Technology Selection to Improve Global Collaboration

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Abstract

Global software development projects face up a variety of challenges respect to communication and control that need to be solved or, at least, minimized. For that reason, processes crucially based on communication, like software requirements elicitation; have to be rethought in such a new context. Since requirement elicitation is a human-centred process, we propose using techniques from the field of cognitive psychology to define a strategy for selecting technology. With this goal, this paper introduces our approach and illustrates how cognitive styles might be used to improve a distributed process by selecting suitable groupware tools and elicitation techniques according to the characteristics of stakeholders.

1. Introduction

Previous works have analyzed the more problematic factors of Global Software Development (GSD), concluding that lack of face to face interaction, time difference between different sites and cultural diversity affect communication [7]. Also during software requirement elicitation, lack of fluent communication is one of the most important challenges in discussion [19]. For those reasons, when analyzing virtual teams working on requirements definition, minimizing communication problems becomes crucial to assure the quality of the software in construction.

Having the main goal of improving communication in virtual teams during the requirement elicitation process, we looked at concepts from two research areas: CSCW (Computer-Supported Cooperative Work) and Cognitive Informatics. On the one hand, since people are distributed along many distanced sites, they must communicate each other using software, called groupware, which is part of the studies of CSCW, a research area that focuses on the development of technology for communication as well as the study of humans when working in group. Some examples of groupware tools used during multi-site developments are e-mails, newsgroups, mailing lists, forums, bulletin boards, shared whiteboards, document sharing, chat, instant messaging, and videoconferencing [7, 13]. They can be classified as synchronous or asynchronous depending if the users have to work at the same time or not [8]. According to GSD literature, both categories are important in group work, because asynchronous collaboration allows team members to construct requirements individually and contribute to the collective activity of the group for later discussion (especially when groups are distributed across time zones), and real time collaboration and discussions are necessary components of group Requirements Elicitation (RE) sessions to give stakeholders the chance of having instant feedback [11]. However, is also true that sometimes people are

IEEE International Conference on Global Software Engineering (ICGSE'06)
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keener on one kind of collaboration than the other. So, as communication among people involves aspects of human processing mechanisms that are analyzed by the cognitive sciences, we decided to look for references into the Cognitive Informatics, an interdisciplinary research area that applies concepts from psychology and other cognitive sciences to improve processes in engineering disciplines like software engineering [17].

After analyzing varied psychological issues, we set our interest in using some techniques called Learning Style Models (LSMs), which may be useful to select groupware tools and elicitation techniques according to the cognitive style of stakeholders [2, 3]. Most of related works using LSMs in informatics concern only educational purposes, such us their influence when learning recursion or programming [16, 18]; and also to define frameworks for designing multimedia courses [4, 15]. On the contrary, few related works use psychological techniques to solve communicational problems in Software Engineering. One work on this direction is the use of cognitive styles as a mechanism for software inspection team construction [14], that describes an experiment to prove that heterogeneous software inspection teams have better performance than homogeneous ones, where heterogeneity concept is analyzed according to the cognitive style of participants. Even when they also used the concept of cognitive styles to classify people, our approach is different because, as we have explained previously, we do not try to say which people seem to be more suitable to work together. On the contrary, our goal is choosing the best strategies to improve communication for an already given group of people.

Having this in mind, we will give an introduction to some basic concepts about cognitive informatics and learning styles models, and we will introduce a methodology, based on concepts from fuzzy logic, to select groupware tools and requirement elicitation techniques. The last sections will present the results of an interesting survey we have carried out, as well as conclusions and guidelines for future work.

2. Relating Cognitive Psychology and Software Engineering Processes

Cognitive Informatics relates cognitive sciences and informatics by using cognitive theories to investigate and look for solutions to informatics, computing, and software engineering problems [6]. That give us a base to use concepts from cognitive psychology (which concern the way people attend and gain information and how these information processing mechanisms affect human behaviour), to improve the requirement elicitation process.

