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Analysing the quality of collaboration in task-oriented computer-mediated interactions: introduction to the workshop proceedings

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1 Introduction

These proceedings are composed of extended versions of papers and discussion reports from a workshop on "Analysing the quality of collaboration in task-oriented computer-mediated interactions" which took place on the 18th of May 2010, in the framework of the COOP 2010 conference. With the growing importance of technology mediation for group work and learning, developing methods for assessing the quality of collaboration is central to research carried out within both Computer Supported Cooperative Work (CSCW) and Computer Supported Collaborative Learning (CSCL). This workshop aimed to bring together researchers from these two fields, working in cognitive, social and computational sciences on understanding collaborative activities. The workshop was co-organised by Françoise Détienne, Michael Baker, Jean-Marie Burkhardt and Hans Spada (University of Freiburg).

2 Motivation

The aim of the workshop was to study theories, models and analysis techniques that enable us to understand the quality of collaborative activity in task-oriented computer-mediated interactions. In this context, the term 'quality' can be understood in descriptive terms (identifying and discriminating the intrinsic properties of collaboration) and/or in a normative sense (identifying what makes 'good' or less good collaboration, considered *sui generis*). These visions of quality can be complementary; and exploring this would require elaborating deep models of the processes of collaboration, articulated with assessment of the degree of achievement of collaboration goals in specific situations, and understanding of productive and creative potentialities of dialogue. Research originating across a broad variety of disciplines in social, cognitive and computational sciences can contribute to these theoretical and methodological aims, within a perspective of making constructive interventions in concrete collaborative work situations. Application domains range from various workplace situations (companies, hospitals, training institutes, schools, …) with varied tasks (collaborative design, learning, decision-making, …). Methodological approaches include qualitative-quantitative interaction and group-work analysis, trace-log analysis, interviews, computational modelling, participant observation, workplace studies of technological mediation and transfer, usability studies, …

Across these various fields there are several reasons why the study of quality of collaboration is important:

- Establishing correlations between quality of collaboration and its outcomes (quality of solution, learning effects, quality of products, adequacy with respect to design constraints, creativity and innovation of products…);
- Establishing correlations between characteristics of tools that mediate collective action and quality of collaboration;
- Devising methods for training groups, in the workplace, in educational institutions, for more effectively collaborating;
- Enabling participants in group work and learning to become reflexively aware of the nature and quality of their participation and collaboration.

Aspects of this kind (the list is non-exhaustive) contribute more generally to the elaboration of theories and models of collaboration as well as to devising methods for evaluating computer-supported cooperative/collaborative work and learning.

3 Collaboration processes in problem solving oriented activities

Research focused on the analysis of collaborative activities in task-oriented situations (e.g., collaborative design, see for example, Olson, Olson, Carter & Storrosten, 1992; Stempfle & Badke-Schaub, 2002; Burkhardt, Détienne, Moutsingua-Mpaga, Perron, Leclercq & Safin, 2008; Détienne, Burkhardt, Hébert & Perron, 2008) has highlighted collaborative processes along different dimensions. They can be classified according to their orientation toward design-task processes, group processes or communication processes.

Firstly, collaboration concerns the activities related to the evolution of tasks, e.g. design activities (elaboration, enhancements of solutions and of alternative solutions) and evaluation activities, supported by argumentation and negotiation mechanisms. These content-oriented activities reveal how the group resolves the task at hand by sharing and co-elaborating knowledge concerning the task resolution, by confronting participants' different perspectives, and by converging towards negotiated solutions.

Secondly, collaboration concerns group management activities such as project management and coordination activities, e.g., allocation and planning of tasks; and meeting management activities, e.g., ordering, postponing of topics in the meeting. These process-oriented mechanisms ensure the management of tasks interdependencies, which is highly important in a tightly coupled task such as design.

Thirdly, communication processes are highly important to ensure the construction of a common reference by the group of collaborators. The establishment of common ground is a collaborative process (Clark & Brennan, 1991) by which the participants mutually establish what they know so that task-oriented activities can proceed. Grounding is linked to sharing of information through the representation of the environment and the artefact, the dialogue, and the supposed "pre-existing" shared knowledge. This activity ensures inter-comprehension and construction of shared or compatible representations of the current state of the problem, solutions, plans, design rules and more general design knowledge.

Finally, recent research on collaboration processes (Baker, Détienne, Lund & Séjourné, 2003; Barcellini, Détienne, Burkhardt & Sack, 2008) considers the roles of participants according to communication, group management and task management and the balance between these roles as an important aspect in collaboration.

4 Analysis of collaboration and groupware evaluation in CSCW

Although most authors in CSCW generally agree upon the importance of these various aspects of collaboration (even if research works may have specific focuses), the notion of quality of collaboration remains most often quite implicit.

Regarding user studies, there are many methods that rely on different data collection and analysis techniques: they can be based on computers logs, interactions between participants (coding methods or ethno-methodological methods), or interviews. The indicators used to analyse collaboration processes are often focused on quantifying fine-grained interactions. An example, as given in a recent review by Hornbæk (2006), they concern the measure of “communication effort”: number of speakers’ turns; number of words spoken; number of interruptions, amount of grounding questions. However this does not give an indication of how well the group collaborated. Furthermore, user-based methods to assess collaboration concentrate only on one or two dimensions leaving aside a more global view of collaboration: for example, verbal and gestural communication to assess the grounding processes. The balance/symmetry of individual contributions are rarely considered, although they reflect complementary aspects of collaboration assessment. Ethno-methodological methods are often most sensitive to approach quality of collaboration on the basis of qualitative analyses.

Regarding groupware evaluation methods, their focus remains clearly on task modelling (e.g., Tromp, Steed & Wilson, 2003), i.e. eliciting goals and actions required for users to interact together and not on the collaboration processes and their quality *per se*. Some usability inspection methods (e.g., Pinelle, Gutwin & Greenberg, 2003) consider a large spectrum of collaboration aspects.

As one important issue in CSCW is to understand to which extent technology mediation affects or supports collaboration processes, we propose that one key question is to understand what differentiates good from poor collaboration. It is an important step to understand on one side the relationship between collaboration quality and group performance or efficiency and on the other side the effects of technology affordances on these both aspects.

In the related field of CSCL[1], the analysis of the process of collaboration is also a central topic of research and the notion of quality of collaboration has become an important issue.

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1 This field has its own journal, the *International Journal of Computer-Supported Collaborative Learning* (http://ijcscl.org/) and biennial international conference (http://www.isls.org/cscl.html ; e.g. http://www.isls.org/CSCL2009/welcome.htm), both organized under the aegis of the International Society for the Learning Sciences (http://www.isls.org/about.html).

5 Collaboration processes in learning oriented activities and the notion of quality of collaboration

Research on collaborative learning emerged as a field from the 1980s onwards, from two related research trends. Firstly, researchers working in 'mainstream' cognitive psychology and information-processing models of individual reasoning, problem-solving and learning, began to turn their attention to learning in groups, largely motivated by the possibility and necessity of understanding how students worked together with and around computers (see, e.g. the synthesis in Dillenbourg, Baker, Blaye & O'Malley, 1996). A second strand concerned the attempt to extend Piaget's theories of development, again, largely focussed on the individual, to learning in social interaction. This gave rise to the theory of socio-cognitive conflict (Doise & Mugny, 1984). Across these approaches, the 1990s saw the recognition that in order to understand the conditions for efficient collaborative learning, beyond relations between individuals' characteristics, and features of the task, it was necessary to analyse the nature of the interactions between students, to identify productive or constructive forms of interaction that could explain learning effects. The phenomena identified and analysed included self-and-other explanation, grounding that went beyond what was strictly required for mutual understanding, forms of mutual regulation, and various types of constructive resolutions of argumentative interactions. More generally, a consensus has emerged in this field on the nature of collaboration as a continued and synchronous attempt to construct and maintain a shared representation of the problem to be solved (Teasley & Roschelle, 1993; Baker, 1995; Dillenbourg, 1999).

In other terms, collaboration is seen as a type of "super-cooperation", probably only occurring in isolated phases of group work, during which students go beyond aligning and concatenating individual solutions, to genuinely co-constructing them, on the basis of a shared understanding of what the problem is. The analytical problem is to identify when such collaboration occurs, and it appears that it can take several different forms, within a "knowledge negotiation" process (Baker, 1994; Baker, 2002). In this context, the quality of collaboration can be seen as relating to the extent that, and the way that, students 'take up', reformulate and elaborate their partners' contributions, rather than elaborating their own thinking 'in parallel'. The space of collaboration, of greater or lesser quality, can also be circumscribed by identifying the reasons why "smart groups fail" (Barron, 2003), basically, because whilst high-quality solutions may be proposed within some groups, they are often not collectively recognised, taken up and elaborated.

In sum, collaborative learning research has gravitated towards trying to understand the nature of collaboration, its different manifestations and quality, with the specific goal of relating it to learning outcomes. There have been calls

(Crook, 1994) of growing insistence and recognition for extending this almost exclusive focus on measures of the size of the learning effect, towards considering collaboration in learning as a specific socio-relational experience that may be more or less personally rewarding.

Finally, if we know what 'good' and 'bad' collaboration for learning are, it might be possible to instruct students in how to collaborate, and thus validate the model of collaboration. Thus Mercer (1994) has demonstrated precisely this, with respect to a set of 'ground rules' of collaborative conversation, which, when put into use by students, lead to superior learning effects than without such instruction.

A central issue in CSCL is also how to design communication interfaces and shared learning task spaces that 'structure' or 'script' collaboration in ways that are designed to be optimal for learning (see e.g. Fischer et al., 2007, for a collection of works on this theme). Collaboration can be structured in several ways, for example by constraining the set of available speech acts (Baker & Lund, 1997), by imposing a strict task sequence, by providing specific semiotic means of expression, such as argumentation dialogue diagrams (see Andriessen, Baker & Suthers, 2003). There has recently been a debate in this field about 'over-scripting' (Dillenbourg, 2002), or rather as to just how much collaboration can and should be scripted, so as to favour optimal forms of collaboration yet without preventing the essential creativity of dialogue.

Evaluating the quality of collaboration is another central issue. The Spada rating scheme (Spada, Meier, Rummel & Hauser, 2005) is certainly the most representative of recent effort made to evaluate collaboration and its quality. It has been developed to compare and assess collaboration in collaborative learning tasks, with respect to various learning methods or technical support. A recent review of the literature (Voyiatzaki, Meier, Kahrimanis, Rummel, Spada & Avouris, 2008) provides theoretical arguments to consider five aspects (communication, joint information processing, coordination, reciprocal interaction, individual task orientation) as central for successful collaboration under the conditions of video-mediated communication and complementary expertise.

