Using Microworlds to Study Teamwork at the Cognitive Level

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ABSTRACT
This paper studies teamwork using a Microworld: a synthetic environment that allows analyzing the cognitive behavior of teams in the laboratory. We developed a Microworld supporting the following functionality: control the experimental conditions; mediate collaboration; integrate testable technological affordances; execute experimental protocols; and collect experimental data. An extensive study with the Microworld involving critical incident response management is described in the paper. The study demonstrates that the Microworld supports analyzing teamwork at the cognitive level and facilitates the overall laboratorial set up.

Categories and Subject Descriptors
H.4.2 [**Information Systems Applications**]: Types of Systems—*Decision Support*. H.5.3 [**Information Interfaces and Presentation**]: Group and Organization Interfaces—*Computer-Supported Cooperative Work, Synchronous Interaction, Evaluation/Methodology*.

General Terms
Measurement, Performance, Design, Experimentation, Human Factors.

Keywords
Situation Awareness, Mobile devices, Microworlds.

1. INTRODUCTION
This paper discusses teamwork from a cognitive perspective. The distinction between teamwork and other terms like collaboration, cooperation and coordination is somewhat faint. We may take the propositions discussed by Oravec [1] to point out that our research addresses interdependent work teams "who share responsibility for outcomes of their organization." The focus on the cognitive perspective also underscores that our aim is to understand how the cognitive processes of the mind support teamwork. Within this context we may account for important phenomena such as information sharing, sensemaking [2, 3], decision-making [4], attention [5, 6], situation awareness [7, 8] and information overload [9].

The selected application area concerns Critical Incident Response Management (CIRM), a collaborative task performed by highly focused teams who often make complex decisions in dynamic contexts, facing emerging events, constant time pressure, and the need to recover normal operational levels without severe losses [10-12]. Critical incidents (CI) are characterized as unwanted, unexpected, and to some extent unprecedented problems. Instead of one single event, CI often involve chains of events, making the course of action even more uncertain [13]. Examples of CI range from common failures of key organizational resources to extreme natural hazards and industrial disasters.

CIRM assumes a collaborative dimension because teams can leverage expertise, information processing, flexibility, decision-making and confidence. Under extreme circumstances, CIRM teams must lead the organizations beyond pre-established structures, rules and behaviors. CIRM is strongly dependent on the team's knowledge and experience. Furthermore, as largely emphasized by the related literature [14, 15], Team Situation Awareness (TSA) constitutes a critical asset for high performance teams working in emergency situations. Therefore the role of cognitive processes (considering a broader perspective of cognition) on establishing TSA is a fundamental dimension of teamwork analysis.

Our main research objective is studying - at the cognitive level - teams performing CIRM activities. More specifically, we have been trying to understand how teams use technology to communicate, coordinate and collaborate under the demanding conditions raised by CIRM. The adopted research approach relies on Microworlds.

Microworlds are real-time, task-oriented and synthetic environments used to study human behavior in simulated scenarios [16-18]. Furthermore, a key characteristic that distinguishes a microworld environment regarding other simulation approaches is the fact that it implements an autonomous dynamic of the evolving situation. In other words, the effects from users interaction with the environment are not linear. The research literature has been gathering evidence that Microworlds are capable to support behavioral studies in challenging scenarios such as the ones presented by CIRM [19]. Microworlds must be carefully designed to support experimental manipulation and control of the task environment without removing many of the naturalistic conditions faced by teams. One important challenge posed to Microworlds is engaging teams in synthetic scenarios up to the point that their behavior becomes natural and can therefore be analyzed as if in a naturalistic setting [20]. A number of reasons impelled us to adopt Microworlds to analyze CIRM scenarios:

1. Incidents and their response have unexpected courses of action therefore are difficult to set up in traditionally highly controlled experiments. The inherent microworlds dynamic characteristics allow specifying quasi-realistic scenarios and still preserve some degree of control;

2. The ways teams address incidents are context dependent, which often makes it difficult to generalize the findings. Microworlds can control the experimental context across multiple scenarios and thus ease the definition of generalizable causal interpretations;

3. Due to the nature of their work, the access to CIRM teams operating in critical scenarios is typically difficult. Microworlds accomplish two main purposes: training and unveiling team processes dynamics.