Part of cognitive psychology theories are cognitive styles, which classify people's preferences about perception, judgment and processing of information [14], with the goal of analyzing and understanding differences in human behaviour. With the same idea, learning styles models (LSMs) classify people according to a set of behavioural characteristics that concern the ways people receive and process information, while their goal is improving the way people learn a given task.

So far, LSMs have been discussed in the context of analyzing relationships between instructors and students but we propose taking advantage of this kind of models by adapting it to virtual teams that deal with distributed elicitation processes. To do so, we consider the following analogy between stakeholders and roles in LSMs: as Hickey and Davis have mentioned, elicitation is about learning the needs of the users [12]. From our point of view, users and clients also learn from analysts and developers (for instance, they learn how to use a software prototype or a new vocabulary). Taking this into account we can say that during the elicitation process everybody "learns" from others.

The model we have chosen as the basis for our research is called the Felder-Silverman (F-S) Model. This model was selected after studying different LSMs. The analysis shows that the F-S model is the most complete because it covers the categories defined by the most famous LSMs (like the Myers-Briggs Indicator Type, the Kolb model, the Herrmann Brain Dominance Instrument, etc.) and, additionally, the F-S model has been widely and successfully used with educational purposes in engineering fields [10]. The F-S Model introduces four categories (Perception, Input, Processing and Understanding), each of them further decomposed into two subcategories (Sensing/Intuitive; Visual/ Verbal; Active/Reflective; Sequential/Global) as it is shown in figure 1.

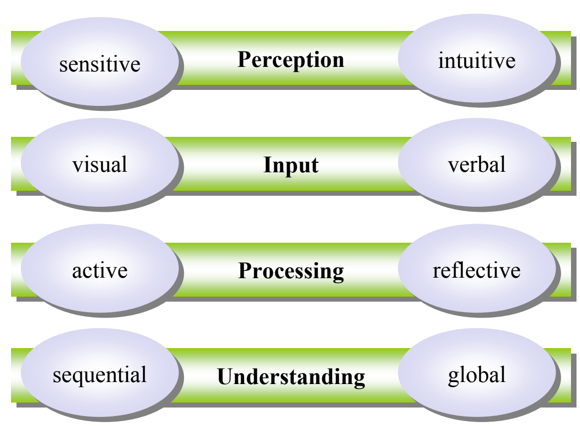

Figure 1: Felder and Silverman categories and subcategories

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Characteristics of each subcategory [9] are:

- *Sensing people* prefer learning facts and solving problems by well-established methods, while *Intuitive people* prefer discovering possibilities and relationships, and dislike repetition.
- *Visual people* remember best what they see (such as pictures, diagrams, flow charts, time lines, films, and demonstrations). On the contrary, *Verbal people* get more out of words, and written and spoken explanations.
- *Active people* tend to retain and understand information by doing something active with it (discussing or applying it or explaining it to others). In contrast, *Reflective people* prefer to think about information quietly first.
- *Sequential people* tend to gain understanding in linear steps, with each step following logically from the previous one, whereas *Global people* tend to work in large jumps, absorbing material almost randomly without seeing connections, and then suddenly "getting it".

People are classified into the different categories by filling a multiple-choice test, available on the WWW (http://www.engr.ncsu.edu/learningstyles/ilsweb.html), which returns a rank for each subcategory. Depending on the circumstances, people may fit into one category or the other, being for instance, sometimes active and sometimes reflective; so preference for one category is measured as strong, moderate, or mild.

According with their authors, people with a mild preference are balanced on the two dimensions of that scale. People with a moderated preference for one dimension are supposed to learn more easily in a teaching environment which favours that dimension. Finally, people with a strong preference for one dimension of the scale may have difficulty learning in an environment which does not support that preference. With the goal of making everybody feel comfortable in the virtual environment, we propose choosing groupware tools and elicitation techniques more according to their learning styles, as we explain in the next section.

3. Supporting Personal Preferences in Distributed Requirement Elicitation

In order to support personal preferences when selecting technologies for virtual teams we propose a methodology that comprehends a series of phases which are summarized in figure 2.