6 Organisation of the proceedings

The one-day workshop was organised into paper sessions in the morning, and discussion groups in the afternoon, followed by verbal reports to all attendees and the writing of discussion reports for the proceedings. The extended version of the papers in these proceedings are organised around the three themes of the workshop sessions. These are followed by reports of discussion groups which debated on the workshop themes.

Theme 1: From qualitative to quantitative dimensions of collaboration

1. A descriptive model of collaboration to underpin a collaboration profiling methodology. *Harshada Patel, Michael Pettitt, Scott Hansen, John Wilson*

2. Study of correlations between logfile based metrics of interaction and the quality of synchronous collaboration. *Georgios Kahrimanis, Irene-Angelica Chounta, Nikolaos Avouris*

3. Quantitative assessment of collaboration. *Stéphanie Buisine*

4. Quality of collaboration in a distant collaborative architectural educational setting. *Stéphane Safin, Aurélie Verschuere, Jean-Marie Burkhardt, Françoise Détienne, Anne-Marie Hébert*

Theme 2: Collaborative processes in groups

5. ‘Slow’ Collaboration: Some uses of vagueness, hesitation and delay in design collaborations. *Janet McDonnell*

6. Close collaboration, dialogical thinking and affective regulation. *Michael Baker*

7. Collaboration as constructive interaction and the jigsaw method as its enhancer. *Hajime Shirouzu*

8. Understanding collaboration in team design task-oriented interactions. *Chrysi Rapanta*

Theme 3: Collaboration in flexible open communities

9. Virtual learning communities and groups dynamics in the overcoming of obstacles. *Christophe Gentil, Marie-Laure Betbeder, Jacques Beziat, Eric Bruillard*

10. Assessing Writing and Collaboration in Learning: Methodological Issues. *Philippe Dessus, Stefan Trausan-Matu, Sonia Mandin, Traian Rebedea, Virginie Zampa, Mihai Dascalu, Emmanuelle Villiot-Leclercq*

11. Assessing the quality of collaboration in open, online, calculus help forums. *Carla van de Sande*

12. Task-oriented collaboration: not just what is inside the task, but what the task is inside of. *Charles Crook*

Discussion reports

13. Report on discussion group 1. *Stéphane Safin, Jean-Marie Burkhardt, Stéphanie Buisine, Giorgos Kahrimanis, François Charoy*

14. Report on discussion group 2. *Michael Baker, Janet McDonnell, Chrysi Rapanta, Hajime Shirouzu*

15. Report on discussion group 3. *Charles Crook, Françoise Détienne, Philippe Dessus, Christophe Gentil, Carla van de Sande*

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A descriptive model of collaboration to underpin a collaboration profiling methodology

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Abstract. We have developed an explanatory, descriptive model broad enough to reflect the different elements of collaborative work which are part of commercial and public organisations. Our model aims to establish a structured representation of the attributes which influence and form part of collaborative work. It is predominantly based on the existing literature on computer supported cooperative work, distributed cognition, education, social and organisational psychology, management science, and collaboration within healthcare teams; and is additionally supported by our experience of working with a range of industrial organisations. We applied the model in a practical way to underpin the concepts of a new methodology called CoScope, which was designed to assess the collaboration capability of organisations. The methodology focuses on the extent to which

the fundamental conditions for collaboration are created, sustained and standardised across teams and organisations.

1 Identifying the constituent factors of collaboration

The work presented in this paper was carried out within the context of the CoSpaces project - a European Commission funded Integrated Project developing innovative collaborative working solutions that are responsive to the needs of designers and engineers in the aerospace, automotive and construction industries.

Human factors researchers were tasked with developing a descriptive model to provide a simplified representation of the main factors which form and influence collaborative work. Such a model could give teams a clear overview of the areas which impact on their collaboration and overall performance and provide a framework for defining user requirements for collaborative technologies/working structures and can subsequently inform change management strategies and evaluation.

CoSpaces technology will support collaboration at different levels, from small teams to larger project teams working across numerous international organisations. Our understanding of what it means to collaborate must, therefore, have the flexibility to embrace interpersonal relationships and the factors that drive people to work together successfully, and also higher level organisational aspects of the collaborative working environment.

Our first step towards a model of collaborative work involved conducting a trans-disciplinary review of collaborative working, and of the factors or activities which define it, and then structuring our findings in a way that became the basis for a descriptive model of collaborative work (Patel et al. 2009). The review included literature from computer supported cooperative work, psychology, management science, computer science, collaborative engineering, cognitive ergonomics, healthcare and education.

The literature identified: existing models and frameworks which describe collaboration and its processes (e.g. Gutwin and Greenberg, 2000; Harvey and Koubek, 2000; Neale et al., 2004; Weiseth et al., 2006), team effectiveness/team collaboration models (e.g. Campion et al., 1993; Hackman, 1987; McNeese et al., 2000; Salas et al., 2005a;), and attributes of successful collaboration (e.g. Mattessich and Monsey, 1992; Montiel-Overall, 2005; San Martín-Rodríguez et al., 2005).

Models have focused on different influential factors, tasks and processes, and on different levels of interaction. Of the few existing models proposed seeking to structure the factors influencing collaboration, there is a tendency towards simplicity or to focus on only a small part of collaborative work.

This literature base was extended and tested against outcomes from our empirical work with industrial teams, and findings from workshops and expert brainstorming sessions (Wilson et al., 2009a). We analysed collaborative work on selected activities at CoSpaces user partner sites through semi-structured interviews, carried out as part of scenario development during the user requirements elicitation phase of the project (Wilson et al., 2009a). This helped us to gain an understanding of how teams work collaboratively, the problems they face, the critical success factors and so on. These user scenarios provided compelling examples of the factors highlighted in our literature review.

2 Representational form of the descriptive model

The review highlighted factors which were consistently discussed in the literature as forming or influencing collaborative work. We isolated seven main categories of factors involved in collaborative work: Individuals, Teams, Interaction Processes, Tasks, Support, Context, and Overarching Factors (which are relevant across two or more of the previous factors, e.g. goals are associated with individuals, teams, tasks and organisations). Based on feedback from focus groups, we decided on a ‘web’ representation for our model (see Figure 1).

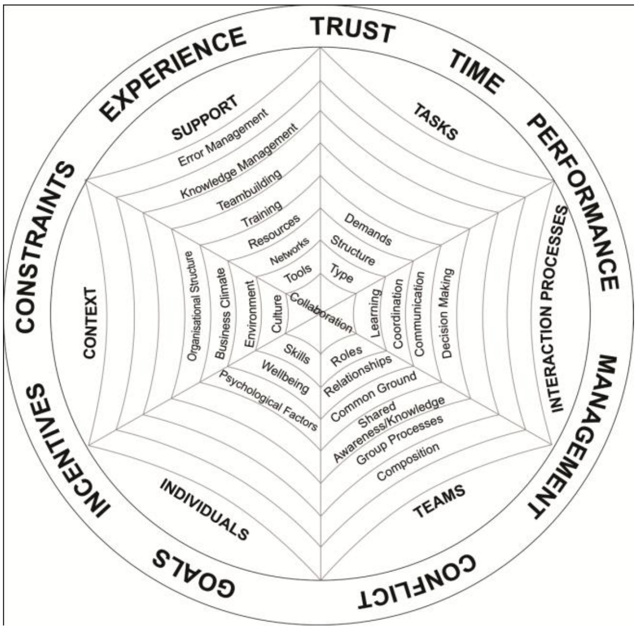

Figure 1. The CoSpaces model of collaborative work.

The web illustrates the mutually dependent relationship between the main factors of collaboration. **Individuals** and **teams** are central to the process of collaboration, engaged in intra- and inter-group collaboration (Bratman, 1992; McNeese et al., 2000; Schrage, 1990; Sundstrom, 1999; Unsworth and West, 2000; Warner et al., 2003). They are involved in **interaction processes** (Steiner, 1972; Weiseth et al., 2006) which are required in order to work together to perform **tasks** (Harvey and Koubek, 2000; Warner et al., 2003). Providing **support** is essential for ensuring that collaborative work is effective and efficient, and that individuals and teams have access to the resources required to perform their tasks, and meet their goals and needs (Hackman, 1990; McNeese and Rentsch, 2001; Weiseth et al., 2006). **Context** forms the final segment of the web, usually dictating the individuals and teams, tasks, and support that is/are needed/provided - and thus will impact on the actual process of collaboration itself (Neale et al., 2004; Unsworth and West, 2000; Warner et al., 2003; Weiseth et al., 2006). Sub-factors associated with these main factors are shown within the web, and factors which '**overarch**' the main factors are shown circling the web.

Metaphorically, the web clearly shows the close relationships between the main factors – breaking any of the links in the web would make it weaker overall. It should be noted that the distance of the factors from the centre of the web is not of any significance. Furthermore, there is no special relationship or connection between factors which lie side by side next to each other.

3 Collaboration profiling tool

We applied the CoSpaces model and our empirical work with CoSpaces user partners in a practical way to underpin the concepts of a new methodology called CoScope, designed to assess the collaboration capability of organisations and organisational readiness for collaborative technologies across multiple dimensions. The CoScope methodology uses a collaboration profiling model which utilises methods defined in the ISO/IEC TR 15504 standard. This standard was extended to support additional processes and factors related to collaboration which were derived from the CoSpaces model. The methodology is broad enough to accommodate the different collaboration styles found in commercial and public entities.

A CoScope assessment involves three assessors carrying out a structured interview whilst recording data simultaneously. The interview involves multiple stakeholders (with different roles) working on the same project. Projects are assessed on four life cycle processes: delivery (including collecting information on information production, decision making, communication, coordination, learning and error management), team working (including roles, group processes, team composition, common ground and shared awareness), support (including knowledge management, team building, training, networks of support and tools) and organisational processes (including trust, conflict, goals, incentives, integration and management). Some metrics associated with the project being assessed are also collected, for example, information about user satisfaction, user participation, supplier responsiveness, project duration, annual spend, return on investment etc.

The involvement of different stakeholders identifies contrasting perceptions and differing understandings of the collaborative process, and can help to improve communication and understanding of collaborative processes among team members. This method is supported by the CoScope software tool which collects the assessment data and produces collaboration capability profile graphs which are based on all stakeholder viewpoints.

CoScope focuses on the extent to which the fundamental conditions for collaboration are created, sustained and standardised across teams and organisations. For example, whether there are formalised procedures in place for error management, or whether procedures vary between teams, or whether such a process is mainly conducted ad hoc. Six process attributes are used in CoScope to measure the capability of the four organisational life cycle processes, ranging from whether certain processes or tasks are performed, to whether employees have the skills to perform these processes, and whether processes are performed consistently across the organisation and at a high level of quality.