Of course Microworlds also exhibit some limitations that should be recognized beforehand. One that has been raised by several researchers is the lack of ecological validity, i.e. results that are significant beyond the laboratory. [21, 22] also present two other concerns: (1) the need to design experimental scenarios that provide trustworthy representations of the problem domain; and (2) the need to specify dependent and independent variables that focus on the naturalistic aspects and overcome the artificial traits of the laboratorial scenarios. The research described in this paper delves into these problems, proposing a Microworld that streamlines the construction of experimental scenarios and management of experimental variables.

The paper is organized in the following way. We start with a review of the related work. In Section 3 we present the main requirements for developing a Microworld. Section 4 briefly describes the developed Microworld. In Section 5 we provide experimental data from one extensive study done with the Microworld. Finally, Section 6 discusses the obtained results and provides some concluding remarks.

2. RELATED WORK

The study of teamwork at the cognitive level has been evolving over the past 20 years [23, 24]. Broadly speaking, the main focus of research has been centered on understanding how teams: detect salient cues in the environment; assimilate and combine information; solve problems and make decisions; remember significant information; plan courses of action; and develop high-performance abilities.

Team cognition is deeply rooted on the traditional constructs of individual cognition, including perception, interpretation, planning, and execution [25], memory storage and retrieval, and filtering mechanisms [26]. Still, team cognition encompasses more than the sum of individual cognitions, namely it covers team processes such as communication, which has been regarded as a critical function [27-29].

The most recent research is converging towards understanding how teams operate in naturalistic settings, that is, in realistic tasks that require collaboration in the real world [30, 31]. This area of concern is known as Macrocognition [32].

One major concern of Macrocognition is preserving the real-world context while doing laboratory studies. This raises considerable challenges, particularly when teams have to operate in complex settings like CIRM. Cognitive phenomena such as emergence, sensemaking, and attention must therefore be studied closer to natural settings as much as possible [33].

Reinforcing this perspective, the research on Naturalistic Decision-Making (NDM) has been trying to understand how teams make decisions in time-pressured environments [34]. One fundamental assumption of NDM is that teams diverge from the typical rationalistic approach in which problems are analyzed in detail and options are thoroughly evaluated until the best one is selected [35]. According to NDM, decision makers tend to experience, recognize, classify, and react in fast cycles.

The Macrocognition and NDM bodies of research extend cognition beyond the traditional information-processing paradigm [25] considering the role of collaboration, pro-activity, and continuous interaction in shaping decision making and action. Such perspective shares the ground of ecological psychology. Ecological psychology relies on the concept of affordances as properties of the interaction between the individual and the environment to unveil opportunities/possibilities for action [36]. The dynamic, continuous, and exploratory nature of affordances thus provides the conceptual basis for understanding decision and action [37].

The development of this “ecological” perspective raises some epistemological implications. By acknowledging affordances, we must recognize that cognition extends beyond the human towards the material setting. Thus team cognition is distributed across human and material settings, involving group interaction and embodiment [38, 39]. Based on this ecological perspective, Macrocognition studies may therefore focus on observable interactions, taken in a broad sense, encompassing *human-human*, *human-technology*, and *human-environment* interactions.

In [40], the authors distinguish internalized and externalized mental processes employed by teams during one-of-a-kind problem-solving situations. The internalized mental processes can only be analyzed through indirect measurements, typically based on qualitative methods such as questionnaires and think-aloud protocols, and also via surrogate quantitative metrics like pupil size and skin response. On the other hand, externalized mental processes are associated with actions that are analyzed through methods such as process tracing and communication analysis.

Bringing collaborative technology to this fore raises many methodological concerns [41], The analysis must be multidimensional, since it must consider the individual, the group, and the *technological affordances* as units of analysis that mutually influence each other. Several models such as TAM [42] and TTM [43] have been developed to address these problems. One common characteristic of these models is the notion that both the technological affordances and the needs experienced by individuals and teams should be confronted.

TAM states that perceived usefulness and perceived ease of use are instrumental to determine the users’ behavioral intentions and consequently predict the human-technology interactions. TTM builds on TAM to incorporate other cognitive factors such as perceived frequency of net value and perceived magnitude of net value. Both models highlight the importance of the group in the construction of a positive or negative attitude towards the technological affordances.