Our methodology of selection is based on concepts from fuzzy logic and fuzzy sets [1], which are used to obtain rules from a set of representative examples, in the way of patterns of behaviour.

The methodology is divided into two big stages: the first one is independent of any project and comprehends phases 1 to 4, and the second one is dependent of a given project and covers phases 5 and 6.

Phases 1 to 3 are about looking for a set of examples (which are real data about preferences of stakeholders in their daily use of groupware tools and requirements elicitation techniques), and analyzing them to discover their relationship with classifications in the F-S model.

During the **Phase 1** we ask a wide set of people to fill the learning style test and obtain their classification for F-S Model. In **Phase 2** the same people are required to express their preference about groupware tools ("Which is the groupware tool you feel more comfortable using it to communicate with your partners?"). And in **Phase 3** people are required to express their preference about requirement elicitation techniques ("Which is the requirement elicitation technique you feel more comfortable using it during an elicitation process?"). The way we can obtain examples for groupware tool is quite straightforward: people use email, instant messaging, and chat quite normally in their life and even if they have never used videoconferencing or shared whiteboards they can easily imagine how they would feel about them, so a simple question is enough to get an output variable for our model. On the contrary, selecting a requirement elicitation technique it is not so easy because analysts usually know a couple of techniques and users and clients usually do not know any. Then, in order to get a ranking of preferences for elicitation techniques we need to develop a series of experiments so as, after some training in a set of requirement elicitation techniques, we could ask stakeholders about their experience with each one.

Once phases 1 to 3 have been completed, we would count with two sets of examples: θ_1 and θ_2, where θ_1 represents stakeholders' preferences for groupware tools and θ_2 represents stakeholders' preferences for requirement elicitations techniques.

Each set of examples would be represented like $\theta = \{e_1, e_2, \ldots, e_m\}$, where each example e_i has the form $\{(x_{i1}, x_{i2}, x_{i3}, x_{i4}), y_j\}$. In such a context the values x_{i1}, x_{i2}, x_{i3}, x_{i4} represent the rank for each category of the F-S Model, and y_j is the output variable that represents the preference of a particular person. Each x_{ij} takes a value from a set we have defined for each category of the F-S model, for instance by using the adverbs (and their correspondent abbreviations): Very (V), Moderated (M) and Slight (S), that correspond to *strong*, *moderate* and *mild*, respectively, in the F-S model (we have chosen the adverbs in that way to avoid confusion with respect to the use of the first letter).

For instance, the probable values for the variable x_{i3} that represents the preferences for the category Reflective-Active, would be: Very active (VAc), Moderately active (MAc), Slightly active (SAc), Slightly reflective (SRe), Moderately reflective (MRe), Very reflective (VRe).

Following the same format for the rest of the categories in F-S model, a possible instantiation of an example in the set θ_1 would be {(MIn, MVi, VAc, SSq), videoconference} and for the set θ_2 would be {(SIn, VVi, VAc, VSq), prototype}.

Once we count with both sets of examples, θ_1 and θ_2, it is time to obtain the preference rules that will support the technology selection in future. To do so, in **Phase 4**, we propose using a machine learning algorithm to analyze the examples in a systematic way, and generalize common features or patterns of behaviour.

The algorithm we have chosen to obtain the preference rules is the one proposed in [5] that finds a finite set of fuzzy rules that reproduce the input-output system's behaviour. We have selected this algorithm because it was designed to obtain rules with a maximum degree of generality. To do so, it reduces the antecedent part of the rules as much as possible so as to obtain rules that can be easily understood and highly approximated to the real-life examples.

In short, the mechanism can be explained as follows:

- Convert each example in one rule.
- Remove from the initial set those rules that are the same.
- Analyze every initial rule so that (whether it is possible) to extend it and generate a definitive rule.

Using this machine learning algorithm we can obtain rules such as *Ro: if X1 is VVi then Y1 is Instant Messaging,* which is interpreted as: "If a user has a strong preference for the Visual subcategory, the groupware tool that this person would prefer is Instant Messaging".