An example of one of the questions in CoScope is: 'Are teams motivated to use new communication tools?' The assessor uses a number of statements or indicators as probes during the interview in order to determine how well the process is performed; so all the indicators potentially affect the team's motivation to use new tools. For this question the indicators are:

- Team members are aware of the limitations of current communication tools (if any)
- New communication technologies are selected according to team needs
- Benefits of new communication technologies are clearly articulated
- Team members participate in the selection of new communication technologies
- The impact of introducing new communication technologies is assessed in advance
- Appropriate strategies (e.g. phased introduction, staff training, change management) are established for introducing new communication technology

Figure 2 shows an example of one of the CoScope output graphs from an assessment carried out with an industrial project team. The graph shows the different processes assessed using CoScope and the ratings associated with the different attributes for each process. Due to limitations of time (90 minutes were available), this assessment focused on whether a process is performed, whether resources are available to support the process/task, and whether the task is planned and if the plan is reviewed and managed). Notes were taken during the assessment to provide a record of some of the reasoning behind the ratings given to each of the criteria listed above. A summary of these notes accompanies the graphs produced by CoScope to provide a detailed assessment of the current situation to the project team. Overall, this project team is performing at the largely achieved level for the majority of areas covered in the interview.

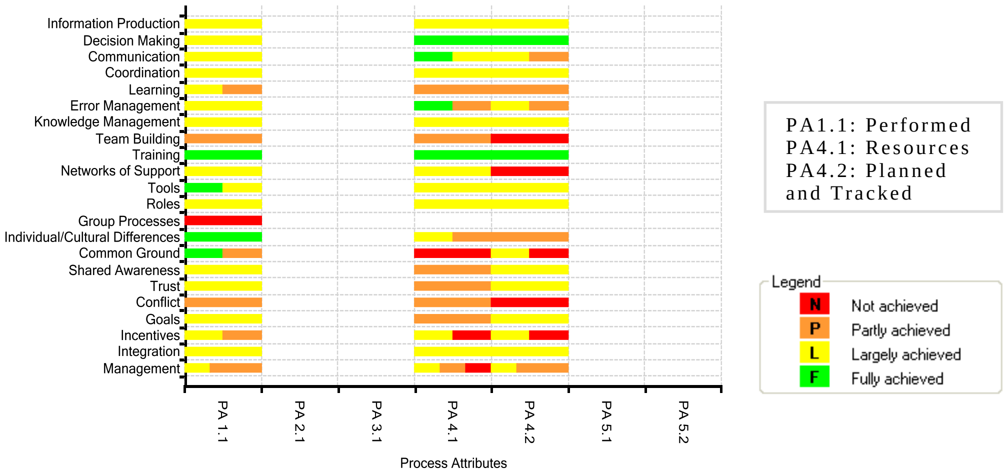

Figure 2. Process attribute ratings associated with different project lifecycle processes.

The CoScope output can highlight areas of strengths and weaknesses within a project team, providing a measure of whether organisations have in place the best conditions for collaborative work – it provides a profile of measures and attributes that indicate the maturity or sophistication of each of the most important collaboration processes as defined in the CoSpaces model. The assessment also helps to identify achievable targets for improved collaboration related to specific business needs and objectives, and identify the organisational and technical changes that will be necessary to meet those targets. This tailored approach is expected to result in greater success in the adoption of collaborative technologies and to provide substantial benefits to organisations that invest in improving collaboration.

Pilot studies have shown the CoScope methodology to be powerful in its analytical capabilities and capable of being used as a first appraisal or for a comprehensive and in-depth organisational analysis. The pilot studies highlighted areas which could be improved and thus the methodology is still under development. The time available for the pilot studies was between 90-180 minutes. A more thorough assessment of an organisation could take between three and five days. Ideally, several assessments would be conducted with different teams within an organisation, in order to generate a more comprehensive and comparative analysis of collaborative work across the organisation. Each team assessment would likely require a full day. In spending this amount of time with a team, assessors would be able to employ all the process attributes in the tool.

CoScope can be used to re-assess collaboration following the implementation of changes and the output can be used to compare different teams within an organisation.

4 Discussion

Collaborative work is inherently complex and the factors which constitute and influence it are multiple and their importance and interactions between them vary depending on the situation. Findings from an extensive literature review and empirical work with industrial companies have fed into the development of a descriptive model of collaborative work. This model is broad enough to reflect the different elements of collaborative work which are part of commercial and public organisations. Such a model provides teams with a clear overview of the areas which impact on their collaboration and overall performance and provides a framework for defining user requirements for collaborative technologies, new collaborative working structures and support mechanisms (e.g. training) and can subsequently inform change management strategies and evaluation.

The CoSpaces model of collaborative work underpinned the concepts of the CoScope methodology which was designed to effectively assess the collaboration capability of industrial project teams across a range of dimensions, with the overall aim of providing guidance on areas which could be improved in order to enhance collaborative work. CoScope involves conducting small group semi-structured interviews with project team members who perform different roles. Such a tool could eventually support benchmarking to assess projects against each other or against themselves over time, and possibly even compare companies in the same sector against each other.

The CoSpaces model of collaborative work has been broadly accepted by the CoSpaces industrial and research partners, and by a wider industry and academic audience through training workshops that we have run at key conferences associated with the collaborative engineering, ICT and human factors communities. In addition, initial pilot studies using the CoScope methodology verified its usefulness at assessing the conditions for collaborative work, and the industrial partners involved were very positive about its practical benefits.

5 Acknowledgments

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Study of correlations between logfile-based metrics of interaction and the quality of synchronous collaboration

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Abstract. This paper presents a study that investigates correlations between various metrics of interaction based on interaction events automatically recorded by an online collaboration tool, and collaboration quality as it is assessed by human agents according to a rating scheme. The study concerns a large dataset of synchronous problem-solving technology-enhanced collaborative learning activities.

1 Introduction

Research on technology-enhanced collaborative learning has focused on analyzing and assessing computer-supported collaborative activities with the aid of various analysis and evaluation tools. Collaboration support systems allow automatic loggings of users' actions that are maintained in suitably structured logfiles, which can then provide the basis for the calculation of automated metrics of interaction. In technology-enhanced collaborative learning, the state of evolving knowledge must be continuously displayed by collaborating participants with each other (Stahl, 2002). Therefore, what one participant communicates with others is accessible to researchers through logfile entries, providing thus an objective source for analysis (Dillenbourg et al.,, 1995). Such data can then be subjected to automated statistical elaborations which, in the form of suitably implemented metrics, may be useful for indicating important aspects of collaboration quality.

There is, however, limited evidence that automatic metrics of interaction reported in the literature are capable of indicating collaboration quality (e.g. Avouris et al., 2004). There either is no rigorous examination of their indicatory value, or they are compared to indirect indications of collaboration quality such as the quality of the outcome of a collaborative process (Aditomo, & Reimann, 2007).

This study presents an extensive set of metrics of interaction that were designed and implemented in order to be statistically tested for their suitability to indicate core aspects of collaboration quality. Each metric was kept rather simple, so that potential results would be easily interpretable and additional, more sophisticated metrics would be developed in the future, informed by current findings. Correlational statistical tests were then carried out comparing scores that the metrics took in a large dataset with collaboration quality ratings applied following a different methodological approach (Kahrimanis et al., 2009).

2 Automatic metrics of interaction

Metrics designed and developed in the frame of this study were informed by an existent metric set implemented by the Synergo tool, which provides a chat and a shared workspace supporting collaborative modelling activities (Avouris et al., 2004). Like most collaboration support tools, Synergo keeps logs of events of users' interaction with the tool in a logging format inspired by the Object-oriented Collaboration Analysis Framework (OCAF) (Avouris et al., 2003). According to OCAF, collaborative activity can be described in a four-dimensional space, the four axes of which are *time, actor, object,* and *typology. Time* refers to the temporal moment of the occurrence of a users' action, *actor* is the collaboration participant who generated an action, *object* refers to an object created throughout the process (e.g an item in the shared workspace or a chat message), and *typology* contains a characterisation of an event according to some predefined categorisation. In that manner, all Synergo logfile records follow a format based on these core dimensions, and metrics of interaction are calculated taking advantage of the structure of data gathered.

For the purposes of this study, the existent set of metrics of interaction of Synergo was reshaped and significantly augmented. Four categories of events were defined based on the kind of object that an event relates to: *Chat messages (C)*, *Main actions in the Workspace (MW)* (including only these actions in the workspace that lead to significant changes in the developed model), *Overall actions in the Workspace (OW)* (including actions in the workspace of secondary importance as well, such as the movement or resizing of existent objects), and *overall EVents (EV)* (including all categories of events captured). Generic types of metrics were then defined that involve calculations of the data logged, taking advantage of other information of log annotations, such as the typology of actions, temporal aspects, and interchanges of the actors of events. Eight such types of metrics were then developed, each one of them applied for each category of events mentioned above: *number of [], rate of [], symmetry of [], alternations in [], rate of alternations in [], mean response time in [], median response time in [],* and *number of [] gaps per X (parametric) seconds* (with the square brackets standing for any category of events). 4 additional metrics that could not be covered by the above typology were also added so that the final set used consisted of 36 metrics. The whole metric set is illustrated in Figure 1.

