Facing Communication Challenges in Global Software Development

Gabriela N. Aranda[1], Aurora Vizcaíno[2], and Mario Piattini[2]

[1]GIISCo Research Group, Universidad Nacional del Comahue, Computing Sciences Department, Buenos Aires 1400 - 8300 Neuquén, Argentina. *garanda@uncoma.edu.ar*

[2]ALARCOS Research Group, Information Systems and Technologies, Department UCLM-INDRA Research and Development Institute, Escuela de Informática, Universidad de Castilla-La Mancha, Paseo de la Universidad 4 - 13071 Ciudad Real, Spain. *aurora.vizcaino@uclm.es, mario.piattini@uclm.es*

Abstract. The main challenges during global software development projects are related to the lack of face-to-face communication. Since stakeholders satisfaction is crucial as a factor that can influence a team performance, we have focused our research on the need of people feeling comfortable with the technology they use. In this article we introduce an approach that proposes a way of choosing the most suitable technology for a given group of people, taking advantage of information about stakeholders' cognitive characteristics, and we present preliminary results of an experiment we have carried out to validate our proposal.

1 Introduction

Communication is a common problem in Global Software Development, as well as the time difference between different sites and the cultural diversity of stakeholders [1,2]. In such scenario, groupware tools become the main channel for communication, then analyzing their impact on stakeholders' perception and performance is an interesting focus for research.

One of the most common ways of classifying groupware is according to their synchronous or asynchronous characteristics (depending on if the users have to work at the same time or not) [3]. According to GSD literature, both categories are important, because asynchronous collaboration allows team members to construct ideas individually and contribute to the collective activity of the group for later discussion (especially when groups are distributed across time zones), but also real time collaboration and discussions are necessary components of group dinamic to give stakeholders the chance of having instant feedback [4]. However, is also true that sometimes people are 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 [5]. 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 [6]. Most of related works using LSMs in informatics concern only educational purposes [7], however there are a few related works that use psychological techniques to solve communicational problems in Software Engineering. A work in that direction is [8] where cognitive styles are used as a mechanism for software inspection team construction. By means of a controlled experiment, this work proves that heterogeneous software inspection teams have better performance than homogeneous ones, where the heterogeneity concept is analyzed according to the cognitive style of participants. In our approach we choose a different perspective, and even when we 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. Instead, 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 compare results from two different surveys we have carried out in order to get examples to validate our methodology and we will present some conclusions and guidelines for future work.

2 Cognitive aspects of communication

Cognitive Informatics relates cognitive sciences and informatics by using cognitive theories to investigate and look for solutions to software engineering problems [9]. Doing so we can use concepts from cognitive psychology (concerning the way people attend and gain information), to improve the requirement elicitation process. Cognitive styles are a part of cognitive psychology theories that classify people's preferences about perception, judgment and processing of information [8], and try to explain differences in human behavior. Similarly, learning styles models (LSMs) classify people according to a set of behavioral characteristics that concern the ways people receive and process information, while their goal is improving the way people learn a given task. Considering that elicitation is about learning the needs of the users [10], and also an scenario where users and clients also learn from analysts and developers (for instance, they learn how to use a software prototype or new vocabulary), we can say that during the elicitation process everybody "learns" from others. Then, even when LSMs have been discussed in the context of analyzing relationships between instructors and students, we propose taking advantage of LSMs by adapting it to virtual teams that deal with distributed elicitation processes. The model we have chosen, after studying different LSMs, is called the Felder-Silverman (F-S) Model. According to our analysis, 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 [11]. 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). Table 1 shows a summary of the characteristics for each subcategory [12].

Table 1. Felder and Silverman categories and subcategories

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

Classification into the different categories is obtained by filling 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 the other, being for instance, sometimes active and sometimes reflective; so preference for one category is measured as strong, moderate, or mild. A sample result is shown in Figure 1.

Numbers 9-11 mean a strong preference, 5-7 moderate, and 1-3 slight, therefore, the stakeholder in the example in Figure 1 has a slight preference for the reflexive and sensitive subcategories, moderate for the global subcategory, while his preference for the visual subcategory is strong. 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

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

```
ACT                              X                        REF
      11  9   7   5   3   1   1   3   5   7   9   11
                          <-- -->
SEN                          X                            INT
      11  9   7   5   3   1   1   3   5   7   9   11
                          <-- -->
VIS       X                                               VRB
      11  9   7   5   3   1   1   3   5   7   9   11
                          <-- -->
SEQ                                      X                GLO
      11  9   7   5   3   1   1   3   5   7   9   11
                          <-- -->
```

Fig. 1. Sample F-S test results for a stakeholder

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.