Once both sets of preference rules are obtained we would finished the *project independent* part. At this point we should remark that our methodology has the characteristic that the example and preference rule databases can be improved along surveys are applied on more and more GSD projects.

The remaining phases consist of the application of our methodology to a specific GSD project during a requirement elicitation process, so that it is called the *project dependent stage*.

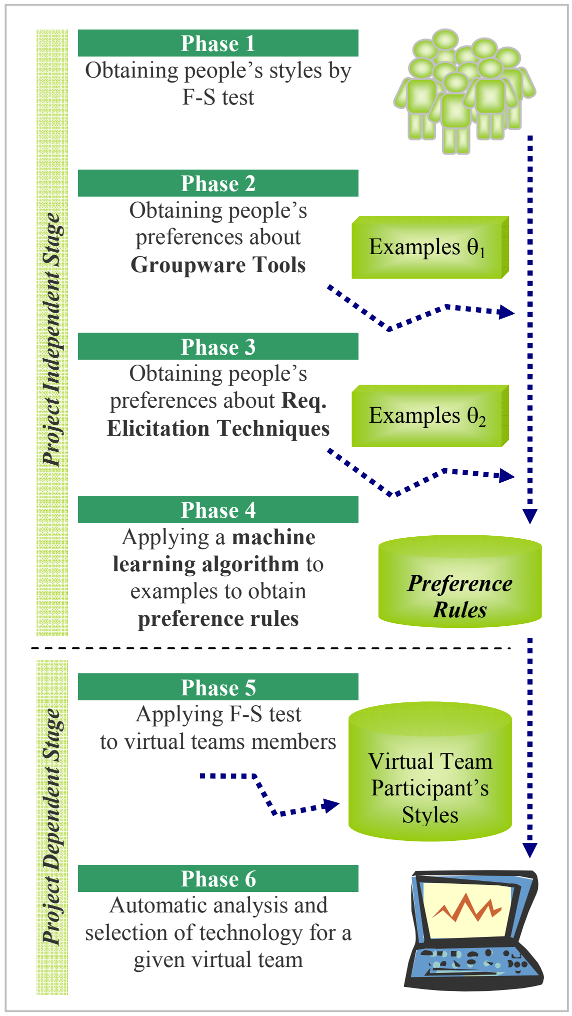


Figure 2: Phases to define and analyze personal preferences to choose appropriate technology in Virtual Teams

First of all, we would need to obtain the personal preferences of every person who will work in a virtual team by asking him to fill the learning style test (**Phase 5**). This information will be stored in a database that can be accessed every time a group of people needs to communicate to each other.

In **Phase 6**, the technology selection process itself is done. To do so, the personal preferences of a set of stakeholders that need to communicate to carry out a given task, are studied and confronted, by means of an automatic tool, to choose and suggest the most appropriated set of technology. As we have explained in [3] such strategies must take into account other factors besides cognitive profiles of stakeholders, like time difference between sites, the degree of sharing of a common language, and the current situation at the requirement elicitation process.

4. A case study

In order to obtain useful information for illustrating our approach, we have designed a survey to inquire about personal preferences of stakeholders and to look for patterns of behaviour. As a first attempt, we have focused on the preferences about groupware tools, leaving the analysis of preferences about requirement elicitation techniques as future work.

The subjects under study were software developers and users that were accustom to use groupware tools and had some proficiency using at least two of them (email, instant messaging, chat, forum, videoconference). Part of the interviewees worked for private organizations that develop software for third parts; and the rest were academic staff of universities that cooperate with software development projects and users of software systems at different organizations.

The first task for everyone was filling the learning style test and sending us the results. Then we asked them to fill a survey about their preferences during their daily work with groupware tools. The questions we had prepared explored preferences by asking people to give a rank to a set of groupware tools. To have the chance of analyzing differences, we separated questions to ask for preferences when they had to work with only one partner or with a group of them, but in this article we only present the results for answers that consider communication between more than two stakeholders.