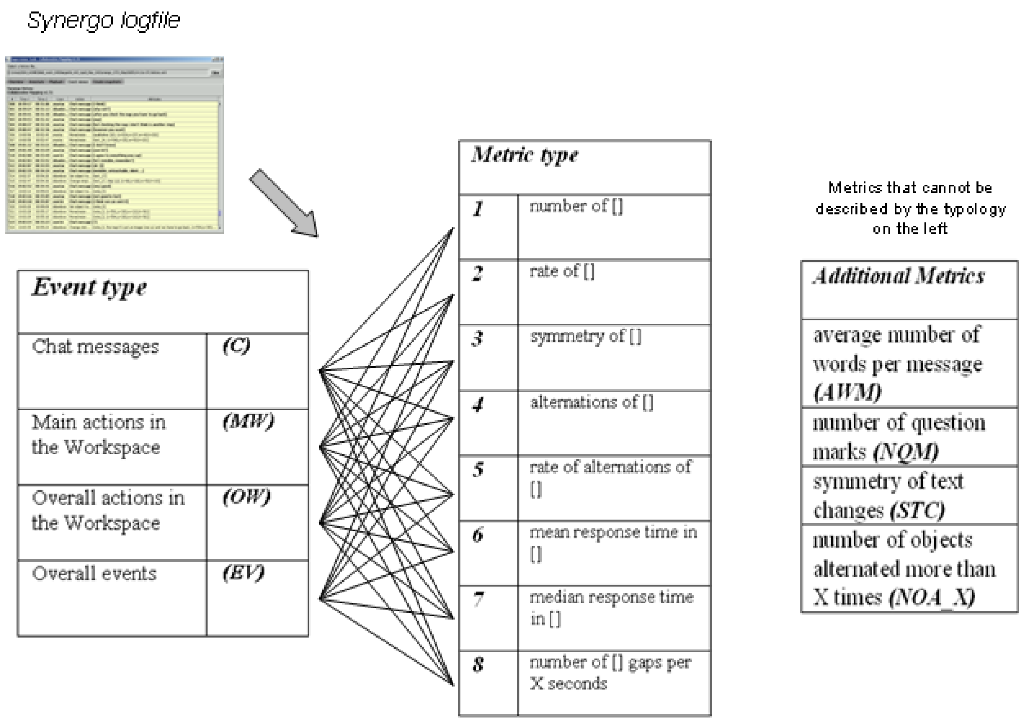

Figure 1. The augmented set of Synergo's automated metrics of interaction

3 Collaborative setting

The objectives of this study implicated that the newly developed metrics should be tested empirically in a large-scale, real-world scenario. Therefore, extended collaborative activities were designed and put on, in order to provide a rich data source for statistical analysis of the values that metrics take in common, naturalistic CSCL activities. The collaborative activities studied involved approximately 350 university students in the Computer Engineering in the Electrical and Computer Engineering Department of the University of Patras, Greece, engaged in jointly building the diagrammatic representation of an algorithm as an assignment of a two-hour laboratory session that was part of the first-year of studies course “Introduction of Computers and Algorithms”. Students interacted synchronously through Synergo (Avouris et al., 2004), communicating via an integrated chat tool, and jointly designing a flow-chart representation of an algorithm in Synergo’s shared whiteboard. Collaborative sessions lasted from 45 to 75 minutes and students worked in dyads. In order to motivate students to work on the exercises collaboratively, they were informed that the grade they would get for the particular lab session (all the laboratory exercises determined 30% of their final course grade) would be formed equal parts determining the quality of their collaboration and the completeness and correctness of their joint solution. Dyads were arranged in space in a way that it was impossible for the students to use any other means of communication apart from these provided by Synergo, practicing thus the case of distant collaboration. The final dataset used in this study consisted of the collaborative sessions of 228 dyads.

4 Rating collaboration quality

Due to the limited evidence of the value of automatic metrics of interaction for indicating important aspects of collaboration, a statistical approach was followed that aims at comparing the information provided by these metrics with quantitative assessments of collaboration from another methodological standpoint. For that reason, a rating scheme approach was followed that involves human agents assigning ratings of collaboration quality in several of its core dimensions. Apart from leading to quantitative results, suitable for integrated elaboration with the metrics’ values, this approach takes into account deeper aspects of collaboration than calculations on event logs can convey, at least from a first point of view.

A rating scheme or a rating scale is “a measuring instrument that requires the rater or observer to assign the rated object to categories or continua that have numerals assigned to them” (Kerlinger, & Lee 2000, p. 736, cited in Meier 2005). Rating schemes are discriminated from coding schemes in that they are used to make a judgement on a larger piece of data each time, and are based on the knowledge and the critical skill of the human agent that applies them, in contrast to coding schemes that demand from the coder to neutralise the process by following strictly defined rubrics (Kerlinger, & Lee 2000).

The conceptual framework for the definition of core aspects of collaboration quality to be rated for each case is influenced by the work of Meier et al. (2007). This framework defines the main dimensions of collaboration quality that were operationalised using a concept-oriented rating scheme, stating precise definitions of the concepts that determine the rating grades, and providing information of the means of correctly applying the process (Guilford, 1954). For that reason, a handbook including anchoring examples and guidelines for the correct conduction of the rating process is provided (Meier 2005). Therefore, the rating approach is normative, i.e. it compares assessments to an exemplary case of desired collaboration quality.

Due to some significant changes in the setting of collaborative activities, the mediating tools, the profiles of the students, and the design of the task, the framework and the rating tool were generalized and adapted so as to be suitable for the settings of activities of this study (Kahrimanis et al., 2009). The resultant rating scheme consists of 7 dimensions of collaboration quality: *collaboration flow, sustaining mutual understanding, knowledge exchange, argumentation, structuring the problem solving process, cooperative orientation,* and *individual task orientation* (Kahrimanis et al., 2009). The adapted version of the scheme is depicted in Table I, which contains each dimension of the rating scheme related to the general aspect of collaboration quality that it belongs to.

Table I: Dimensions of collaboration quality as defined by the adapted version of the rating scheme

General aspect of collaboration covered	Dimension of the adapted version of the rating scheme
Communication	Collaboration flow
	Sustaining mutual understanding
Joint information processing	Knowledge exchange
	Argumentation
Coordination	Structuring the Problem Solving Process
Interpersonal Relationship	Cooperative orientation
Motivation	Individual task orientation

Each collaborative session was then rated using a Likert-like scale: {-2,-1,0,1,2}. The rating process was based on video-like reproductions of the activities facilitated by the Synergo's playback tool, and an adapted rating handbook that guided raters' decisions (Kahrimanis et al, 2009). One rating was assigned for each session and dimension of the rating scheme. Two raters with prior experience with the task were responsible for the ratings, which were tested for inter-rater reliability using 33% of the dataset. Reliability scores were good: ICC ranged between .83 and .95, adjusted ICC between .84 and .95, Cronbach's alpha between .91 and .98, depending on the dimension rated (Kahrimanis et al, 2009). The resultant rated dataset was then ready for correlational analysis with the automatically calculated values of the metrics developed.

5 Correlation between metrics of interaction and collaboration quality

All statistical correlations between each metric and the ratings of collaboration quality for each dimension of the rating scheme were calculated. Some indicatory results are provided in Table I.

Table II: correlations between six metrics and dimensions of the rating scheme (including the average and absolute difference of the ratings in individual task orientation of the two participants and the average of the six first dimensions of the scheme). Upper value: Kendall's τ coefficient, and lower Spearman's ρ coefficient (distributions not normal)

	Coll. flow	**Sust. mut. unders.**	**Knowl. exch.**	**Argu-men-tation**	**Struct. Probl. Solv. Proc.**	**Cooper. Orient.**	**Ind. Task Orient. (avg)**	**Ind. task Orient. (abs. diff.)**	**Avg 6 dim.**
C1: # of chat messages	.389** .507**	.317** .421**	.411** .534**	.410** .529**	.308** .409**	.366** .473**	.299** .388**	-.211** -.270**	.409** .564**
C4: altern. chat mes.	.407** .527**	.349** .460**	.406** .535**	.427** .552**	.309** .414**	.389** .503**	.327** 420**	-.247** .314**	.425** .583**
C6 mean res. time in chat	-.351** -.464**	-.304** -.405**	-.372** -.489**	-.379** -.494**	-.308** -.413**	-.330** -.439**	-.284** -.374**	.213** .274**	-.380** -.529**
MW1: # of MW actions	-.164** -.215**	-.102* -.135*	-.100* -.131*		-.116* -.153*				-.119** -.168*
MW3 symmetry in MW		.150** .203**		.125* .168*		.215** .282**	.270** .354**	-.340** -.433**	.112* .166*
EV3 symm. in EV	.131** .175**	.213** .286**		.137** .185**	.117* .157**	.247** .324**	.243** .317**	-.320** -.410**	.152** .220**

** p<0.01, * p<0.05

The main findings of this analysis are summed up in the following: chat-based metrics are highly correlated with all dimensions of collaboration quality. The highest correlations were found for the *collaboration flow* dimension and the dimensions that indicate information processing (*knowledge exchange* and *argumentation*). The most valuable chat-based metrics for indicating collaboration quality were the *number of chat messages*, the *alternation of chat messages* and the *mean response time in chat messages*. Almost all chat-based metrics correlated at statistically significant levels with most dimensions of the rating scheme. A notable exception was the *symmetry of chat messages* which did not correlate with any of the rating scheme's dimensions, since it took rather stable values throughout the dataset.

Concerning workspace-based metrics, one of the most notable findings relates to *symmetry in main actions* or *overall workspace actions*, which is a strong indicator of the difference in *individual task orientation* between participants, while it correlates at more moderate levels with *cooperative orientation,* *sustaining mutual understanding,* and *argumentation* as well. On the other hand, metric MW1, the *volume of workspace-related actions*, is a negative indicator of collaboration quality on most of its dimensions and especially on the two communicational ones. The latter finding indicates that too much activity in the workspace is usually related to bad coordination and redundant actions in the workspace and hinders rather than aids communication and task coordination.

Overall events metrics usually convey similar information to the combination of metrics of the two distinct categories. In some cases, such as the total number of overall events metric (EV1), the two effects counteract and lead to non-statistically significant correlations with most dimensions. In other cases, however, this category provides metrics that provide additional information regarding their association with dimensions of collaboration quality. Such is the case with the symmetry in overall events (EV3), which correlates with dimensions of collaboration following approximately the same pattern with MW3 but with somewhat higher scores in most cases.

6 Conclusions and further research

This paper presented a study that designed and implemented a large set of metrics of interaction and examined the extent to which they can indicate core aspects of collaboration quality as the latter was defined and operationalised by Meier et al. (2007) and adapted by Kahrimanis et al. (2009).

Results of extended correlational statistical analysis in a large dataset of real-world collaborative activities revealed the extent of association of each metric with each distinct aspect of collaboration quality. Chat-based metrics were generally proved quite informative of desired collaboration practices or their absence, whereas workspace-based metrics provided insight into subtler issues of collaboration quality, reflecting negative facets of collaboration as well.

A respectable number of metrics was correlated at medium or high correlation scores with dimensions of collaboration quality, providing thus opportunities for the future development of models of automatic assessment of collaboration quality built on metrics reported above. Furthermore, findings obtained so far can inform the further refinement and development of automated metrics of interaction that belong to categories extensively correlated with dimensions of collaboration quality.

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Quantitative assessment of collaboration

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Abstract. This paper presents a short literature review of a research trend that endeavors to model collaboration by quantifying each group member's contribution. In such a view, *equity* is considered as the ideal collaborative situation. We review some foundational elements of this approach, some methodological aspects, describe a case study applying such concepts and analyses, and present examples of design implications for Computer-Supported Cooperative Work.

1 Equity as a paradigm for collaboration

Our aim in this paper is to present a research trend initially born in Psychology and Management science and later used in Human-Computer Interaction, modeling collaboration through the quantification of each participant's contributions. In this approach equity is sought, whatever the quality of contributions. Indeed for tasks involving negotiation, for collaborative learning, and every time it is important for all members to have their say, equity *per se* is a desirable state (Marshall *et al.*, 2008) regardless of the quality of contributions. Equity also refers to "democracy", in Habermas' sense (1984), as a set of ways to ensure the information communicated by the various participants is done so with minimal distortion (as opposed to a repressive communicational framework). There are many professional situations, for example in design, where contributions from multiple participants are expected to speed up exploration of the problem space, and to ensure that decisions are made through integrating multiple points of view (Sommerville *et al.*, 1998; Wolff *et al.*, 2005). Equitable or democratic decision making should be promoted, except for specific situations such as crisis management, where authoritarian decision making will be considered as more efficient and will be preferred.

