCP* teams with GPS perform better in all trials (Figure 6). This result follows the presumed expectations for the study. The results also show that the RSCP teams achieved the expected learning curve during the day.

The result for the *MCP* teams was unexpected (Figure 7). The results show that the teams with GPS do not perform better than the teams with paper maps. The results also show that the teams with GPS have no learning curve. They have the same performance in the last trial as in the first.

The result for GPS setting shows that RSCP and MCP are not equal with regards to performance. The RSCP have significant, $t(6) = 4{:}20$, $p < .006$, less burned out area than the MCP in simulation trial 5. The result for the paper map setting show that RSCP and MCP perform equal in simulation trial 5. The task was not too difficult for any of the teams when a traditional support was used in the command post.

One important task for the teams is to synchronize the activities and use their resources in an effective way. Figure 8 shows the average number of active units. This is an indication of the participants' ability to use their resources. The data shows that all teams have a positive learning curve. It also shows that RSCP teams with GPS put their resources to work to a greater extent than the other team compositions. This is an expected result.

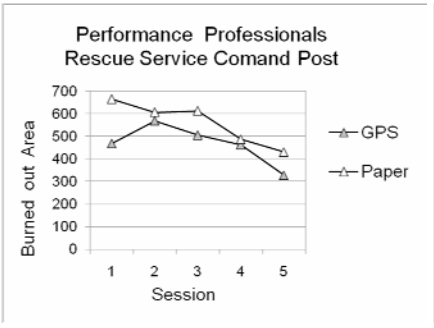

Fig. 6. Performance RSCP

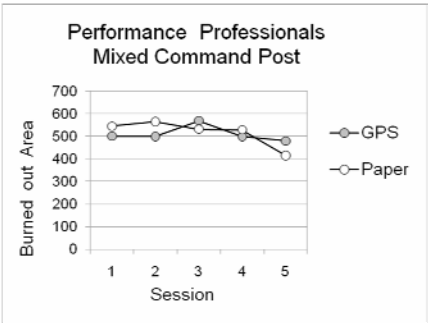

Fig. 7. Performance MCP

4.2 Time to First Engagement

In emergency response the time from alarm to first response is important. After an alarm, there should be two parallel tasks going on. The first is that the command post should create a long-term plan for the response. The second is that the ground chiefs start first response based on their local knowledge about the situation and previous instructions. When the command post have sized up the situation and created a long term plan they should command the fire fighting chiefs to start acting according to plan. The metric "Time to first engagement" (Figure 9) indicates the behavior learned by the ground chiefs, if they act directly or if they wait for order from the command post.

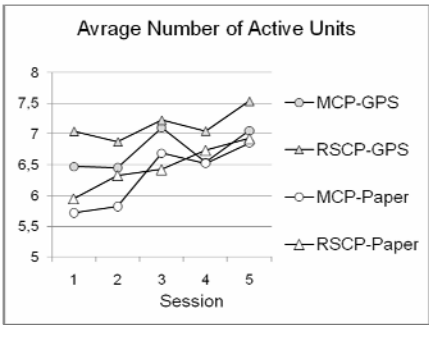

Fig. 8. Average number of active units

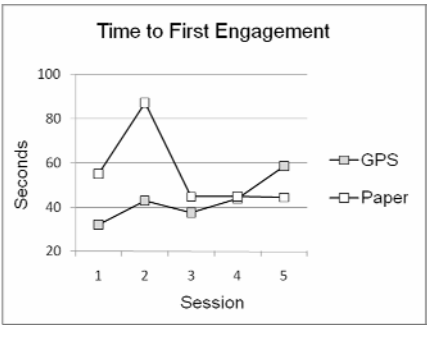

Fig. 9. Average number of seconds between the alarm and the first engagement

The result shows that the ground chiefs in teams that have paper map in the command post, have after the third trial learned a routine for response and they perform the same routine with the same speed every time. The result also shows that the teams that have GPS do not initiate first response according to a predestined routine. They await orders from the command post. This is an indication that the decision making process is altered by the GPS. The short term decisions are in the last trial no longer made by the ground chiefs they are passed over to the command post, and no short term instructions have been developed by the teams.