The people who returned the survey were 43, but as the number of examples was not large enough to analyze each tool separately, we decided to analyze preferences taking into account two big groupware tool groups – asynchronous and synchronous – according to the classification proposed in [8]. Thus, we have email and forum as asynchronous tools and chat (or instant messaging in a one-to-one version) and videoconference as synchronous. As we have mentioned before, this separation is not capricious, since it is usually taken into account in GSD literature [7, 13] to analyze how their use affect, or not, global software development.

Once we had our initial set of examples, we firstly decided to analyze the preferences of stakeholders respect to their gender; to be sure that data was independent of such a factor. We confirmed that results did not present any important difference between male and female answers.

As it is shown in figure 3, approximately the same percentage of representatives of each gender choose synchronous and asynchronous tools respectively, so we can conclude that gender is not a factor that influences the type of groupware tool people prefer using.

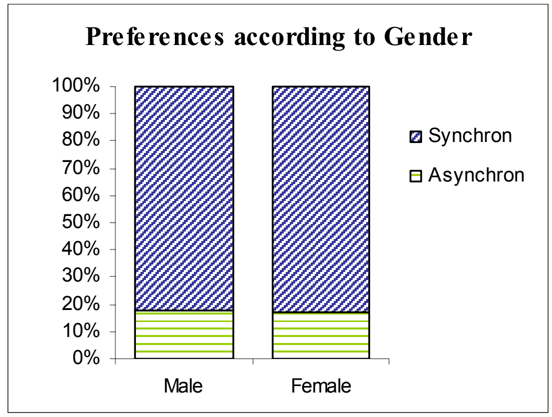


Figure 3: Relating preferences about Asynchronous and Synchronous Groupware Tools according to gender.

Later, we analyzed the preferences of stakeholders with respect to their age, setting intervals of 10 years each. We decided this because it is a general thought that younger people are keener on synchronous tools (like instant messaging) than elders. Again, as figure 4 shows, results did not present any important difference between preferences of people with different age. That means that the age of the stakeholders does not seem to be a factor that influences the preference for synchronous or asynchronous tools neither.

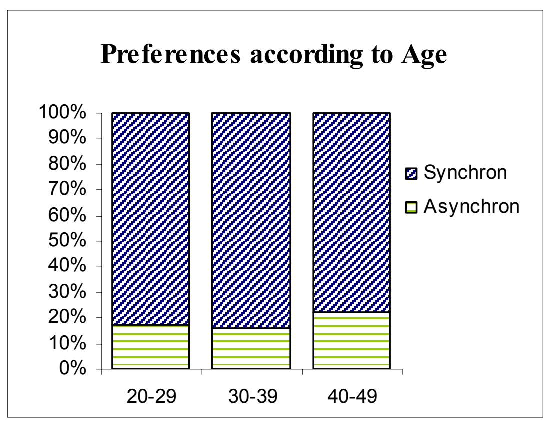
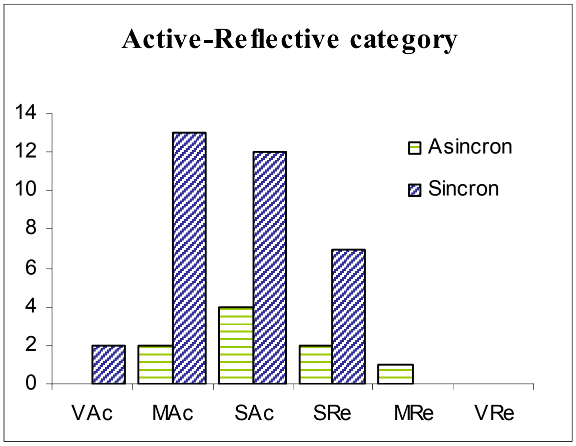
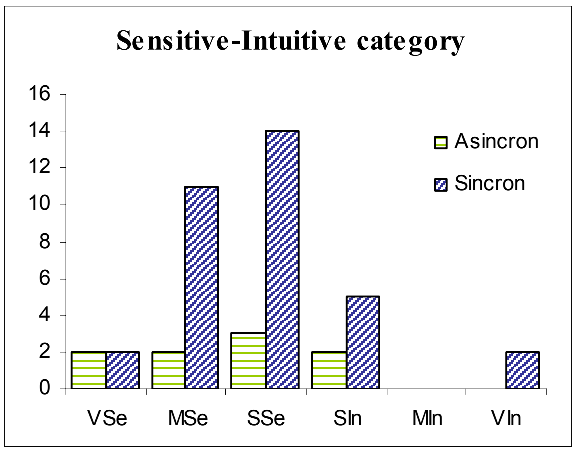
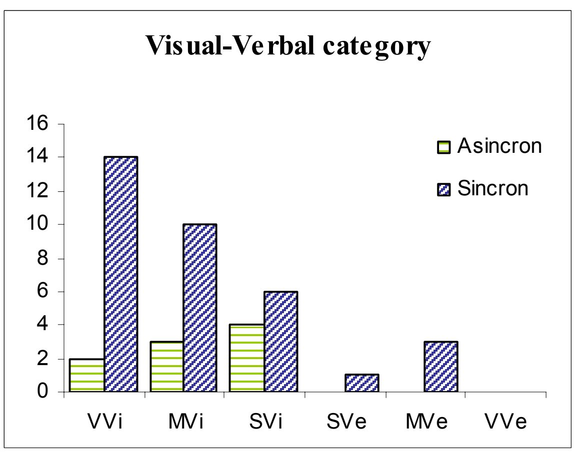