Disregarding the quality of contributions (at least at first) to favor equity is also justified in the context of tasks such as creative brainstorming, where a strongly established paradigm points to "team idea generation" as a key element of work. In brainstorming, participants are indeed prompted to produce as many ideas as possible, to rule out criticism and self-censorship, to take each other's ideas to combine and improve them (Osborn, 1953). This has two major consequences: the quality of individual contributions cannot be assessed since contributions are merged together so that ideas belong to the group and cannot be attributed to a single member. Secondly, quantity of contributions becomes the only way to assess individual engagement in the task.

The equity paradigm has given rise to the observation of social phenomena such as social loafing and social compensation (Karau & Williams, 1993; Serva & Fuller, 1997): in a group situation, some participants tend to under-contribute with comparison to a situation where they would work alone (which is called social loafing) and other participants tend to over-contribute (social compensation). Social compensators become group leaders and social loafers become followers, which is a frequently-observed but not particularly desirable phenomenon. Indeed, it was shown that social loafing can be moderated by e.g. group cohesiveness (Karau & Hart, 1998), self-evaluation (Harkins & Szymanski, 1988), individual motivation (Brickner *et al.*, 1986; Shepperd, 1993) or by the use of special collaborative devices as will be reported in section 4.

2 Methods for measuring equity in collaboration

Several metrics have been proposed to measure the equity of collaboration:

- The standard deviation of interface actions made by individuals (Ringel Morris *et al.*, 2006): the larger the standard deviation, the less equitable the collaboration. A disadvantage of standard deviation is that it varies with both group size and the total number of actions, it is therefore difficult to compare across different study designs (Marshall *et al.*, 2008).
- The Gini Coefficient (Fitze, 2006) which has been used to measure the equity of contribution in groupware systems, classroom dialogue, economic income distributions, etc. It varies between 0 (perfect equity) and 1 (perfect inequity: 1 person has all of the income). However, the Gini coefficient in its standard form seems unsuitable for small numbers of participants (Marshall *et al.*, 2008).
- For analyzing brainstorming activity, we used the A index of inequity (see Table 1) where N=size of the group, E=the expected proportion of events if each participant contributes equally, and O_i=the observed

proportion of events for each individual (see section 3). A normalized version of such index (see Table 1, Equation B) can also be used (Hiltz *et al.*, 1989; Marshall *et al.*, 2008) when one intends to compare varying tasks or contexts or study designs.

A	$I = \frac{1}{N}\sum_{i=1}^{N}\lvert E - O_i \rvert$	B	$I = \frac{\frac{1}{N}\sum_{i=1}^{N}\lvert E - O_i \rvert}{\frac{1}{2}(1 - \frac{1}{N})}$

Table 1. Inequity indices: Equation A (Buisine *et al.*, submitted) and B (Marshall *et al.*, 2008). N=size of the group, E=the expected proportion of events if each participant contributes equally, and Oi=the observed proportion of events for each individual.

All these metrics can be applied to conversational turns and/or interface actions and/or artifact actions and/or nonverbal communicative behaviors. Furthermore, they can be combined to complementary metrics including questionnaire data to investigate the perceived equity. In this respect, when equity is considered, subjective perception and post-hoc reports can significantly differ from observed “objective” behavioral metrics.

3 Case study

We conducted an experimental study to understand if and how the use of an interactive tabletop system (Scott & Carpendale, 2006; Shen *et al.*, 2006) would improve brainstorming. We compared 4 experimental conditions (Buisine *et al.*, in revision): the reference situation of creativity sessions (pen-and-paper tools in front of a paperboard), pen-and-paper tools around a non-augmented table, and 2 augmented multi-user tabletop systems (see Fig. 1), with more or less innovative interaction styles.

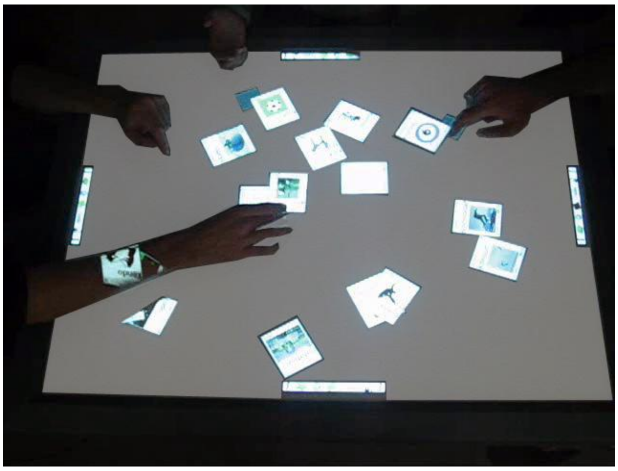

Figure 1. Our interactive tabletop system (Circle twelve DiamondTouch) for brainstorming (4 participants allowed).

Overall, 80 participants were involved in the experiments by groups of 4 people at the same time, and each group performed 2 creativity exercises (within-group experimental design). Three kinds of variables were collected: performance criteria (number of ideas generated, width and depth of production), subjective data (ex: ease of use, effectiveness, pleasantness, motivation), and collaboration as assessed by the inequity index (see Table 1, Equation A). For the calculation of the inequity index we numbered the following behaviors from the video recordings of the sessions: assertions (e.g. giving an idea), information requests (e.g. requesting a clarification about an idea), action requests (e.g. asking a participant to "send a note over"), answers to questions, expression of opinions, communicative gestures related to the task, and off-task talk. The "communicative gestures" variable includes for example pointing to an item, moving a note, interrupting someone or requesting a speech turn by a gesture.

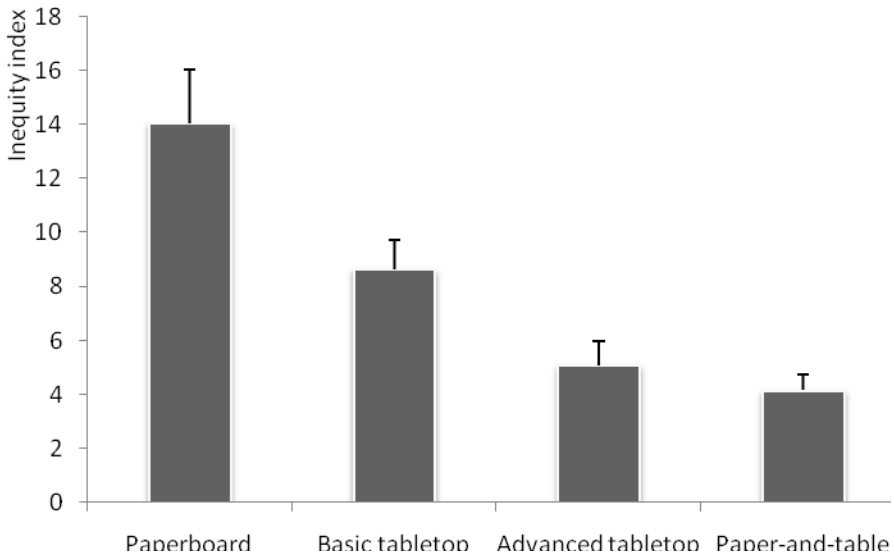

Figure 2. Average inequity in the 4 conditions: Paperboard, Basic digital tabletop, Advanced digital tabletop, and paper-and-table.

The results showed that creative performance increased with the around-the-table spatial configuration (advanced digital tabletop and paper-and-table conditions). Moreover, subjective evaluations were globally in favor of the advanced tabletop condition: users preferred this device to pen-and-paper tools, especially because of the pleasant and fun nature of the interface. Our results also show that extrinsic motivation significantly increased in the advanced tabletop condition, which can be attributed to the attractiveness of the device. Regarding the participants' collaborative behaviors, we observed that inequity was highest in the paperboard condition, and lowest in both the advanced tabletop and paper-and-table conditions (see Fig. 2). Improved collaboration in paper-and-table compared with paperboard can be explained by the around-the-table setup, and improved collaboration in advanced tabletop compared with the basic tabletop condition may result from improvements in the prototype (ex: interaction styles more adapted to the task).

Overall, we have several results suggesting that the around-the-table setup (either with pen-and-paper tools or with an interactive multi-user device) should be promoted for increasing performance and improving collaboration in brainstorming. Inequity of contributions was lower when the participants brainstormed around a table, which means that social loafing and social compensation were lower, and therefore the emergence of leaders and followers was limited. The underlying phenomenon might be related to an increase of social comparison: when sitting around the same table, participants may have more opportunities to compare their own performance to the others'. Social comparison was indeed shown to be a source of motivation for brainstorming participants and to improve idea generation (Harkins & Jackson, 1985; Bartis *et al.*, 1988; Paulus & Dzindolet, 1993; Dugosh & Paulus, 2005; Michinov & Primois, 2005).

The fact that performance and collaboration were better with the "around-the-table" configuration is a ground-breaking result for research on creativity processes. The spatial configuration of participants facing the facilitator and generally sitting side by side constitutes a traditional and undisputed paradigm of creativity sessions. Our results suggest this convention should be questioned, even with pen-and-paper tools.

4 Design implications for CSCW

The research and findings about equitable collaboration has provided inspiration for numerous studies in Human-Computer Interaction and Computer-Supported Cooperative Work, since some designs and devices were found to significantly increase equity of collaboration:

- Providing real-time explicit feedback on each member's quantity of contributions (see Fig. 3) was shown to favor equity of collaboration (Ringel Morris *et al.*, 2006; Kim *et al.*, 2008).
- McKinlay *et al.* (1999) showed that a remote electronic brainstorming application decreased social compensation with comparison to a co-located brainstorming session, resulting in more equity but also in a an overall decrease of contributions.
- Providing multiple entry points or multiple input devices on the collaborative medium, for every member to be directly able to interact with the task material, increases equity of collaboration (Marshall *et al.*, 2008).
- As seen in the previous case study, around-the-table spatial configuration also leads to a better balance between participants' contributions. This result challenges WYSIWIS (What You See Is What I See) groupware (Stefik *et al.*, 1987; Zhu, 2004). Indeed a founding paradigm in CSCW

was to give priority to sharing the same view on the same data amongst group members. Around-the-table participants are in a rather relaxed-WYSIWIS setting since users' views diverge with respect to their position, but group awareness is given a higher priority with close proximity and more opportunities for subtle communication channels (e.g. eye contact, facial expressions or body language). This seems to constitute an efficient tradeoff between information sharing and group dynamics.