According to several authors, two complementary research paradigms have been guiding the study of technological affordances: Behavioral Science and Design Science [44-46]. Behavioral Science develops models and theory explaining and predicting how humans and organizations behave. Causal models, and controlled laboratory experiments contribute to develop rigorous studies of team cognition. Nevertheless, the relevance of these results may vary, as pointed out by [47].

The Design Science paradigm has its roots on engineering and is primarily a problem-solving endeavor. It seeks to understand how technology may solve specific problems in particular domains. Thus, theory is subsumed by technology development. In this view, the Design Science paradigm emphasizes a cyclic approach where iterative developments followed by evaluation actions contribute to understand complex cognitive phenomena.

The Design Science paradigm targets practical knowledge construction. As such, its rigor has been questioned, mostly because it frequently relies on common sense and heuristics [48]. When contrasted with the Behavioral Science paradigm, the Design Science approach often lacks a commonly accepted reference model.

The strengths and weaknesses of these paradigms lead to their complementary use in technology development. Each paradigm may be viewed as one particular phase of the technology development lifecycle. The Behavioral Science studies contribute to establish the theoretical grounds for understanding human-human, human-technology and human-environment interactions, while the Design Science studies contribute with substantive test cases for the claims brought by behavioral studies [49].

Hevner [50] proposed a research framework that combines these two paradigms into three cycles: 1) the *relevance cycle* establishes that relevance is attained through the identification of requirements and field-testing of concrete technological affordances; 2) the *rigor cycle* posits that rigor is achieved by grounding the technological developments in solid conceptual foundations, including methodologies, models, and theory; and 3) the *design cycle* is responsible for the conception and implementation of technological affordances. We adopted this framework in our research.

2.1 Microworlds as a Design-Evaluation Tool

The emphasis on naturalistic environments to study team cognition and the interplay between the behavioral and design sciences in the development of technology that we identified earlier can be combined in *microworlds*.

Microworlds are carefully crafted to support the laboratorial manipulation of the task environment without removing its naturalistic characteristics [20]. An important feature is they explicitly handle the dynamic and emergent aspects of the task, a long-time prime concern of many decision-making studies, to the point that microworlds are also known as “management flight simulators” [51], which implies a degree of realism and engagement in the “games managers play” [52].

Microworlds have also been adopted in scenarios such as naval warfare [53], industrial process control [54], air traffic control [55], naturalistic decision-making [16], fire fighting [19], and other complex problem solving situations [17, 56], mostly for training purposes. The potential to deal with unpredictable events has also been investigated, uncovering many intricacies of cognitive behavior [21]. Thus, microworlds definitively address the relevance cycle.

A key aspect of microworld engagement is the dialog between mental models and the running simulation [57]. This is because disparities can happen between the beliefs people have about the environment and team behavior: the former is described by complex cause/effect networks, while the latter is oftentimes dysfunctional, unpredictable, and yet naturally emergent, revealing, for instance, contradictions in team strategies [52]. Consequently, microworlds enable teams to learn from empirical experimentation, and allow them to evaluate and redesign existing policies.

This kind of practical knowledge construction reflects the design cycle, which has also been applied to identify and resolve situation awareness problems in automation systems [58], to examine how human behavior varies with the design of the human-computer interface [22], and particularly, to augment the functionality of a preliminary tool for crisis response [59].

Furthermore, since microworlds can capture large amounts of data, which are necessary for hypothesis testing, they also definitely contribute to the rigor cycle. We may therefore hypothesize that microworlds may be excellent *design-evaluation* tools.

3. A CONCEPTUAL FRAMEWORK FOR MICROWORLD DEVELOPMENT

We define a set of requirements for the development of a Microworld supporting teamwork studies at the cognitive level:

1. **User engagement elements.** In order to experience realistic teams’ behavior the microworld environment must accommodate elements that promote engagement regarding the task and environment (these elements may range from representations that mimic real situation affordances to more sophisticated user immersion elements)

2. **Control the experimental conditions.** This requirement is at the core of any laboratory approach, on which Microworlds are grounded. It assumes that the experimental setting must be controlled to ensure precision and generalizability [60]. The Microworld should provide experimental control while at the same time preserving some degree of realism. For instance, controlling the chain of events while reproducing real-world incidents.