4.5 Training Assessment

The result on how the participants perceived the training can be seen in Figure 10. On the question about what they thought they had been training on, the participants were given ten topics, over which to distribute a total of 100%. The topics were common goals, common task, functional roles, good communication, common situation awareness, problem solving, decision making, conflict solving, empowerment and managing recourses. The basis for the eleven topics was described by Offermann and Spiros (2001) but somewhat adjusted to meet the simulation based training situation.

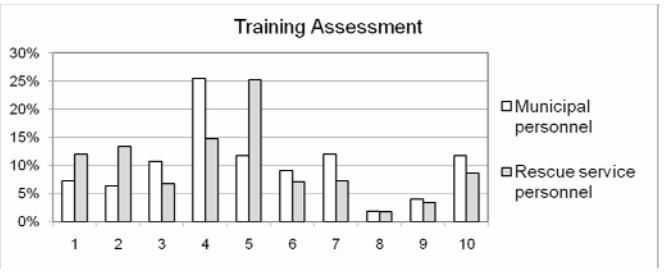

Fig. 10. The percent on each topic the participants think they have been training on

The results show that rescue service and municipal personnel's opinions on the training differs in topic 4, communication and 5, common situation awareness. The municipal personnel strongly thought that they are training on how to communicate in a crisis even. The rescue service personal strongly thought that they are training on how to create common situation awareness in a crisis even.

5 Discussion

The study used experiential learning in the research method. The teams were expected to evolve during the experiment to learn and acquire a working method adapted to the decision support the team had access to. The results in terms of performance, resource usage, time to first engagement, and perceived training gives a picture where the command post with GPS support has more tasks to handle compared to the command post that have paper maps as support, and the work is more evenly distributed between the command post and ground chiefs in the paper map condition.

GPS support offers more information than papers maps to the participants, and the simulated task should reasonably be easier to solve with the help of GPS. With a closer examination of the performance data on the rescue service personnel command post, RSCP, and municipal employee command post, MCP, it appears that this is not the case. Compared with the RSCP and MCP in the paper map condition has RSCP a better result in the GPS condition, but the MCP in GPS score lower, especially in the 5th and most important attempt (Figure 6 och 7). The RSCP and MCP teams in paper map, and the RSCP teams in GPS, all have a positive learning curve with regards to performance. MCP in GPS is different. They have no learning curve. They have no performance development over the five trials.

The problem here is how the groups solve allocation of work and the ability of their command post to handle the work. The teams in GPS and paper map have different strategies to allocate responsibility. In the *paper map condition*, the time between the ground chief detect fire and first response is constant for the simulation trials 3-5. The ground chiefs act in a tactical command mode and in accordance with the procedures developed by the team during their AAR. Discovery of fire is communicated to the command post, and then the direct responsibility for response is with the ground chiefs who act accordingly. The time between fire detection and extinction can be kept constant as c3fire specific tasks, ie moving the units and use the communication tool are at an unattended tactical level. The instruction for fire detection is used in the same way every time; the manner is leaned and generates the same measured time in trial 3-5 (Figure 9).

In the *GPS condition* the allocation of responsibility is different. The time between detection and first extinguished cell is not constant (Figure 9). From the third attempt, where c3fire specific tasks have reached an inattentive tactical level, the time between discovery and response is increased. The explanation is that the instruction that the GPS groups uses is different. The ground chief that detected fire, alarm the command post and awaits orders. The direct, as well as long-term, responsibility for response lies with the command post. The ground chief still has execution at his lot, but wait until the plan is set and reach him via an order. With this the command post in the GPS condition is more stressed than the command post in the paper map condition, and the GPS ground chiefs is relieved of work load. RSCP teams in GPS have the best performance of all subgroups. This means that they can handle the extra stress of the total, direct and long-term, responsibility for planning. MCP teams' performance in GPS has no progress, which means that this allocation of responsibility is unfavourable to them. They have no ability to strategically manage both direct and long-term planning. Their control mode is lowered to an opportunistic level.

