A process to improve Collaborative Work through shared understanding in problem-solving activities

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Abstract. Collaborative work is becoming increasingly complex and assertive communication is necessary to solve problems in collaborative activities, where the actors must coordinate so that the group works effectively and efficiently. However, achieving true collaboration is not an easy task, there are many factors that influence its achievement, where many of these have been investigated, but the analysis of critical cognitive factors is very scarce, and more those that allow good communication and consequently good coordination. One of them is shared understanding since when working collaboratively there must be common knowledge and understanding, which works as a joint reference base to work effectively and efficiently. Therefore, this work seeks to define a process to improve collaborative work through the construction, monitoring, and assistance of shared understanding. The process has had several versions and each of them has been validated in different contexts, obtaining different types of results, both in terms of its specification and formalization, as well as in terms of its use related to ease of use, feasibility, and usefulness in the construction of shared understanding, which has allowed improving the aspects that have been identified. Through a final validation in a case study, it was determined that the process does improve collaborative work, however, it is still necessary to have technological support elements and it is necessary to lighten the elements that compose it to make it more agile to use.

Keywords. Collaborative work, Shared understanding, Problem-solving activities, Improved CSCW.

1 Introduction

Working collaboratively is not an easy task [1], wrongly it has been believed that having the technological infrastructure guarantees effective collaboration [2], so it

arises the Computer-Supported Collaborative Work (CSCW) concept, which is a multidisciplinary research field that focuses on tools and techniques to support multiple people to achieve a common goal [3]. But to ensure effective collaboration, some external factors should be further analyzed [4], such as the design of the activities, tasks and steps that compose it [3]. In this sense, Collazos [5] in his research divided Computer-Supported Collaborative Learning into 3 phases (work that served as the basis for this research, where the process elements were adapted and improved). The Pre-Process phase begins with the activity design and specification, in the Process phase, the collaboration activity is executed, and finally, the Post-Process phase, a review is carried out to verify the achievement of the proposed objective. Improvements have been made to collaboration in the context of learning [5], [6], [7], and in different aspects of collaborative work [8], [9], [10]. with particular attention paid to the processes and tools provided to aid communication and interaction; but the critical cognitive aspects that ensure that the team works collaborative- ly effectively and efficiently are often absent [11]. One of these cognitive processes is shared understanding, which refers to when group members share a perspective (mutual agreement) or can act in a coordinated manner [12].

Considering the above, it was proposed in this research to define a process (In two levels: the conceptual level that defines the how and a technological level that provides technological support to achieve it) to improve CSCW through the construction, monitoring, and assistance of shared understanding in problem-solving activities. The main objective is to improve collaborative work, making use of the shared understanding benefits in a specific context of problem-solving activities.

2 Problem statement

One of the main collaborative work problems is that collaboration success is hard to achieve [13]. At the same time, collaboration does not occur as easily as one may expect [4], and it is difficult for all the members of a group to participate effectively in the development of the idea with all the other members, and even more so with people who are geographically distant [14]. In this sense, collaboration is defined as "… a coordinated, synchronized activity that is the result of a continued attempt to construct and maintain a shared conception of a problem" [15]. It follows from this definition that, for collaboration to occur, there must be a shared understanding of the problem being solved, thus, being an important determinant of the performance of collaborative groups [16]. Therefore, seeking to improve collaborative work, may consist of finding the application of techniques that support the creation of a shared understanding in heterogeneous groups, it is expected that these groups gain efficiency in their work and produce better group results [17].

Considering the literature, there are some problems related to shared understanding, lit- tle attention has been paid to the systematic development of the processes that lead to shared understanding [18]. and the specific patterns that lead to its construction are not known [19]. Therefore, the practitioners need guidance on how to evoke the processes deliberately and repeatedly [19].

Considering this, the research question was: *How to construct, monitor, and assist the Shared Understanding for improving the CSCW in problem-solving activities?*

3 Research Methodology and Approach

To achieve the objectives of the project, the scientific method described by Bunge [20] was selected as the research framework, which was executed in an iterative and incremental manner. Also, this framework was adapted, and the three cycles defined by the multi-cycle action research methodology with bifurcation [21] were used. The first cycle refers to the Conceptual Cycle, where the research topic is identified, the analysis of the relevant literature is performed, a plan and design of the research project is made, and as a mile-stone, the problem statement is obtained. The second cycle refers to the Methodological Cycle, where the steps for the definition of the process are executed and what was planned in the previous cycle is implemented; it is here where the research disciplines are executed, the main activities proposed by Bunge [20], and the defined and validated process is obtained as a milestone. Finally, the third cycle refers to the Evaluation Cycle, where the research is supervised, and the validated hypothesis is obtained as a milestone.

4 Evaluation Plan

To validate the process, five iterations were carried out, where each version of the process was validated, considering the results obtained in the previous iterations:

- First iteration: The existing processes and elements of a collaborative learning activity were analyzed. Subsequently, with the review of the literature and the identified opportunities for improvement, the elements of collaborative work and those that allow the construction of a shared understanding were analyzed. With this, the first version of the process was defined, which contained 2 phases, the Pre-Process phase, and the Process where shared understanding is built [22]. This version was validated through an exper iment with a group that used the process and a control group that did not, validating its feasibility and usefulness [23]. In addition, an exploratory study was conducted to validate if promotes and improves shared understanding [24].
- Second iteration: Version 2 of the process was defined, which was validated by experts in software and process engineering, who validated the syntax and semantics of the process, in such a way that some errors were identified in the process specification made in SPEM 2.0 [25] were identified and a validation was also performed with AVISPA-Method [26] to make a visual analysis of the process model [27].
- Third iteration: A third version of the process was created, which was called THUNDERS (CollaboraTive work through shared UNDErstanding in pRoblems-solving activities), was applied in an academic context to validate whether THUNDERS promotes and improves shared understanding in a problem-solving activity. This version was also applied in a requirement engineering context,

validating its completeness and usefulness [28].

- Fourth iteration: Version 4 was generated and was subjected to validation by experts in collaboration issues, in order to select the tasks that are or are not mandatory in the execution of the process, with the objective of lightening and simplifying it, and allowing to obtain new processes for specific contexts, being as extensive or light as required, depending on the characteristics of such contexts.
- Fifth iteration: Corrections and updates were made, thus generating version 5, which was validated in a case study, with a group that used THUNDERS and a control group that did not use it, analyzing that its application does improve collaborative work.

5 Conclusions

As a result of this research, the characterization and materialization of the process were obtained, in which different elements of collaborative work are conceptualized, related, collected, and proposed, such as: instruments, strategies, measurement mechanisms, tools involved, and necessary in the construction of shared understanding in problem-solving activities, with formation of heterogeneous groups, from the moment a collaborative activity is designed, executed and the fulfillment of the solution of the problem and the proposed objectives is validated. Proposing a formal and enriched process with activities, tasks, steps, roles, flows, and work products (inputs, outputs, assistance documents), which when applied supports the improvement of collaborative work through the construction, monitoring, and assistance of shared understanding, obtaining better results and achieving the objective of the activity.

In the process of building THUNDERS, several iterations were carried out that allowed the construction in an iterative and incremental way, achieving that the process in the versions that were built was feasible, useful, complete, promoted, and improved shared understanding, and finally, it was obtained that the complete process improved collaborative work, applying it in the context of education and software development. This provided the community with empirical evidence on the construction of shared understanding, its measurement, and the strategies to achieve it, in collaborative problem-solving activities.

6 Ph.D. Stage

Late Stage

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