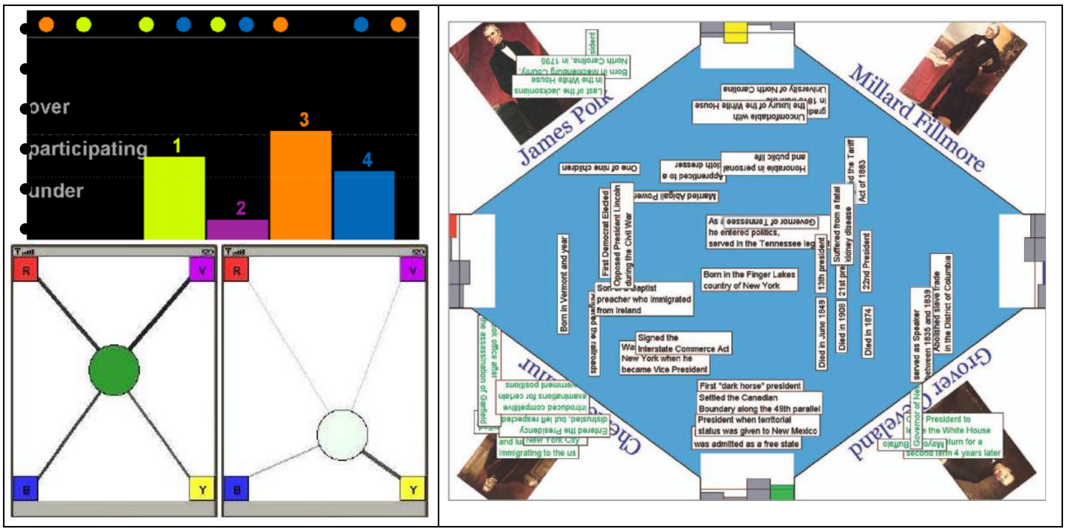

Figure 3. Participation feedbacks designed by DiMicco (2004, see top left picture), its tabletop version (Ringel Morris *et al.*, 2006, see right panel) and a design for phone interface (Kim *et al.*, 2008, see bottom left picture).

5 Perspectives

The equity paradigm and the attempt to quantitatively evaluate collaboration have produced valuable findings such as the identification of some social phenomena arising during collaboration and the design of collaborative media influencing these phenomena. However this remains an incomplete approach to collaboration since quality of contributions and collaboration efficiency are disregarded. In this respect interesting research perspectives include the combination of qualitative and quantitative indices in order to draw a more general model of collaborative activities and allow the design of more efficient collaborative media and situations.

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Quality of collaboration in a distant collaborative architectural educational setting

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Abstract. This paper analyses the quality of collaboration of two student teams in a longitudinal study of a collaborative distant architectural studio. Based on a simple method to assess several dimensions of this quality of collaboration, we compared the two groups at three stages of the design process. We also analysed how the quality of collaboration evolved over time and as a function of the design stage. We finally discuss the interests of the method and some insights to support a better understanding of mechanisms of collaboration.

1 Introduction

This study aims at assessing the quality of collaboration in a distant computer-mediated collaborative setting, in the domain of architectural design. We have analysed several dimensions of the quality of collaboration in two sudents teams which collaborated remotely during three months in a distant architectural studio,. The teams used both asynchronous (emails, file exchange servers) and synchronous collaborative tools (chat, a videoconferencing system,) including a prototype of augmented tabletop called Distributed Collaborative Design Studio (DCDS). The present report focuses on a selection of synchronous work sessions with the DCDS, in order to observe the challenges of a good collaboration and its evolution regarding the design process. The quality of collaboration was assessed with a rating-based method previously validated on short(er) episodes of collaborative design activities (Burkhardt et al., 2009b).
The remaining of this paper is organized as follows. We provide first a brief presentation of the pedagogical context of the study. It is followed by a description of the main features of the DCDS prototype used in this experiment. We then report on the method of the study. The main results are provided followed by a short discussion.

2 A pedagogical experiment with a distant computer-mediated collaborative design studio

The experiment takes place in the framework of a collaboration between the Nancy School of Architecture (France) and the Faculty of Applied Sciences of the University of Liège (Belgium). 16 students, 5 in Belgium and 11 in France, worked during one term (3 months, 4 hours a week) on an architecture program. The students were distributed by groups of 4 (2 in Belgium and 2 in France, or 1 in Belgium and 3 in France). The teams were given the task of designing collaboratively and remotely a polyvalent concert hall. The program was completely defined, and the proposed site was visited during the first meeting in presence of all the participants. Each student in a team were assigned two predefined role among the following ones: Architectural design, interior architecture, structure, environmental quality, acoustics and lighting, special techniques, coordinator. They could use all the synchronous and asynchronous collaborative tools they want. In addition to these, they were allowed to use a prototype called Distant Collaborative Digital Studio (DCDS) one hour per week. The DCDS enables distant students to share voice, gestures and graphics productions in real-time (see following section).

The entire experiment was supervised by a pedagogical staff of four persons (2 in Belgium and 2 in France). During each collaborative synchronous sessions on DCDS, two teachers were present (one at each place). At the end of the term, the students proposed their architectural solution, as well as a critical analysis of their collaborative work and of the tools to support this collaboration.

3 The Distant Collaborative Digital Studio prototype

The Distributed Collaborative Design Studio (DCDS) is composed of:

- a hardware part – the Design Virtual Desktop – (fig 1) which consists of an electronic A0 table with a suspended ceiling equipped with a projection system offering a large working surface (approximately 150x60 cm). An electronic stylus allows the drawing of virtual sketches onto this surface. The central unit is located in the ceiling. This leaves the stylus as the only interaction tool, so that the computer can disappears from designers' mind.
- a software part SketSha (for sketch sharing) which is a shared drawing environment allowing several virtual desktops to be connected to the same drawing space (fig. 2). Various functionalities, such as importation of CAD plans and bitmap images, a panel of colored pens (and an eraser) and navigation functions (zoom, translate, rotate), are proposed through intuitive graphical widgets. This software captures the strokes that compose the sketch and shares them between the distant locations (through internet connection).
- a 24 inches display with an integrated camera and a videoconferencing commercial module, that allows the participants to see and talk to each others, in an almost 1/1 scale, during a real-time conference (see fig 3).

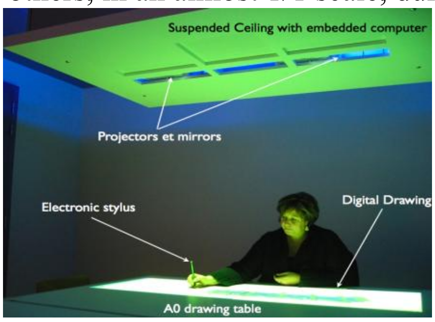


Fig 1 : Virtual Desktop.

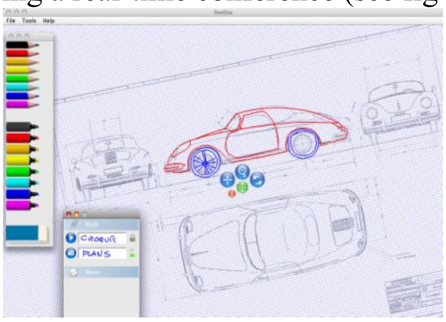


Fig. 2 : SketSha Interface.

Fig. 3 : Distributed Collaboration Design Studio.

This environment aims to recreate at distance the conditions of copresence. It has proven to be efficient in supporting design activities, in professional and educational settings (Safin et al. 2009; 2010; Kubicki et al. 2008; Elsen & Leclercq 2008).

4 Methodology

We followed two groups among the four during the entire experiment. All their exchanges were recorded and their weekly meetings on the DCDS were videotaped. These groups have been chosen regarding to their efficiency, as assessed by the pedagogical staff at the beginning of the project (after 3 weeks). One group (G1) has been evaluated as efficient, while the second (G2) has experienced a difficult start. The whole process has been monitored by a researcher, and three selected extracts per groups have been more deeply analyzed to assess the quality of collaboration and the role of the pedagogical staff.

To assess the quality of collaboration, we use a method we previously developed (Burkhardt *et al*, 2009a, 2009b). It is partly based on the rating scale by Spada *et al.* (2005) adapted to collaborative design activities. This method allows a quick coding of video extracts, by judges required to give explicit answers (yes, no, yes/no) to paired questions with positive or negative valence, targeting specific indicators relative to 7 dimensions of collaboration (see table 1). This method has proven to have a strong reliability based on inter-raters correlations (see Burkhardt *et al.*, 2009a, 2009b).

Dimensions	**Definition**	**Indicators**
1. Fluidity of collaboration	It assesses the management of verbal communication (verbal turns), of actions (tool use) and of attention orientation	– Fluidity of verbal turns – Fluidity of tools use (stylet, menu) – Coherency of attention orientation
2. Sustaining mutual understanding	It assesses the grounding processes concerning the design artefact (problem, solutions), the designers' actions and the state of the AR disposal (e.g. activated	– Mutual understanding of the state of design problem/solutions – Mutual understanding of the actions in progress and next actions – Mutual understanding of the state of the system (active functions, open

	functions).	documents)
3. Information exchanges for problem solving	It assesses design ideas pooling, refinement of design ideas and coherency of ideas.	– Generation of design ideas (problem, solutions, past cases, constraints) – Refinement of design ideas – Coherency and follow up of ideas
4. Argumentation and reaching consensus	It assesses whether or not there is argumentation and decision taken on common consensus.	– Criticisms and argumentation – Checking solutions adequacy with design constraints – Common decision taking
5. Task and time management	It assesses the planning (e.g. task allocation) and time management.	– Work planning – Task division – Distribution and management of tasks interdependencies – Time management
6. Cooperative orientation	It assesses the balance of contribution of the actors in design, planning, and in verbal and graphical actions.	– Symmetry of verbal contributions – Symmetry of use of graphical tools – Symmetry in task management – Symmetry in design choices
7. Individual task orientation	It assesses, for each contributor, its motivation (marks of interest in the collaboration), implication (actions) and involvement (attention orientation).	– Showing up motivation and encouraging others motivation – Constancy of effort put in the task – Attention orientation in relation with the design task

Table 1 : Dimensions and indicators (note the last dimension has not been investigated) in this paper).

5 Results

We first characterized the evolution of the design process in both groups along three stages (figure 4.) : (1) a stage of *definition* of the main components of the building, (2) a stage of *decision* about the whole set of building components and (3) a stage of *production* of representations (plans, 3D). The results show that the two groups clearly managed the design process in a different way. The first group G1 was more advanced while the second one G2 took a lot of time to converge during the definition phase. .