The participants' perception of training shows that municipal employees, as opposed to rescue service personnel, strongly feel that it is communication that has been trained during the experiment. One explanation may be that Swedish municipal employees normally are not involved in managing crises, therefore the need of preparedness training. Their communication is normally based on consensus as an ideal. Rescue personnel have from experience knowledge about communication and work processes for managing crises. This in itself means that the municipal employees teams acquire an additional burden and are in the case of GPS not capable to evolve in terms of performance due to cognitive over load.

Otherwise, the participants' perception of the training shows that all 10 proposals for training were trained (Figure 10). This is reasonable as the scenarios in the simulation where designed to be open to team development, no predetermined direction or training area was designated.

Refernces

Artman, H., Waern, Y.: Distributed cognition in an emergency Co-ordination Center. Cognition, Technology & Work 1, 237–246 (1999)

Brehmer, B., Dörner, D.: Experiments With Computer-Simulated Microworlds: Escaping Both the Narrow Straits of the Laboratory and the Deep Blue Sea of the Field Study. Computers in Human Behaviour 9, 171–184 (1993)

Brehmer, B.: Microworlds and the circular relation between people and their environment. Theoretical Issues in Ergonomics Science 6(1), 73–93 (2005); Gestrelius, K.: Simulation and training games: Experiential learning, SAAB Training Systems, AB (1998)

Granlund, H.: Experiential Learning in computer based simulation training - Experiences from research on team decision making. In: proceedings of, International Conference on Information Technology in Education within CSSE, Wuhan, China (2008)

Granlund, R.: Web-based micro-world simulation for emergency management training. In: Future Generation Computer systems (best papers form the conference Websim 1999), vol. 17, pp. 561–572. Elsevier, Amsterdam (2001)

Granlund, R., Granlund, H., Johansson, B., Dahlbäck, N.: The Effect of a Geographical Information System on Communication in Professional Emergency Response Organizations. In: Proceedings of 7th International Conference on Information Systems for Crisis Response and Management, ISCRAM 2010 (2010)

Hollnagel, E., Woods, D.D.: Joint Cognitive Systems. Foundations of Cognitive Systems Engineering. Taylor & Francis, Boca Raton (2005) ISBN 0-8493-2821-7

Hutchins, E.: Cognition in the Wild. MIT Press, Cambridge (1995)

Johansson, B., Trnka, J., Granlund, R., Götmar, A.: The Effect of a Geographical Information System on Performance and Communication of a Command and Control Organization. The International Journal of Human-Computer Interaction, Special issue on Naturalistic Decision Making with Computers 26(2&3), 228–246 (2010)

Kolb, D.A.: Experiential Learning – Experience as a source of learning and development. Prentice Hall, Inc., New Jersey (1984)

Lindgren, I., Smith, K.: Using microworlds to understand cultural influences on distributed collaborative decision making in C2 settings. In: Proceedings of the 11th The International Command and Control Research and Technology Symposium (ICCRTS), Cambridge, UK, Awarded the Willard S. Vaughan, Jr. Best Student Paper Award (2006)

Offerman, L.R., Spiros, R.K.: The Science and Practice of Team Development: Improving the Link. Academy of Management Journal 44(2), 376–392 (2001)

Rasmussen, J.: Skills, Rules, and Knowledge; Signals, Signs, and Symbols, and Other Distinction in Human Performance Models. IEEE Transactions on System, Man, and Cybernetics smc-13(3) (May/June 1983)

Schmidt, K., Bannon, L.: Taking CSCW seriously. Supporting Articulation Work. Computer Supported Cooperative Work 1, 7–47 (1992)