Figure 4: Relating preferences about Asynchronous and Synchronous Groupware Tools according to the age of stakeholders

Only in a next stage we analyzed preferences of stakeholders in relation with their learning style. The results of such a comparison are shown in figure 5, and by studying them we found out that there are no significant differences when preferences for the subcategories are slight or moderated. That means, most of slight and moderated preferences for all the categories of the F-S model keep the same relationship between the numbers of people adhering to every group of groupware tools.







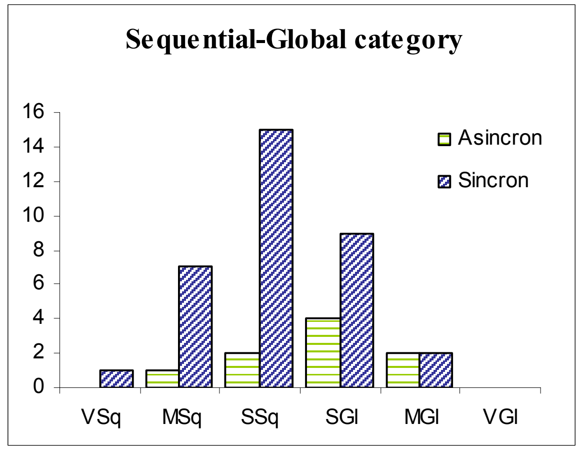


Figure 5: Relating preferences about Asynchronous and Synchronous Groupware Tools according to F-S model classification categories

With respect to the strong preferences, the number of stakeholders who chose between synchronous and asynchronous tools is not similar, especially for the Visual-Verbal category that presents the wider difference. In this case, when preference for the Visual subcategory is strong, the difference between preferences for both types of tools is about 15% for asynchronous against 85% for synchronous tools. This shows that, generally speaking, people with strong preference for the Visual category would prefer using synchronous tools instead of asynchronous.

But, why to know that can be important? As we have said before, requirement elicitation is crucially based on communication between analysts, users and clients, and the quality of the process affects the quality of the final product. If the use of only one type of groupware tools is possible and some people in the group have a strong preference that make them feel uncomfortable with the technology in use, it is possible that their lack of motivation would lead the group to a poor collaboration that can be reflected on quality of the final product. Since groupware tools, as well as elicitation techniques, are commonly chosen in an arbitrary way because of personal preferences of managers or analysts, our intention is offering a strategy that takes into account information from all the stakeholders. From our point of view, information about cognitive characteristics of stakeholders can be easily gathered and can be worthwhile for doing a first approach to technology selection.

