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WHICH GROUPWARE TOOL IS THE MOST SUITABLE FOR THIS GROUP?

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Abstract

Improving communication and knowledge sharing are the main challenges in global software development projects. Since stakeholders in such environments must communicate by means of groupware tools, our research focuses on analyzing people's preferences, according to their cognitive characteristics, in order to discover behaviour patterns that will help us to define the best choice for them. In this paper we present a methodology for groupware selection for a given group of people, along with some preliminary results of a controlled experiment.

1 Introduction

Although Global Software Development (GSD) is now definitively installed in the modern software industry [10] many issues are still under study, the objective being to improve distributed teams' performance. Most of the difficulties in GSD projects are related to communication, especially those resulting from a lack of face-to-face interaction, such as the fact that people interpret things in the light of their own background assumptions, and that uncertainty generates useless information [14]. Another important problem is knowledge sharing since information comes from many sources and people who are distributed throughout many distanced sites [5]. Bearing this in mind, we have focused our study on how to improve communication and knowledge exchange by taking into account human aspects. We have therefore focused our research on groupware tools and their influence on interpersonal communication and people satisfaction, since groupware tools are the main means of knowledge sharing used by stakeholders in GSD. To do this, we have proposed a process that considers people's cognitive characteristics as the basis for groupware tool selection.

The remainder of the paper is organized as follows: first we analyze different categories of groupware tools and describe models with which to analyze people's cognitive characteristics. We then explain our proposal for choosing the most suitable groupware tools according to the group's features. Next, we present an experiment carried out to validate part of our proposal. Conclusions and future work are addressed in the final section.

2 Groupware tools categorization

Knowledge sharing and the misunderstandings caused by a lack of face-to-face interaction are important problems in GSD. In order to deal with such problems we decided to study which groupware tool is the most suitable for a team by taking into account its members' cognitive features. These features are very important both when it is necessary to process information and when people wish to share their tacit knowledge. Therefore, our goal is to attempt to make the externalization and internalization processes easier (see SECI model [13]).

Distributed development teams usually choose a combination of two or three groupware tools, according to their possibilities and the kind of task they are attempting to carry out. They may also choose between using a groupware package that offers a combination of tools or they may use individual tools in an ad-hoc manner. However, the most common tools for communication in virtual environments are e-mail, forums, wikis, instant messaging or two-way chat, shared whiteboards, videoconference, audio-conference, phone, etc.

These groupware tools can be categorised in different ways. For example, the first

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categorization concerns the need to interact in real time (synchronous) or otherwise (asynchronous) [6], as Table 1 shows.

Table 1: Groupware tools classification considering real time interaction

Asynchronous	Synchronous
– e-mail – discussion groups or forums – wikis – asynchronous shared whiteboards	– instant messaging or two-way chat – videoconference – audio-conference – synchronous shared whiteboards

Both types of collaboration are important in geographically distributed environments: through asynchronous collaboration team members can work individually and contribute to the collective activity of the group for later discussion [10], which is especially important when groups are distributed across time zones and it is difficult to schedule real time meetings. Synchronous tools, on the other hand, allow people to work together at the same time, providing them with the possibility of instant feedback.

A different categorisation concerns the way in which groupware tools offer people information, for example with regard to visual or verbal characteristics (as is shown in Table 2). In this case we need to differentiate plain-text (email or chat) from enriched-text, since the latter may, in some cases, improve people's attention [7].

Table 2: Groupware tools classification considering input channels

Visual information	Verbal information
– enriched-text e-mail – shared whiteboards – video-conference	– plain-text emails – wikis – plain-text instant messaging or two-way chat – audio-conference

There is also a set of characteristics that contributes to achieving the common ground inherent in communication media, such as sequentiality (the capability to follow a line of conversation), reviewability (the capability to review old conversations) or revisability (the capability to review a message before sending it). In Table 3 groupware tools are compared to each other and are also compared with face-to-face interaction (adapted from [14]).

As can be seen, there is a wide set of available groupware tools to choose from. However there is no defined protocol to say which is the most suitable for a given group of people in a given situation. They are therefore usually intuitively chosen by project managers or the stakeholders themselves. Our effort is focused on analyzing how people's cognitive preferences are related to performance as regards groupware tool selection, and whether performance and stakeholders' satisfaction may be improved.