3. **Mediate interaction, communication and collaboration.** These are the foundational elements of team cognition. They emerge from the externalized mental processes and provide the outputs necessary to analyze team cognition. The Microworld should operationalize these outputs using a number of measurable metrics about human interaction, communication and collaboration.

4. **Accommodate testable technological affordances**. This requirement meets the fundamental tenet of supporting the design-evaluation cycle. The Microworld should smoothly integrate new technological designs in a way that ease innovation but also model building and rigorous testing.

5. **Execute experimental protocols.** The Microworld should be able to execute experimental protocols in accordance with a domain specification. The domain specification should account for the roles, tasks, messages, affordances and actions that constitute the teamwork setting.

6. **Collect experimental data.** The Microworld must capture and preserve data regarding interaction, communication and collaboration. This data should be kept in context with the environmental and task conditions that influenced teamwork. The granularity may range from the keystroke level to voice conversations. The flexibility handling various levels of detail is essential to feed teamwork analysis.

We note that exploratory studies may have to be conducted before starting a design-evaluation action using the Microworld. These exploratory studies generate the contextual information necessary to define the above-mentioned experimental protocols. These exploratory studies are also crucial to reproduce the application domain with some degree of realism.

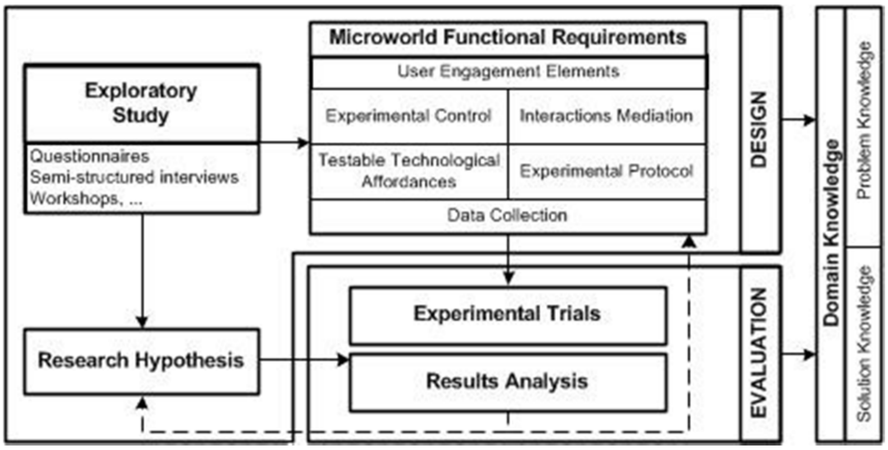


Figure 1. Microworld development framework

Figure 1 highlights the main concepts underlying the Microworld development. It positions the exploratory study as a first step leading to subsequent design-evaluation actions. The dashed arrows emphasize the iterative nature of the Microworld approach.

4. THE DEVELOPED MICROWORLD

4.1 Architecture

The developed Microworld adopts the client-server architecture shown in Figure 2. The client consists of four different applications:

1. **VoIP** (Voice over IP) application, which allows two team members to communicate with each other, emulating typical phone and walkie-talkie conversations;
2. **Task environment** application, which loads a set of rules and actions that the operators may accomplish in the environment, e.g. move around;
3. **Mobile Emulator**, which emulates a mobile device delivering the technological affordances under evaluation; and
4. **Freeze-probe Questionnaires**, which periodically freezes the task to inquire the team about a set of cognitive factors, e.g. situation awareness and sensemaking.

The server was developed as an application proxy that integrates the required server components of the client applications. The VoIPServer, manages the VoIP communications and the MobileServer, synchronizes clients running in the mobile emulator.