5. Lessons Learnt

During the case study we have learnt some issues that we consider are important to remark:

- People that work on global software development processes are willing to collaborate with research that may help finding strategies for technology selection, mainly because they are conscious about the need of such methodologies.
- Also, we noticed that stakeholders do not think that filling a test that takes 15 or 20 minutes is impossible to do, and since the methodology has a psychological approach it is easy to understand even for people that are not professionals on informatics.

Specifically from the analysis of the results of the survey:

- We found out that neither gender nor age influences the way people prefer communicating with a co-worker.
- We could discern some tendency for preferring synchronous tools when preference for the Visual subcategory is stronger.
- Tendencies for the rest of the subcategories are not visible in this case study. To improve these results we need much more examples involving people with strong preferences. Currently we are designing new surveys to increase the gathered information.

6. Discussion

Our research focuses on learning styles of stakeholders as a source of information for technology selection in GSD.

In a first approach to validate our proposal, we have designed a survey whose results show that people prefer using synchronous collaboration when their preference for the visual subcategory is stronger. Even when the separated analysis of each category is an important factor, it cannot be conclusive for technology selection by itself. Otherwise, the combination of the preferences for the four categories must be taken into account. That is why we propose taking advantage of fuzzy sets theory to find patterns of behaviour in real life people's preferences when working with groupware tools and requirement elicitation techniques. With such an idea, we are currently working on the implementation of the machine learning algorithm that will offer us rules that combine different values for each category. As an example, a rule we have obtained so far (which needs to be validated) is:

If X1 in {VAc,VRe) and X2 not in {SSe,SIn) then Chat

which is interpreted as "if stakeholders have a strong preference for subcategories Active and Reflective and do not have a slight preference for Sequential and Intuitive subcategory, they would prefer using chat"

Also, we are aware that our model faces a challenge regarding the possibility of having people in a virtual group whose preferences are the opposite. To deal with such cases we are currently working on designing strategies that take into account not just a "unique" appropriate technology, but a ranking for each style, so as when conflicts between personal preferences appear, they could be solved by looking for the technology (groupware tool or requirement elicitation technique) closer to all the participants, that could not be the first option for all of them.

7. Conclusions and Future Work

Many organizations have adopted a distributed structure where members communicate through groupware tools. In such a scenario requirement elicitation can face some kind of problems if technology is not selected in a proper way. To help in this selection we propose a methodology that can bring several advantages to GSD. First of all, the most suitable elicitation techniques and groupware tools are chosen by analysing stakeholders' cognitive profiles. Consequently, it is expected that by improving the channels of communication the elicitation process also improves, for instance, by reducing the number of mistakes produced during this stage.

On the other hand, our approach also takes into account other aspects that affect the GSD such as different culture and language. A suitable selection of groupware tools can help to minimize the effects of these aspects, too. Therefore, the stakeholders would feel more comfortable and the number of misunderstandings probably would also decrease. However, we must test these hypothesises in real groups in order to validate them.

Current effort focuses on defining strategies to select technology when cognitive profiles in a virtual team are opposite. In order to accomplish this, we are working on the application of a machine learning algorithm at different levels of preferences, so as to define a ranking of preferences for each cognitive profile. Having such a ranking, it would be possible to define technology selection strategies that take into account most stakeholders' preferences in the virtual team. Moreover, we are analyzing and classifying collaborative tools with the goal of finding what tools can be considered “neutral” and could be used under most circumstances since are accepted by almost all profiles, reducing in this way, the problem of having stakeholders’ with opposite preferences.

Additionally, our current work should be extended to analyse combined influences on selection, for example, cognitive profiles, background, organizational knowledge, and motivation. So far, we are following a step-by-step approach trying to consolidate preliminary results before focusing on more complex analyses.

Acknowledgements

This work in partially supported by the MÁS project (TIC2003-02737-C02-02), Ministerio de Ciencia y Tecnología; the ENIGMAS project (PBI-05-058), Junta de Comunidades de Castilla-La Mancha, Consejería de Educación y Ciencia, both from Spain; the CompetiSoft project (506PI0287); and the 04/E059 project, Universidad Nacional del Comahue, from Argentina.

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