To work easily with the F-S test results, we have decided to express it as a 4-tuple, in the same order they are returned in the results' web page. To clearly identify the opposite subcategories, we have chosen using a negative sign for the categories that appear on the left side (active, sensing, visual, and sequential) and with a positive sign for the others (reflective, intuitive, verbal, and global). Doing so, the sample stakeholder's learning style presented in , would be expressed like (1, -1, -9, 5). This convention will be used in the rest of the paper.

3 Supporting personal preferences in global software development

In order to support personal preferences when selecting technologies for virtual teams, we propose a methodology that uses concepts from fuzzy logic and fuzzy sets [13], to obtain rules from a set of representative examples, in the way of patterns of behavior.

The methodology is divided into two stages: the first one (Stage 1) 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, as it is shown in Figure 2. 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. To do so, we have used the machine learning algorithm proposed in [14] to turn each example into an initial rule and iteratively we found a finite set of fuzzy rules that reproduce the input-output system's behavior, which has been presented in [15]. For instance, one of them is: *If* X_1 *in {VAc,SRe,VRe} and* X_2 *in {SSe,MIn,VIn} and* X_4 *not in {SGl,MGl} then Email* which can be interpreted as: If a user has a strong preference for the Active subcategory or a slight or strong preference for the Reflective subcategory, and a slight preference for the Sequential subcategory or moderated or strong preference for the Intuitive subcategory and his preference for the Global subcategory is not slight or moderate, he would prefer using Email (no matter which preference would be for the Visual-Verbal category). As we mentioned before, phases 1 to 4 constitute the project independent part, then, our methodology has the characteristic that the example and preference rule databases can be improved along surveys and applied on more and more GSD projects. The remaining phases (Stage 2) 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*. In this stage, we obtain the personal preferences of every person who will work in a given virtual team, by asking him to fill the learning style test (*Phase 5*). This information is stored in a database that can be accessed every time a group of people needs to communicate to each other. Later, 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 (*Phase 6*). As we have explained in [15] 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.

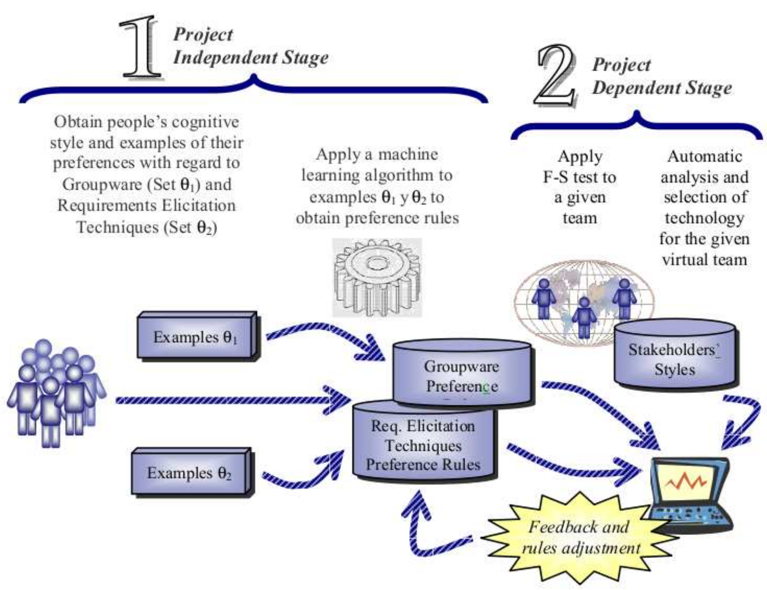

Fig. 2. Phases to define and analyze personal preferences to choose appropriate technology in Virtual Teams

4 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 2.

Table 2. Assigned groupware tools

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

Aditionaly, we ensured that the remaining variables were fixed for all the treatments. Therefore, 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 [16]) 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. To do so, stakeholders where asked to rank their satisfaction through the use of a scale of 0-4 (0=very bad, 1=bad, 2=acceptable, 3=good, 4=very good).

5 Analyzing stakeholders' satisfaction about communication

Analysing the data collected by means of the post-experiment questionnaire, we obtaine*d* 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" (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.

