Improvement of Interactions in Interactive Environments and Knowledge Management from the Distributed Cognition Approach

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Abstract: In the field of Computer Supported Collaborative Work and Knowledge Management supported by computer, the cognitive and sociological dimensions can not be neglected in the accessing analysis of their designs. The material and social environment models the cognitive processes since the vast majority of them are mediated by interaction with other agents and other artefacts. Following these premises, in this work, a methodological framework for the analysis of the interaction between agents in a socio-technical system is applied, based on the approach of distributed cognition, oriented to the knowledge management, in an academic context at the upper university level. In particular, the analysis focuses on the interactions of cognitive agents, that occur during the cycle of knowledge management (activities of using, creating, distributing and sharing knowledge), and on how coordination, communication and collaboration is affected, which are key aspects of group work. From the problems detected in the interactions, changes are proposed in the design of the interface of the artefacts, where the interactions between agents in the cognitive system are reflected.

1 INTRODUCTION

The collaborative contexts in the domain of CSCW (Computer supported Collaborative Work) and Computer-supported Knowledge Management have cognitive and sociological dimensions that cannot be neglected in the evaluative analysis of their designs. The physical and social environment models the cognitive processes since the vast majority of them are mediated by interaction with other agents and other artifacts. Computers connected through the Internet are becoming key elements of these interactions. Human beings generate cognitive potential by creating and actively modifying the environment in which cognitive operations are performed (Feltrero Oreja, 2003). If it is admitted that the user interface, as a key element of a computer, is part of this cognitive environment, then the user interface presents very relevant cognitive characteristics that will determine the type of activities and social relations mediated and enabled by technologies.

Within the field of psychology, the Distributed Cognition (CD) theory offers a framework for analysis to describe human work systems or socio-technical systems, in computational and information terms, and is useful for the design of technology as mediator of collaborative social activity. For this reason the distributed cognition constitutes an important theory for the field of Man-Computer Interaction, and in particular for person-computer-person interaction in the field of CSCW (Horsky, 2008).

The aspects of human cognition inherent to the context of distributed work with active social agents and tools are generally not taken into account when designing and developing information technologies. In this work we aim at the proposition of applying a Framework for Analysis of Interactions between Agents called MAIA, proposed by (Ferruzca Navarro, 2008) for the evaluation of the usability of a distributed work system, ReSU (Lescano et al, 2011), under the theoretical framework of the theory of distributed cognition. This analysis would lead to the redefinition of the components of the ReSU

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system, based on the foundations of distributed cognition in the applied analysis framework. This analysis will focus on detecting the inconsistencies that may exist during the interactions occurring in the process of knowledge management (use, creation, distribution) and on discovering the nature of these interactions through the application of an adapted distributed cognition model. The aim is to improve the technological tool in order to achieve a better cognitive distribution that favors the interactions involved in the management of knowledge when the partakers work in a collaborative group.

2 MOTIVATION AND BACKGROUND

This work is part of a larger research that tries to determine the way in which the physical and social environment models the cognitive processes of people, when they work with artifacts or with other agents in technology mediated environments. It specially aims at enlightening the aspects of distributed cognition and their incidence in contexts of computer-mediated collaborative work and knowledge management.

Taking into account this vision and interdisciplinarity, we will pinpoint some proposals that are more related to the treated topic.

In (Feltrero Oreja, 2003), a global perspective of philosophical and cognitive type is developed for the evaluation of the interfaces in the IHC field. It is here considered that people create cognitive potential through a dynamic transformation of the environment in which cognitive operations are performed. If the user interface is part of the cognitive environment, the ability to autonomously and actively configure the interface and to exploit all its possibilities is revealed as a basic cognitive tool. In this sense in (Feltrero Oreja, 2003), general philosophical and axiological criteria are proposed so that the design of the interfaces in the field of human-computer interaction considers mechanisms such as referential multimodality and dynamic configuration, according to their own needs and skills. It provides general value principles that guide the design of interfaces.

Another analytical framework is the one developed by (Hussain y De Brujin, 2010), based on the CD approach to guide the evaluation of a collaborative design task around an interactive table. The theoretical approach is useful to understand how people collaborate around the table by analyzing the relationship between actors, artifacts and the contexts in which interactions occur. It is possible to identify the representations that flow through the functional systems as objects of analysis, which allow the researcher to reason about the design and cognitive artifacts within the same conceptual framework. This analytical framework provides a deep understanding of how representations were created, and how this framework contributes to problem solving in a collaborative design environment, ultimately identifying the design features that best support collaborative activities. It is also useful for defining the limits of the unit of analysis and for guiding the analysis of the data.