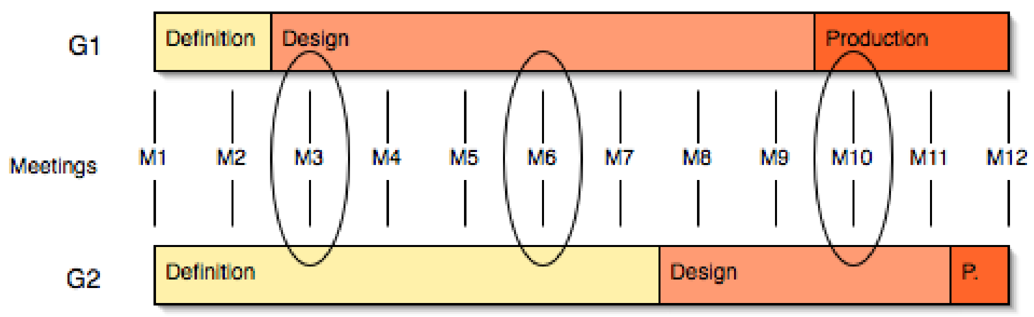


Fig. 4 : Process timeline for the two groups.

During the whole process, each group participated in 12 meetings (figure 4.). The first one was in copresence at Liège, while the last one was in copresence at Nancy. The remaining 10 meetings were done through the DCDS. We applied our method to assess the quality of collaboration on the 3rd, the 6th and the 10th collaborative synchronous distant sessions with the DCDS, Scores on the several dimensions of quality of collaboration grid are given in figure 5.

The main results are provided afterward. We compared the scores of the two group at each of the three meeting, as well as how the scores evolved in a group across the three meetings.

5.1 Between-group comparison

At the meeting M3, results show that the two groups do not collaborate on the same basis : G1 is far more efficient in collaborating than G2, except on the dimensions linked to the process management (TM) and the balance of contributions (CO), which are comparable. These two latter dimensions refer to the “form” of the collaboration, rather to the “contents”.

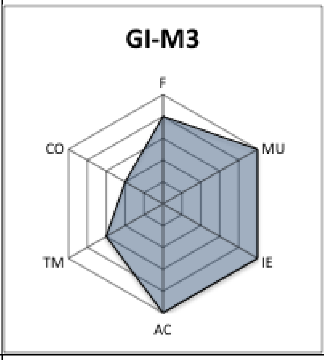
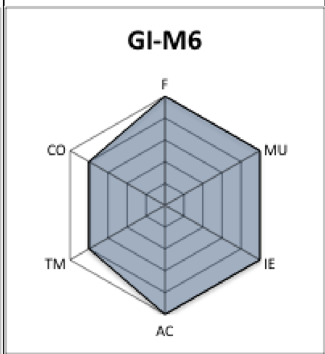
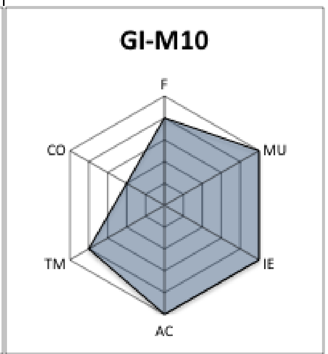
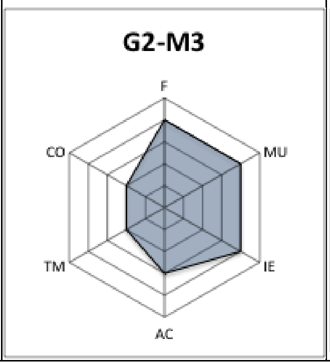
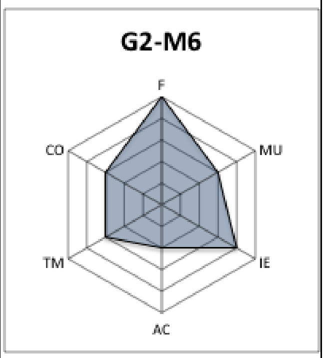
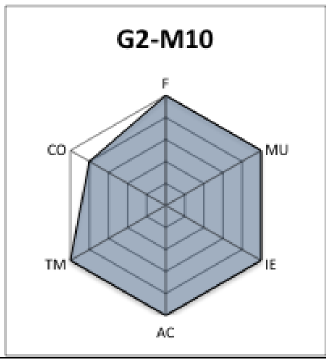
	Meeting M3	Meeting M6	Meeting M10
G 1			
G 2			

Figure 5 : Scores on the Collaboration Quality Scale
F = Fluidity of collaboration ; MU = Mutual Understanding ; IE = Information exchanges ; AC = Argumentation and Consensus ; TM = Task and time management ; CO = Cooperative orientation (balance of contributions)

At the meeting M6, G1 remained better than G2 in terms of quality of collaboration. Both groups enhanced the TM and CO dimensions, but G2 experienced however troubles in the Argumentation and Consensus (AC) dimension.

At the meeting M10, however, the situation seems inverted. G2 exhibited a higher quality of collaboration than GI, regarding the scores in our grid. The two groups had excellent scores, but G1 showed a clear weakness in the balance of contributions (CO).

These results suggest the quality of collaboration to be a multidimensional property that changes over time and that also depends on the task and the phase. For example, G2 was initially rated very low but became excellent in regard to our grid at the end of the design process. At the end of the process, G1 exhibited a lower score for the dimension of balance of contributions than G2. This is easily explained by the fact that at this production phase of design, G1 exhibited a clear distribution of the different production tasks between the team members.

5.2 Intra-groups comparison

The first group G1 exhibited the same pattern during the meetings M3 and M10 (strong collaboration with a weakness in the balance of contributions), whereas during M6, there was an equilibrium between participants. The second group G2 showed a quite difficult start in terms of quality of collaboration (M3 scores were quite low, particularly in management and balance of contributions), followed by a crisis at M6 as the weak score on the Consensus dimension demonstrated. Inversely, G2 exhibited a very good quality of collaboration at the last meeting.

These results may surprised. They must be considered in the light of the design process stages however (see figure 4 : timelines). On the M3 meeting, although G1 is more advanced than G2, the two groups experience difficulties in collaborating (management and balance), that may be explained by the fact they are starting the process. They are able to agree about content but they failed to manage their time and process due to the novelty of the collaboration group and of the collaborative environment. At M6, G1 is collaborating efficiently. The group is engaged in the core design stage, where all decisions may be taken. G2 will have the same collaborative pattern, once the design stage reached, at M10 (M10-G2 is comparable to M6-G1). The Meeting 6 for G2 shows a “crisis” : the group experience difficulties in collaborating, and difficulties to take the core decisions (they are still at the definition stage of the project). At this moment, the pedagogical staff had to intervene, to unblock the decision process. After that, the group is characterized by a great quality in collaboration, and is much more efficient in the design process. Finally, the decrease of the balance of contributions in G1 is due to the fact that the group has entered the production stage. The themes of discussions are related to specific issues relative to the work of only a part of the group, which explain that the contributions are out of balance.

6 Discussion and conclusion

These few results lead us to a number of interesting conclusions. At first, the method, quite simple to apply, allows us to make comparison between and intra groups, which is quite useful to understand the mechanisms of collaboration. They also confirm that collaboration is multidimensional. Indeed, the whole set of dimensions enables us to show how the different dimensions evolve quite differently. Giving a unique score regarding the quality of collaboration would have weakened the richness of what can be observed.

Our data show also that the quality of collaboration and the design process have a double relation : a good collaboration allows the design process to progress, and the progression of the process gives the conditions for a good collaboration. It is thus necessary to take into account the context to draw conclusions about the quality of collaboration: depending on external factors (the stage in the design process, the task at hand), some dimensions may be judged differently. Furthermore, it shows that our prototype DCDS enables to support efficiently distant collaboration design processes.

Finally, another part of this study (which is not described here) shows also some strong relations between the quality of collaboration and the role assumed by the teacher during the meetings (see Safin et al. 2010).

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‘Slow’[1] Collaboration: Some uses of vagueness, hesitation and delay in design collaborations

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Abstract. This position paper points out some of the constructive roles vagueness, hesitation and delay play in the spoken interaction which takes place during collaboration in support of the early stages of design. These observations serve as a reminder that measures of the quality of a collaboration must be sensitive to the task-orientation (purpose) of the collaboration. Even aggregate measures (macro-level), such as duration, participation contribution distributions and frequencies, and so on, that we use to summarise the spoken interaction components of collaboration, derive from the micro-structure of the talk. Thus, in assessing collaboration quality, over-reliance on surface features without regard to the functions they play in their local context risks undervaluing some of the fundamental mechanisms that allow collaboration to take place.

1 Introduction

Close examination of talk-in-interaction is one important source of what we know about how certain kinds of work are achieved through social interaction (e.g. Drew and Heritage, 1992). The workshop’s concerns are with *analyzing the quality* of task-oriented collaboration. In this paper I briefly draw on studies of

1 Slow as used by the slow food movement originated by Carlo Petrini in 1989 which values pleasure from materials, attention to the local, diversity, fairness, and sustainability and which is concerned with creating understanding and appreciation.

collaboration taking place to achieve some *design-oriented* goals to draw attention to how vagueness, hesitation and delay serve the purposes of collaborations in some contexts.

I take quality to be defined as *fitness for purpose*, thus conversational strategies that serve a conversation's purpose have a direct bearing on the topic of collaboration quality. I draw on my own and other researchers' studies of collaboration in which the essential purpose of the social interaction is to make *design decisions* that draw effectively on the skills and knowledge of (all) the collaborators. The successful outcome of such collaboration is not a design that pleases everyone involved, but one where each stakeholder understands the reasons for the decisions that have been made, and is able to justify them from within their own frames of reference.

The term talk-in-interaction covers both informal and formal conversation, the latter being talk subject to functionally specific or context-specific restrictions, or specialized practices or arrangements [Schegloff 1999, p.407]. The features of talk-in-interaction I attend to below come from inspecting how collaboration takes place conversationally and the observations are based on the method of Conversation Analysis (CA) [Sacks 1995, Schegloff 1997]. From this perspective a turn-at-talk is considered as an action, its meaning is approached by considering the local context, in particular by examining the next action, that is the turn-at-talk which follows it. This approach, in focusing on the performative, thus dispenses with reliance on making claims about what is in a speaker's or a hearer's mind. 'In conversation analytic studies, the point is not to build theory but to unpack how events are organized and ordered - to see how social actions are structured and accomplished. This is not done by employing e.g. theoretically-derived concepts or definitions, but rather it is attempted through analysis of the data on the basis that each turn at talk displays *the speaker's understanding* of what is going on.' [Matthews 2009, p.36]

In the remainder of the paper I briefly describe some observations that suggest that, in *design-oriented* collaborations, vagueness, hesitation and delay, scrutinized in the local context of where they occur, play positive roles in support of the collaboration's purpose. The acknowledgement of this potential has implications for how the measurement of collaboration quality is addressed. To make the argument for the collaboration-serving roles of vagueness, hesitation and delay I draw attention to the positive terms related to each in preference to those, equally closely related, which have pejorative overtones.

2 Vagueness

Vagueness, selected thesaurus related terms: sketchy, **open to discussion**, uncertain, ambiguous, uncompleted, contingent, garbled, deficient, perfunctory, feeble, sloppy, careless, incomplete.