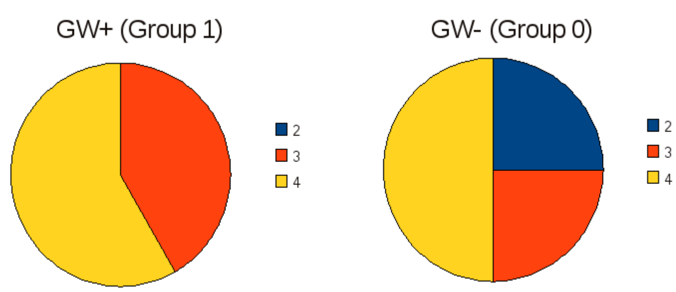

Fig. 3. Stakeholders' satisfaction about communication in both groups

In a second step, we specifically analyzed if stakeholders satisfaction about communication was different considering the cultural or language differences that could happen in a team. To do so we included aditional questions to differentiate stakeholders satisfaction about communication with the member of their own country and with the member of a different country.

Regarding the question about communication with the member of the same country, it could only be ansewered for Spanish people, who has a Spanish partner in each team, therefore only 16 answers could be compared. Then, concerning to *stakeholders' satisfaction with communication with members from the same country*, we obtained that more people in Group 1 ranked their satisfaction as 4="very good", while most people in Group 0 ranked their satisfaction as 3="good" and 2="acceptable" (Figure 4). This difference between both groups would indicate that, stakeholders' satisfaction with communication with members from their own country seems to be better in groups that used the most suitable groupware tool according to our set of preference rules.

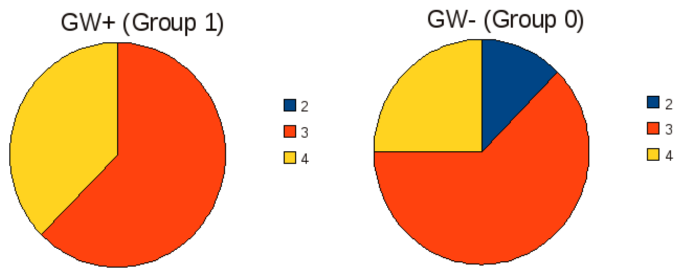

Fig. 4. Stakeholders' satisfaction about communication with members from their own country, in both groups

Similarly, when analyzing *stakeholders' satisfaction with communication with members from a different country*, we obtained that more people in Group 1 ranked their satisfaction as 4="very good", as well as most people in Group 0 ranked their satisfaction as 3="good" and 2="acceptable" (Figure 5). This difference between both groups would indicate that, stakeholders' satisfaction with communication with members from different countries seems also to be better in groups that used the most suitable groupware tool according to our set of preference rules.

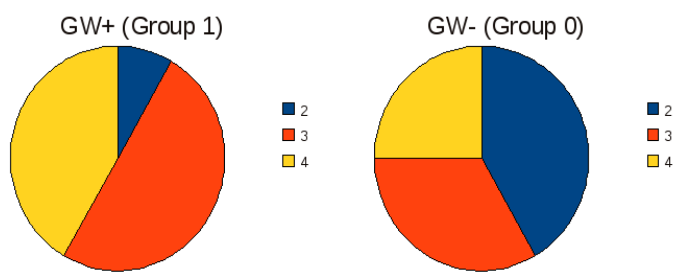

Fig. 5. Stakeholders' satisfaction about communication with members from a different country, in both groups

As a conclusion, our preliminary results show that our proposal seems to improve stakeholders' satisfaction with regard to communication with the rest of the group when using the groupware tool deemed to be suitable for them according to our technology selection approach. Furthermore, stakeholders satisfaction about communication was analyzed considering the possible effects of cultural and language differences between people from different countries, and the results showed that: First, for both groups (0 and 1), stakeholders' satisfaction about communication with team members from the same country was better than satisfaction about communication with team members from a different country (which is understandable, because people from a same country share a lot of information, customs, etc). And second, when considering stakeholders' satisfaction about communication with team members located in a different country, we observed the same difference between groups 0 and 1 that we have observed previously, which means that stakeholders' satisfaction about communication seems to be higher when groupware tools were chosen according to our technology selection approach, no matter if stakeholders are from the same country or not.

Bearing this in mind, 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).