In contrast to the particular-oriented approach, that is generally used for the application of distributed cognition, in (Nobarany et al, 2012) AnalyticStream is proposed as a system to perform a high-level analysis of the project situation and identify the cognitive processes that can be distributed through people to facilitate collaboration. Based on the ideas of distributed cognition, a process is designed to facilitate the recommendation of relevant elements of analysis, as well as a mechanism for the attention management that allows users to have greater control over their flows of shared activities. A study of the AnalyticStream mixed methods shows that the suggestion of relevant artifacts facilitates the discovery and consequently the feasibility of reusing them, and provides awareness of relevant aspects of the context on the activities of other analysts.

More recently, in (Moran et al, 2011) they apply the DCog (Distributed Cognition) approach to study the interaction between agents (human beings or artifacts) in a system, in the same way as the collaboration that can be distributed during air traffic control. The intention is to extract tacit knowledge from observations of the cognitive system, which can be derived from identification of trajectories and the grouping of agent information actions/activities into specific abstract processes. From this perspective they analyze how information is transferred through a system and identify specific areas in which pervasive technology can be introduced. However, they found difficulties related to the contextualization, systematization and excessive time that is taken in the analysis, and thus realized the need for a tool to support this type of analysis, guide the researcher, and reduce the amount of time spent on analysis. They proposed a prototype software, TITAN, designed to support DCog analysis. This tool can be used to support the identification and introduction of new pervasive

technologies to improve system information processing.

Finally, the methodological framework DiCoT (distributed cognition for teamwork) based on distributed cognition is presented by (Vasiliou, 2015), to explain interactions and interdependencies during collaborative learning activities in an ecology of artifacts. They broaden the framework and validate its applicability by understanding how groups of students interact and collaborate, and indicate aspects of redesigning to enhance a learning environment supported by a physical and digital artifact ecology.

Although CD theory has been frequently used to study activities in various work scenarios, (Edmondson y Russell, 2008) (Horsky, 2008) (Mansour, 2009) (Nilsson et al, 2012) (Rajkomar and Blandford, 2011) there are few applications related to collaborative work and knowledge management environments supported by computer in the academic training.

3 PRELIMINARY RESULTS

This section explains the steps taken to apply the Framework of Analysis of Interactions between Agents in the analysis of the interactions that are created during a process of knowledge management (use, construction, distribution), based on the perspective of distributed cognition.

A case of analysis is presented, where students of a higher level solve problems in a group work and collaborative way, mediated by ReSu, a tool oriented to knowledge management. Different stages are carried out in which the following results have been achieved.

First stage: Representation of the ReSU system from a cognitive approach

At this stage, ReSU is displayed as a cognitive system in which structural agents (subjects, artifacts, product, organization and environment) and articulation agents (objectives and tasks) are identified. By means of this identification procedure, concepts of distributed cognition are implemented in a structured way, and a conceptual and graphical representation of the cognitive architecture of the system is achieved.

Second Stage: Cognitive analysis unit's identification

Based on the agents that were identified in the first stage, the aimed aspects to by studied, mainly the interactions which occur in the process of knowledge management are defined. Therefore, the agents and the interactions between them (student-pupil, student-teacher and pupil-artifact) are selected as units of cognitive analysis, and is evaluated with the aid of the use of the system artifacts (forum, Chat, wiki) if the interactions between agents contribute to the construction, distribution and use of knowledge.

The selection of agents as a cognitive unit is consistent with the cognition distribution approach centered on the subject, based on the observation of the use of sign systems (semiotic mediation), the evolution of the intersubjectivity processes (construction of shared meanings), the role of experience in human development, the coordination between the internal structure (mind) and the material structure (artifacts, environment), and finally, the use of other human agents as cognitive resources in the development of activities presented as units of analysis (idea linked to the "proximal development zone").