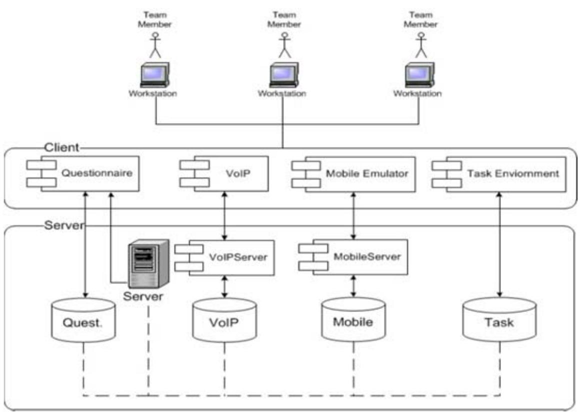


Figure 2. Microworld architecture

Complementarily, the server uses the applications supportive databases to maintain a coherent state between all applications (e.g. to know when to trigger the freeze probes and provide contextually bounded questions). The supportive databases accomplish two main goals: support the necessary data management to provide proper application functioning and persist relevant data for results analysis (e.g. task environment performed operations, freeze probes answers). The complete description of the databases structure is outside the scope of this work, nevertheless one may outline that the Task database holds the exercises description comprehending network structures, allowed operations, existing roles and respective operational profile.

4.2 Experimental set up and management

The major purpose of the developed Microworld is supporting laboratory experiments with collaborating teams while facilitating data collection and experimental control. We overview the main requirements previously discussed and briefly describe how they have been addressed in the developed Microworld in Table 1.

5. EXPERIMENT

5.1 Research goals

The research scenario involved helpdesk teams performing maintenance tasks on a network infrastructure after an unknown event had disrupted connectivity in some network links. These operations are typically distributed on the physical space and the teams rely on phone communications to coordinate their work. For a previous study on the requirements of help desk teams operating in CIRM scenarios see [11].

The main research goal was assessing the impact on team performance and TSA caused by using a collaborative application providing data sharing and task coordination. The hypothesis was that the application would improve performance and TSA. Two main collaborative settings should then be evaluated: one based solely on phone communications, and another combining phone communications with the collaborative application.

5.2 Experimental design

The experiment engaged 33 students from the final year of an undergraduate programme in Informatics and they had already completed a computer networks course. These students were knowledgeable about the task setting and goals. They were organized in 11 teams with three elements. A consent form was signed stating their commitment to the task and authorizing data collec-

Table 1. Experimental set up and management

Requirements	Issues addressed	Implementation
User Engagement	Elements promoting team commitment with the task	Two counts were provided to team members expressing: the total number of team actions and the total moves of team members through the environment (Team score was maximized with minimal counts)
	Task environment representation	A representation of the task environment is provided to teams.
Experimental control	Team size	Currently supports teams with three elements
	Team composition and structure	Different roles may be defined for each team element, distinguishing technological and also environmental actions
	Task complexity	Various tasks and operational environments, with different complexity levels (variety of actions and goals), may be uploaded in the Microworld
	Location of team members	The location of team elements in the physical environment may be emulated by the task environment application
Mediation	Human-human	VoIP application supports one-to-one voice communications
	Human-environment	A predefined set of actions that may be executed on the operating environment is uploaded in the Microworld
	Human-technology	The prototype component may be configured to emulate the user-interfaces and the functionality offered by collaborative applications
Technological affordances	Application design	Various application designs may be emulated by the prototype component
Experimental protocols	Practice task	The Microworld may instantiate a practice task, so that the operators may get familiar with the experimental environment
	Task completion time	The task duration may be defined in the task environment
	Freeze probes	Define moments when the task is frozen and the questions delivered to the operators
Data collection	Record operations	Support three main dimensions of analysis: performance, team processes and situation awareness

tion. Prize money and extra course credits were offered to the best performers to encourage deeper task engagement.

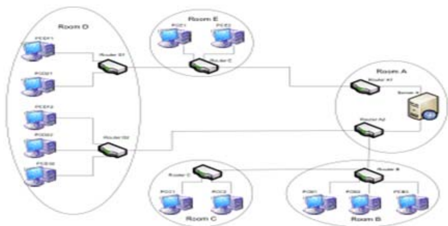
The Microworld was configured to support three different roles: 1) Team Member 1 (TM1) has high-level credentials, allowing operations on servers, routers, and computers; 2) Team Member 2 (TM2) has middle-level credentials, allowing operations on routers and computers, but not on servers; and 3) Team Member 3 (TM3) can only operate computers.

Before the experiment, the teams received a manual describing the experiment goals, roles, and tools. Briefing sessions were organized to clarify any doubts regarding the experiment.