6 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 (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 seem to support our hypothesis indicating the influence of cognitive profiles in the election of groupware tools.

Acknowledgements

This work is partially supported by the ENGLOBAS (PII2I09-0147-8235), MELISA (PAC08-0142-3315), and MECENAS (PBI06-0024) projects, Junta de Comunidades de Castilla-La Mancha, Consejería de Educación y Ciencia, in Spain. It is also supported by the ESFINGE project (TIN2006-15175-C05-05) and PEGASO (TIN2009-13718-C02-01), Ministerio de Educación y Ciencia (Dirección General de Investigación)/ Fondos Europeos de Desarrollo Regional (FEDER) and the FABRUM project (grant PPT-430000-2008-063), Ministerio de Ciencia e Innovación, in Spain; and the 04/E072 project, Universidad Nacional del Comahue, from Argentina.

References

1. E. Carmel and R. Agarwal, "Tactical approaches for alleviating distance in global software development," *IEEE Software*, vol. 18, no. 2, pp. 22–29, 2001.
2. D. Damian and D. Zowghi, "The impact of stakeholders geographical distribution on managing requirements in a multi-site organization," in *IEEE Joint International Conference on Requirements Engineering, RE'02*, (Essen, Germany), pp. 319–328, 2002.
3. C. Ellis, S. Gibbs, and G. Rein, "Groupware: Some issues and experiences," *Communications of ACM*, vol. 34, no. 1, pp. 38–58, 1991.
4. D. Herlea and S. Greenberg, "Using a groupware space for distributed requirements engineering," in *7th IEEE Int'l Workshop on Coordinating Distributed Software Development Projects*, (Stanford, California, USA), pp. 57–62, 1998.
5. Y. Wang, "On the cognitive informatics foundations of software engineering," in *Third IEEE International Conference on Cognitive Informatics, ICCI'04*, (Victoria, Canada), pp. 22–31, 2004.
6. A. Martín, *Personalization of Web Applications: A Reengineering Approach*. Master in software engineering post grade, Universidad Nacional de La Plata, 2003.
7. G. D. Blank, S. Roy, S. Sahasrabudhe, W. M. Pottenger, and G. D. Kessler, "Adapting multimedia for diverse student learning styles," *Journal of Computing in Small Colleges*, vol. 18, no. 3, pp. 45–58, 2003.
8. J. Miller and Z. Yin, "A cognitive-based mechanism for constructing software inspection teams," *IEEE Transactions on Software Engineering*, vol. 30, no. 11, pp. 811–825, 2004.
9. V. Chiew and Y. Wang, "From cognitive psychology to cognitive informatics," in *Second IEEE International Conference on Cognitive Informatics, ICCI'03*, (London, UK), pp. 114–120, 2003.
10. A. M. Hickey and A. Davis, "Elicitation technique selection: How do experts do it?," in *International Joint Conference on Requirements Engineering (RE03)*, (Los Alamitos, California), pp. 169–178, IEEE Computer Society Press, 2003.
11. R. Felder and J. Spurlin, "Applications, reliability and validity of the index of learning styles," *International Journal of Engineering Education*, vol. 21, no. 1, pp. 103–112, 2005.
12. R. Felder and L. Silverman, "Learning and teaching styles in engineering education," *Engineering Education*, vol. 78, no. 7, pp. 674–681, 1988 (and author preface written in 2002).
13. G. Aranda, A. Cechich, A. Vizcaíno, and J. J. Castro-Schez, "Using fuzzy sets to analyse personal preferences on groupware tools," in *X Congreso Argentino de Ciencias de la Computación, CACIC 2004*, (San Justo, Argentina), pp. 549–560, 2004.
14. J. Castro, J. J. Castro-Schez, and J. Zurita, "Learning maximal structure rules in fuzzy logic for knowledge acquisition in expert systems," *Fuzzy Sets and Systems*, vol. 101, no. 3, pp. 331–342, 1999.
15. G. Aranda, A. Vizcaíno, A. Cechich, M. Piattini, and J. Castro-Schez, "Cognitive-based rules as a means to select suitable groupware tools," in *5th IEEE International Conference on Cognitive Informatics (ICCI'06)*, (Beijing, China), 2006.
16. G. Hofstede, *Cultures and Organizations, Software of the Mind: Intercultural Cooperation and its Importance for Survival*. McGraw-Hill, 1 ed., 1996.