Table 3: A complete groupware tools classification

Groupware tool	Co-presence	Visibility	Audibility	Co-temporality	Simultaneity	Sequentiality	Reviewability	Revisability	Visual information
Face-to-face	•	•	•	•	•	•			
Videoconference		•	•	•	•	•			•
Audio-conference			•	•	•	•			
Chat or Instant Messaging				•	•	•	•	•	
Plain text email							•	•	
Enriched-text email							•	•	•
Forum						•	•	•	
Wiki							•	•	
Synchronous shared whiteboards				•	•		•	•	
Asynchronous shared whiteboards							•	•	

3 Cognitive styles categorisation

Cognitive styles are a part of cognitive psychology theories that classify people's preferences with regard to perception, judgment and processing of information [12], and attempt to explain differences in human behaviour. Similarly, learning styles models classify people according to a set of behavioural characteristics that concern the ways in which people receive and process information, while their goal is to improve the way that people learn a given task. After studying different models, we have chosen the Felder-Silverman (F-S) Model, which covers the categories defined by the most famous models (Myers-Briggs Indicator Type, Kolb model, Herrmann Brain Dominance Instrument, etc.) and which has been widely and successfully used with educational purposes in engineering fields [9]. The model [8] introduces four categories, each of which is further decomposed into two subcategories, as follows:

- **Perception**: Sensing/Intuitive
- **Input**: Visual/ Verbal
- **Processing**: Active/Reflective
- **Understanding**: Sequential/Global

A classification can be obtained by filling in a multiple-choice test, available on the WWW[1], which returns a rank for each subcategory. Depending on the circumstances, people may fit into one category or another; so preference for each category is measured as strong, moderate, or mild. According to the authors, people with a mild preference are balanced on both dimensions of the scale. People with a moderate 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 which are in greater accordance with their learning styles, as we shall explain in the following section.

4 A groupware tools selection methodology

In order to support personal preferences when selecting technologies for virtual teams, we propose a methodology that uses fuzzy logic and fuzzy sets [2] to obtain rules from a set of representative examples as behavioural patterns.

The methodology is divided into two stages, as is shown in Figure 1.

Stage 1 comprises of a set of activities to search for a set of examples, which are real data concerning stakeholders' preferences in their daily use of groupware tools, which are later analysed by using a machine learning algorithm (proposed in [4]), in which each example is converted into an initial rule and a finite set of fuzzy rules is iteratively discovered that reproduces the input-output system's behaviour. This algorithm was designed to obtain rules with a maximum degree of generality, reducing the antecedent part as much as possible so as to obtain rules that can be easily understood and highly approximated to real-life examples. Since this stage is project independent, the example and preference rule databases can be improved through surveys applied in different GSD projects.

Stage 2 consists of the application of our preference rules to a specific GSD project, which is therefore called the *project dependent stage*. In this stage, we obtain the personal preferences of every person who will work in a given virtual team, which is stored in a database. The selection process is then carried out by studying and confronting the personal preferences of the people who need to work together. This is done through the use of an automatic tool that chooses and suggests the most appropriate technology.

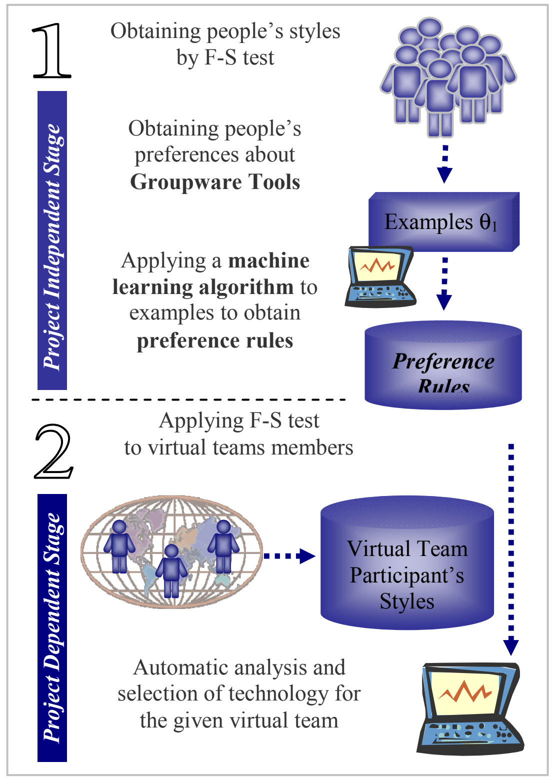

Figure 1: A methodology to obtain preference rules and apply them in virtual teams

As we explained in [3], combination strategies must take into account different factors such as the time difference between sites and the degree to which a common language is shared. In addition, combination strategies must take into consideration the fact that if some stakeholders' preferences are strong and the remaining stakeholders' preferences are moderate or mild, the choices that should be primarily considered are those of the people with strong preferences, since these people perform better when the technology is closer to the way in which they receive and process information [8]. Bearing this in mind, we classified teams according to the occurrence of strong preferences, as follows:

- **Type 1:** There are no strong preferences in the team.
- **Type 2:** There are strong preferences but not on the opposite sides of the same category. For instance: if there are strongly visual people in the team, and there are no strongly verbal people, communication should be

[1] *http://www.engr.ncsu.edu/learningstyles/ilsweb.html)*

based on diagrams and written words, which would increase the involvement of visual people. People with slight and moderate preferences can easily become accustomed to them.