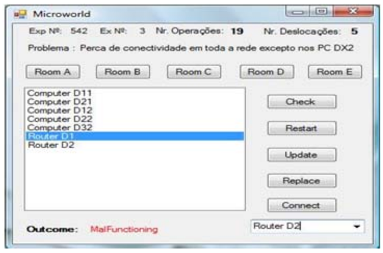
Four exercises were designed and loaded into the Microworld environment. The odd teams accomplished two exercises without the collaborative application support (W/O condition). The first one was for training purposes, while the second one was effective experimental data collection.

After the first two exercises, the odd teams were subject to two more exercises with the collaborative application support (W/ condition). Again, the first one was for training purposes while the second one was for data collection. Even teams performed in the reverse order.

Figure 3a depicts one of the network infrastructures loaded in microworld, which is operated through the task environment application component (screenshot in Figure 3b). Table 2 presents a sample exercise to be performed over the network. The questions used in the freeze probes during the data collection exercises are presented in Table 3. These questions are focused on evaluating situation awareness. Finally, Table 4 presents the set of measurements used to evaluate the research hypothesis.



a. Network Architecture



b. Screenshot of the task environment user interface

Figure 3. Example of a network loaded in microworld

5.3 Results

Concerning performance, [P1] in the W/ condition was significantly longer than with the W/O condition. Considering the data distribution, we used the non-parametric Wilcoxon signed-rank test for pairwise comparisons to evaluate the statistical significance of the results (Table 5). The analysis of [P2] and [P3] did not reveal any statistically significant differences. [C] is on the threshold of statistical significance urging that teams in the W/ condition perform fewer VoIP calls.

Three freeze probes were accomplished during the data collection exercises. [IA] was analyzed for each team role (TM1, TM2 and TM3) and regarding the three questions prompted by the freeze probes (Table 2). The collected data did not reveal any significant statistical differences between the two experimental conditions.

Table 2. Exercise Description

Reported problem	Connectivity lost in rooms B, C, E and Computers connected to Router D1
Problem source	Broken link between Router A1 and Server
Required operations (to optimal solution)	Connect Router A1 to Router A2, Update Router B, Restart Router C and Restart Router D1

Table 3. Questions used in the freeze probes

ID	Question
[Q1]	What are the states of the devices linked to the last operated device?
[Q2]	In what room are the team members currently located?
[Q3]	Which devices are currently constraining the network connectivity?

Table 4. Measurements

ID	Metric	Description
[P1]	Completion Time	Time to complete the exercise
[P2]	Efficiency	$\frac{\text{ideal number of operations to solve the exercise}}{\text{number of operations in the virtual network}}$
[P3]	Efficacy	$\frac{\text{number of working devices}}{\text{achievable number of working devices}}$
[C]	Communication	number of VoIP communications
[IA]	Individual Awareness	$\frac{\text{number of correct items in freeze probes}}{\text{number of questioned items}}$
[ShA]	Shared Awareness	Overlap: $\frac{\frac{2}{3}*\#\text{paired answers} + \#\text{triple answers}}{\text{number of common itens in the question}}$ Precision: $\frac{\text{number of correct answers}}{\text{number of common answers}}$
[DA]	Distributed Awareness	Team average of individual scores in the freeze probes

Table 5. Performance

Metric	W/O	W/	*p* value
[P1]	8.23	10.55	0.016
[P2]	0.78	0.76	0.56
[P3]	0.97	0.98	0.51
[C]	10.09	7.73	0.05

Regarding [ShA] we defined two dimensions of analysis: the overlap of answers between team members (common knowledge) and the precision of the answers (the extent that such knowledge is correct). Table 6 summarizes the achieved scores regarding the three questions during the three freeze probe iterations.

[Q1] scores exhibit a growing knowledge overlap between the first freeze probe and the second and then maintain similar scores at the final freeze probe. The precision scores indicate that the existing overlap is highly accurate regarding the real situation. Nevertheless, no significant differences are observed between the two experimental conditions.

Overlap scores and particularly precision regarding [Q2] decay as exercise evolves. Besides the first freeze probe overlap score and the precision scores in the two first freeze probes reveal slightly better in the W/ condition, no statistically significant differences were found.

[Q3] exhibited the lower overlap scores of the three questions and had kept low through all the freeze probes. Despite the poor common knowledge achieved regarding [Q3] it was accurate, considering the precision scores. Particularly, although without yielding a statistically significant difference, in the W/ condition teams achieved better precision as exercise evolve.