Third stage: Data collection

To collect data on interactions, two questionnaires one for the student and the other for the teacher are designed. The purpose is to get answers that help detect if the resources implemented as knowledge management strategies by ReSU are adequate to promote communication and academic exchange between agents, i.e., if the distribution of cognition on the system is favored. On the other hand, we try find out the perception they have about the effectiveness and efficiency with which they have worked, and the ease and satisfaction of using the artifacts. This information will serve to identify the problems of usability of the system. (Rearte et al, 2014)

In order to design the questions, constructs (concepts, dimensions, factors or variables) are taken into account from which it is expected to obtain information. From the answers in the questionnaires, we need to extract meaning units, namely, fragments of text that represent indications of some problem that occurred during the interactions. Each meaning unit is categorized according to the type of interaction involved (student-pupil, student-teacher and student-artifact).

Fourth stage: Analysis of the units of significance

Units of significance are illustrative and serve as a guide to interpret problems or failures occurring during interactions. Each unit of significance, which represents some detected inconsistency or failure, is represented by a causal diagram, representing the probable issues and its causes. As an example, two causal diagrams are presented, one obtained from

the answers given by the student and another from the answer given by the teacher:

```
Issue "Difficulty editing wiki pages"
Cause Because "the toolbar has few
      editing options."
Cause Because "the wiki uses a
      marked language (Wiki text),
      for editing the pages."
```

To provide a solution to this problem, ReSU is included in an "Improved tool bar" to edit wiki in a simpler way. New features are added that facilitate users to build pages and enrich them including images, tables, lists, in a simple way, without the need to use the proper marked language of the wiki. Improving these aspects has as a result the improvement of the usability of the tool, and therefore it facilitates the student work.

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Issue "Lack of online evaluation
      mechanisms in wiki"
Cause: Because "It is not possible to
      track the progress of the work
      from the application."
Cause: Because "The tool does not
      allow the teacher to give
      feedback to the work group."
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In this case is proposed to make changes in the interface and to include some functionalities in the system. In order to solve the detected problem, an "Online monitoring" tool is included in the system, which enables the teacher to follow up the process while the groups are working. Using the tool, the teacher visualizes the evolution of the work, and can make recommendations or observations, which can be taken into account by the group. This improvement of the tool constitutes a scaffolding for the activity of the group of students, allowing the intervention of the teacher as mediator and facilitator in the construction of knowledge. Under the metaphor of scaffolds, the function of mediation does not derive strictly from the technological stuff, but from the support it offers to the teacher to mediate the collaborative construction of knowledge through scaffolds in space that is created as a "proximal development zone".

Other modifications that have been made in the tool, are related to the incorporation of a chat included in the wiki, since many students considered it uncomfortable to move out from the work environment to communicate through the forum with the other members of the group. A conflict management mechanism is also implemented when working simultaneously on a wiki.

At last, aspects of safety in the access to the area of each group are considered.

From these changes, the verification of the improved tool is proposed by replicating the collaborative group work experiments, to check if these new resources contribute favorably in the cognition distribution of the system.

4 CONCLUSIONS

In this first part of the process, the framework of analysis of interactions between agents has facilitated the structured application of the main concepts of distributed cognition in a system for the formation of collaborative type and oriented to knowledge management. Regarding the distributed cognition approach, its usefulness has been proven since it brings you towards a detailed level of analysis, which can offer clues on how to change the design of an technological artifact. As a pending work, this should continue with the design of new collaborative group work experiences to solve problems, to check if it contributes to the cognitive distribution in knowledge management cycles, taking into account the new artifacts incorporated into the system.

In carrying out this work, it has aroused different concerns, which are considered as future works. We would like first to deepen the determination, scope and implications of the models of distributed cognition in the collaborative and knowledge management systems; emphasizing the aspects of platform, proximal development zone, semiotics, as aspects of interest for Distributed Cognition.

Secondly, to delineate a more systematized prescriptive and proscriptive framework, to guide the analysis, from the first stages (formulation of guiding questions, selection of aspects and factors to be analyzed) to the discovery of problems and their causes, which will lead us to decisions for the improvement and redesign of both cognitive and physical artifacts. Thus to incorporate mechanisms that facilitate the logical linkage of the data with the criteria to interpret the results.

Finally, to generate automated tools that support the analysis of the inherent aspects of distributed cognition, in order to make the analysis more accurate, to register the representational states that are happening as the cognitive processes are distributed. Ultimately, a way to reflect a cognitive architecture and determine if it favors or not the way to distribute the cognition in environments supported by technologies.

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