- **Type 3:** There are strong preferences on the opposite sides of the same category, so there is a conflict of preferences. For example, if there are one or more strongly visual people, and also some strongly verbal people, communication should support both kinds of styles, as we shall discuss later.

For each type of teams we defined a specific strategy which considers the combination of cognitive profiles. For example, in the case of Type 3 team we solve the *conflict of preferences* by means of a machine learning algorithm that returns a ranking of output variables for each rule, rather than only one variable. We thus obtain a ranking of groupware tools for each person, and the conflict the conflict is solved by looking through the ranking for each person with the strongest preferences and choosing the groupware tool that is located higher in the ranking for all the stakeholders, despite the fact that it would not be the first choice for some, or even any of them. Figure 2 shows an example of three stakeholders, in which P1 and P3 have strong preferences on the opposite sides of the same category (Verbal-Visual).

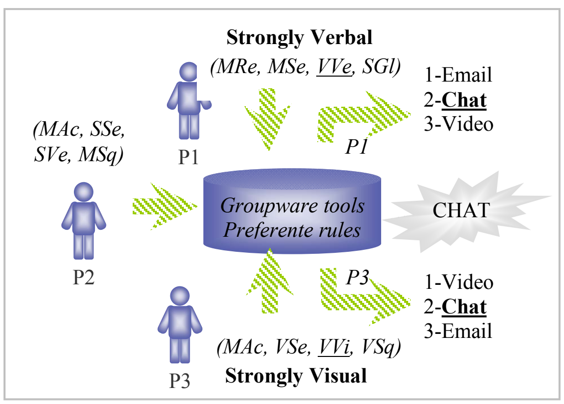

Figure 2: Strategy 3 represented for 3 stakeholders with strong preferences with conflict

Our strategy recommends the groupware for the group by looking through the rankings of both stakeholders and choosing that which is common and is in the first positions for both of them. The tool will therefore recommend the chat, although it is in the second place in both rankings. If the chat were in the third position for P3, chat would be also the tool suggested by our algorithm since it is the tool which is suitable for both stakeholders, and is one of the first in the ranking. Preference rules for stakeholder P2 are not considered by strategy S_3 because, according to the Felder and Silverman learning style model, it will not be difficult for him/her to get accustomed to the chosen tool, since P2 has slight/moderate preferences.

5 Experiment design and execution

In order to validate certain aspects of our proposal we have carried out a controlled experiment with the participation of post-graduate computer science students from the University of Castilla-La Mancha (Spain) and the University of Comahue (Argentina). We chose to apply our experiment in the requirements elicitation process, since communication and knowledge sharing are crucial for stakeholders' (client, users, analyst) common understanding [1]. We divided 24 people into 8 teams, and attempted to simulate global development teams. The teams were therefore formed of three people. Two members played the role of analysts and the other played the role of client. The 'client' had to describe to the 'analysts' the requirements of a software product that the analysts would supposedly have to implement. The analysts then had to use the information obtained from the client's explanations to write a software requirements specification report. As the team members were geographically distributed they had to use a groupware tool to communicate.

As our intention was to compare the teams that used our proposal and the teams that did not, we divided the teams into two groups. Half of them (denominated as Group 1) used the best groupware tool according to our preference rules, and the rest (Group 0) used a different (less suitable) groupware tool. The teams were randomly assigned to one of the two groups and our set of rules was applied to find the most suitable tool for each team. Later, the teams in Group 0 were assigned a different tool, as is shown in the fourth column of Table 4.