The analysis of distributed awareness [DA] was based on the average scores of individual answers to the freeze probes of [Q1, Q2, Q3], constituting an aggregated measure of team knowledge considering the team as the unit of analysis (actionable knowledge existing in the team). Despite the results again not revealing any statistically significant differences between conditions, a more detailed analysis provides interesting insights about the evolution of [DA] over time.

[Q1] shows a slight improvement from the first to the second freeze probe, and then reached a plateau in the third iteration (Figure 4). The answers to [Q2] reveal that as the exercise unfolds the teams loose awareness of where the others are located. However, the W/ condition obtains better scores than the W/O condition (Figure 4). Finally, [Q3] shows that the teams improved their aggregated situation awareness throughout the freeze probes, with a slightly advantage obtained by the W/ condition.

6. CONCLUDING REMARKS

Grounded on previous research streams emphasizing the importance of studying human action in naturalistic settings, i.e. as closer as possible to real operating environments, we have researched the adoption of Microworlds in the study of teamwork at the cognitive level. We have specifically focused on the challenging context of CIRM, where access to real operating environments often reveals difficult or even impossible.

We defined a set of requirements these Microworlds should accomplish to support teamwork studies. Based on these requirements, we developed a Microworld. The capacity of the Microworld to capture experimental data at the cognitive level was evaluated. Along the development process, we also assessed the Microworld's capacity to control the experimental setting and to facilitate the experimental set up and management.

The extensive study briefly reported in this paper demonstrates the relevance of the Microworld approach. In the one hand, it serves to collect large amounts of varied cognitive-level information. In

Table 6. Shared awareness scores

	Iteration 1				Iteration 2				Iteration 3			
	Overlap		**Precision**		**Overlap**		**Precision**		**Overlap**		**Precision**	
	w/o	**w/**	**w/o**	**w/**	**w/o**	**w/**	**w/o**	**w/**	**w/o**	**w/**	**w/o**	**w/**
Q1	0.26	0.25	1.00	1.00	0.57	0.63	0.95	1.00	0.62	0.60	0.99	0.98
Q2	0.75	0.81	0.78	0.93	0.68	0.63	0.61	0.71	0.65	0.63	0.42	0.41
Q3	0.09	0.06	0.96	0.86	0.10	0.09	0.75	1.00	0.14	0.13	0.86	0.93

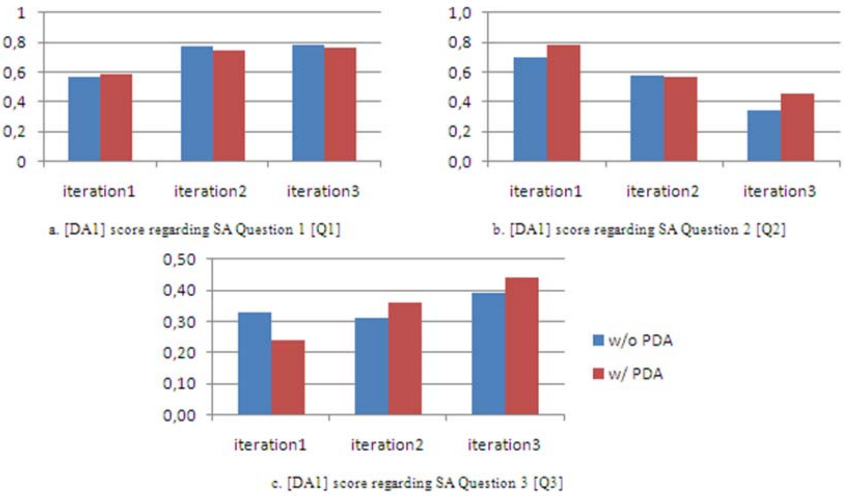


Figure 4. Distributed awareness [DA]

the other hand, it also facilitates de definition and execution of the several experimental conditions necessary to obtain the experimental data.

As it is often the case, the concrete experiment reported in the paper does not reveal a breakthrough technological solution to improve the teams' performance (considering the tested collaborative application). It nevertheless allowed us to analyze at the cognitive level how the collaborative application was used by the teams, and also why significant differences do not actually occur. We therefore conclude that the Microworld environment proved to be a rich and systemic data collection medium and provides solid grounds for consistent data collection and analysis.

7. ACKNOWLEDGMENTS

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