Table 4: Assigned groupware tools

Group	Team	Suitable GW Tool	Assigned GW tool	Suitability
0	G1	IM	Email	-
	G2	Audio	IM	-
	G5	IM	Email	-
	G7	Audio	IM	-
1	G3	Audio	Audio	+
	G4	IM	IM	+
	G6	IM	IM	+
	G8	Audio	Audio	+

We also ensured that the remaining variables were fixed for all the treatments. For instance, requirements elicitation techniques were reduced to interviews and use case models for all the teams, and more experienced people were assigned first to avoid them being in the same team. As there were 3 people in each team, we chose to have two analysts and one user per team, as we considered that such a distribution would give us the opportunity to analyze not only the user-analyst relationship, but also the analyst-analyst relationship. We avoided educational differences by assigning the same roles to people from the same country, so Spanish students played the role of analysts and Argentinean students played the role of users. Finally, we ensured that each team had the same challenges to overcome: they had a time difference of 4 hours, they had the same difference in timetables, the cultural difference was the same (low according to the Hofstede model [11]) and they had the same idiomatic differences as regards pronunciation and vocabulary.

Team members were able to communicate freely for a week, but only by using the groupware tool assigned, and after that time each team gave us the requirements specification that the analysts had written with the user's approval. Finally, on receiving the requirements specification, we asked the team members to fill in a post-experiment questionnaire in order to obtain their personal opinion of the requirements elicitation process and the requirements specification they had written. Satisfaction was scored through the use of a scale of 0-4 (0=very bad, 1=bad, 2=acceptable, 3=good, 4=very good).

6 Preliminary results

According to the analysis of the data collected by means of a post-experiment questionnaire we obtained that, with regard to stakeholders' satisfaction with communication during the experiment, most people in Group 1 ranked their satisfaction as 4="very good", while most people in Group 0 ranked their satisfaction as 3="good" (as is shown in Figure 3). This difference between both groups would indicate that: *Stakeholders' satisfaction with communication seems to be better in groups that used the most suitable groupware tool according to our set of preference rules*.

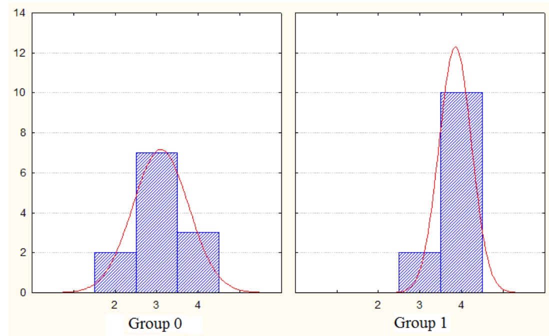

Figure 3: Stakeholders' satisfaction about communication in both groups

Similarly, when analyzing the data collected by the post-experiment questionnaire in relation to stakeholders satisfaction with the quality of the software requirements specification (SRS) they had written during the experiment, we discovered that most people in Group 1 ranked their satisfaction as 4="very good" in comparison with the people in Group 0 (as is shown in Figure 4). This difference between both groups would indicate that: *Stakeholders' satisfaction with the quality of the SRS written during the experiment seems to be better in groups that used the most suitable groupware tool according to our set of preference rules*.

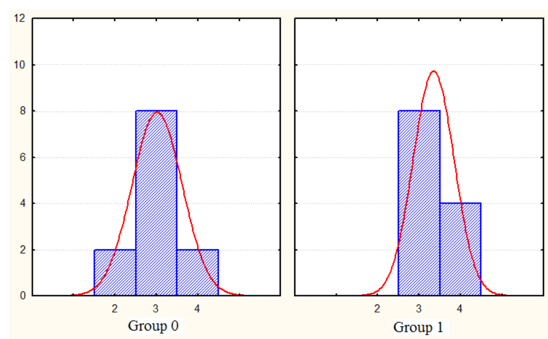

Figure 4: Stakeholders' satisfaction with the quality of the written requirements specification in both groups

These preliminary results show that our proposal seems to improve both stakeholders' satisfaction with regard to communication with the rest of the group and their satisfaction with the software requirements specification they wrote, meaning that they considered that the result of their work was better when using the groupware tool deemed to be suitable for them according to our technology selection approach.

Our current work is focused on analyzing other factors like the quality of software specifications from the point of view of external reviewers (which would consider the product quality), as well as the quality of communication (by means of qualitative research techniques to analyze text and conversations recorded during the experiment).

7 Conclusions and Future Work

In order to save costs, many organisations have adopted a distributed structure for software development, which is called global software development or GSD. In such environments, software development projects are affected by many factors which complicate communication and knowledge exchange.

Bearing this in mind, in this paper we propose a methodology for groupware tools selection which focuses on cognitive style models, by using the Felder and Silverman (F-S) learning style model.

This proposal has been applied in a controlled experiment, and some of its preliminary results are shown here. We believe that this experiment could be seen as a first step in a series of experiments, which must be repeated in order to contrast the results obtained in different scenarios. However, the preliminary results have encouraged us to consider that it would be advisable to take cognitive profiles of team members into consideration in order to choose a groupware tool.

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