The openness to possibilities that is inherent in the nature of sketches, both for the sketcher himself (thinking sketches) and for the audiences of his sketches (communication sketches) [Ferguson 1992] is a phenomenon that has been studied extensively e.g. by Goel [1995]. Thus, it is well understood that ambiguity may be a critical positive quality in some contexts, whilst it is a shortcoming in others. In a related vein in another context, the ways in which lo-fidelity prototypes promote user engagement in interaction design - in contrast to the affordances of hi-fidelity prototypes - is so well understood that it has become an established practice in interaction design processes that engage users. The lo-fi ones communicate suggestions which are fluid, open to revision whereas the hi-fi ones have a specificity that can be interpreted as frozen. (e.g. See Rettig [1994] for a summary of the arguments.)

When we make a close inspection of the turns at talk in design conversation we can see instances of what we might call 'sketchy talk' promoting engagement in collaborative contexts. In a study of conversation between an architect and a building user Glock analyses an episode in which, as he presents a plan for a proposed building, the architect raises the issue of the size of a particular room, a waiting room [Glock 2009]. Glock's micro-analysis examines the architect's choice of phrases to negotiate an increase in the size of the room with the building user. The saying of 'it does look + kind of + small to my eye in relation to the size of the project' allows the architect to introduce a design goal indirectly, encouraging the preferred (agreement) response by a number of devices including delay (+), mitigation ('kind of') and accounting ('in relation to the size of the project') [op.cit., p.293]. Glock goes on to discuss how vagueness infuses the design collaboration with the ambiguity that is essential to certain stages of the design process and makes the point that the vagueness of natural language – in the local context of the example he presents – introduces, and invites the space for negotiation of part of the design detail. He contrasts this with alternative means of raising the matter of the room size by, for example, simply reading off room dimensions from the actual plan over which the discussion is taking place. He suggests that the speaker's way of raising the issue makes a difference to the hearer's understanding of what she is being invited to do.

Inspecting the same dataset as Glock, at a different level of granularity, I have observed weak (vague) scenarios of building use offered by the architect serving to elicit immensely rich use cases from the building users. Here I outline one instance. The architect introduces the topic of the size of the waiting room as indicated above. In response to the reluctance of the building user to comment regarding the size in a quantified way (e.g. the number of seats it can/should be able to hold – as it is a waiting room), the architect sketches out what the room is doing, he says, 'the room is doing so much it's allowing people through to the porch area so it's also allowing access to the loos'. This is actually a rather thin description, a skeletal indication of a way the waiting room will be used.

However what happens next is that the building user responds, not directly with an answer about whether the room is big enough or not but giving an answer on, and in, her own terms by launching into a rich account of what people might be waiting for, the different kinds of 'waiting' the building must accommodate. Effectively she tells the architect what 'waiting' means in the context of that building's use. (It is a crematorium; she talks about the physical, psychological and social needs for separation and waiting that crematorium visitors will have.) Thus, she reveals needs (the functional requirements) for the building and its landscape to accommodate the 'waiting' – needs which cannot be served solely by a designated waiting 'room'. She is prompted to compensate for the deficiencies in what she is offered; and through the conversational opening the vague scenarios provide she is able to contribute valuable information that informs the building design [McDonnell 2009].

3 Hesitation

Hesitation, selected thesaurus related terms: **question, challenge, stop and consider**, skeptical, doubtful, inarticulate, avoid, reluctance, timidity, vacillate, falter, dawdle, irresolute.

Using CA in a manner similar to Glock, and focusing on the same dataset as he does, Oak has proposed that some occasions of hesitation, for example apparently avoiding answering a question, functions as part of the means by which collaborators create their own roles, and the roles of each other in collaboration. On the question of the room size, mentioned already in section 2 above, Oak's interpretation is that 'by offering descriptions (of room uses) rather than straight answers (room dimensions), the client casts the architect into the roles of 'client-interpreter' and 'decision-maker' .. (which) puts the architect into a position from which he is constrained to make decisions about interior spaces without clear direction from her' [op.cit., p.313]. Here, hesitation functions to (en) force responsibility for certain decisions onto a particular party to the collaboration.

However, hesitation, conversationally marked, serves a whole variety of functions – functions we can only intimate through close attention to the local context in which it occurs. Hesitation can serve a similar encouragement–to-contribute function as vagueness. In a recent unpublished study of recordings of two meetings of an architect discussing the elaboration of a design brief with a potential client I have identified a rich variety of conversational mechanisms which render the architect's design proposals open to negotiation for the client. The mechanisms include: explicit enumeration of possible design variations; explicitly open-ended conclusion to a conversational turn; proffering design proposals using a variety of linguistic qualifiers and modals; and use of relational modality cues (through choice of personal pronoun). In this case, these successfully draw the client into the designing activity itself as well as encouraging her to make her own informed choices. In the second meeting, viewed at the macro-level, the architect presents two possible schemes to the client. However, closer inspection of the interaction shows that, using the mechanisms I have listed, a myriad of alternative design possibilities, at all levels of design detail, are opened up through the ways in which the 'two' schemes are talked about. The architect skillfully weaves a course in which he can be seen as authoritative concerning his professional expertise, *at the same time*, inviting challenge regarding those matters that are the domain of the client. He marks his suggestions as negotiable via indications of tentativeness which include hesitation. The extract from their exchange, shown in Figure 1, gives a glimpse of this.

Second meeting at site of work between client (c) and architect (a). The architect has presented a fluid variety of alternatives at every level of detail through the way he has talked through 'two' proposals. At the point below the client seeks advice about 'hassle, timescales and costs:

c: I have no frame of reference so

a: yeah I mean that one's going to be a lot more expensive

c: yeah

a: cos although the the plumbing is there you're going to be putting in a lot of services whereas here you're doing minimal

c: um

a: and so here I'm just about moving the (.) and I tried not moving the (.) sink

c: well we can run to that

a: we can keep it to where it is

c: um

a: you're you're falling away there um you almost could do it

c: um

a: you could almost do it within that (.) that space

c: um

a: and take it out

c: um

a: and leave this

c: um well the kitchen would actually come out if I'm doing this

a: and you'd just have this

c: um

a: even more um even less work

c: um

a: erm and then take it out and open

c: um

a: and we could virtually put that on and play a few games with the rules

c: um

a: and treat it as a conservatory

c: which means we do it

a: which makes it a few easier things for building regs

c: yeah ok

a: and controls what have you erm even more minimal

c: it's just about being sensible isn't it (.) cos I like I mean the I love the (.) I like the big open space and I think

a: yeah

c: you know I think I think something like this is the right thing to do the question is *a* can I afford it and *b* can I really stand to go through three months of hell (.)

Figure 1

4 Delay

Delay, selected thesaurus related terms: **deliberate, take time, defer,** postpone, prolong, procrastinate, suspend.

Studies of design have shown that, even where there is no collaboration, a design is not developed monotonically. Breadth first, depth next characterizes expert design, and this, and the need to be able to backtrack, implies that parallel lines of enquiry are sustained simultaneously. Deferral, then, is part of what we see in the movement between parallel lines of enquiry, as is the delaying of decisions as a deliberate strategy to cope with uncertainty or an information deficit. Deferral is a healthy feature of a natural design process.

In a recent study of collaboration between two professional software designers I observed delay in the resolution of some critical differences of perspective between the collaborators (about the fundamental organizing principles regarding the system architecture of the software they were designing) which appeared to be motivated by an overriding need to keep designing productively. Again, working within the CA approach, it appeared that the collaborators were aware that they did not share a common framing of the design. Nevertheless, they were able to work (on), deferring resolution by deliberately setting aside the potential obstacle using two strategies to underpin the delaying. First, they signaled contributions (that rested on the delayed issue) as conjectural, including by enumerating the (two) alternative framings in their talk. Second, they 'bracketed' the (two) associated belief sets by wrapping them in encapsulating terms. They were then able to progress with the design, referring to the delayed (unresolved) issue obliquely, via the encapsulating terms, without having to 'stop' to confront it. Of-course whether this coping strategy turns out to be folly or masterly collaboration skills in action can only be judged post hoc when the design task is completed and the design can be seen alongside those decisions that have influenced it. Delay may be inappropriate procrastination, but, equally, it may be a valid, pragmatic response.

5 Conclusions

Looking at the thesaurus terms I have listed related to the three phenomena I have chosen to highlight we can see that they range from positive to negative. In the observations I have chosen to mention, the positive is emphasised by selectively referring to the constructive roles these phenomena can play in design-oriented collaboration.

Clearly, depending on the collaboration's purpose and the local conversational context within the collaboration itself, each of the phenomena I have selected may contribute negatively, producing effects which neither serve the collaboration's goals nor support the smooth flow of the collaboration itself. The purpose *each* occurrence serves can only be established by examining the local context, the surrounding turns-at-talk. Baker's paper in this collection [Baker 2010] makes a closely related argument as he unpacks the contrasting roles different forms of dialogical thinking (expressed through talk) may serve. They may contribute to the collaboration constructively *or* destructively, just as laughter may relieve tension or enhance conflict according to when it occurs. The observations about vagueness, hesitation and delay offered here are a reminder that to measure collaboration quality firstly we must pay attention to what the collaboration is intended to produce; here I have focused on *design-oriented* collaboration goals to point out that in designing delay is integral to a sound process. Secondly, we must be sensitive to the individual contexts of what we are counting in our measurement and question what lies beneath surface features. Compare the two drawings in Figure 2 which were referred to during the crematorium design collaboration referred to above. Without any contextual information (a) looks like a sketch which might suggest a certain fluidity of ideas, whereas (b) the plan, looks more concrete. However, close examination of the design interaction where these two representations appeared revealed that (a) represented, what is an invisible entity (Brooks 2010, p.8), namely the design concept, something that was not at all, in the view of the architect, a negotiable item (Luck 2009); (b) on the other hand shows a detailed plan for the building, many aspects of which were, like the waiting room I have mentioned, up for revision through discussion.

In assessing the quality of any collaboration, the micro-features on which aggregate measures are based, e.g. duration or any of a range of metrics characterizing collaborators' contributions, need to be scrutinised so that we take into account what some of the fundamental conversational mechanisms are contributing to make social engagement possible at all.

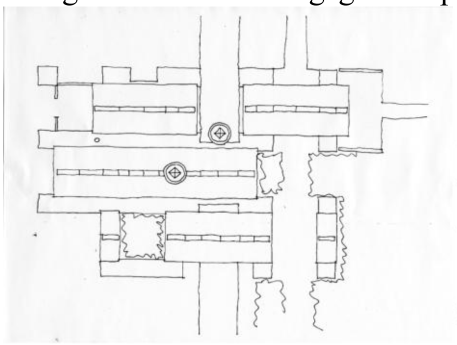

Figure 2a

Figure 2b

6 Acknowledgments

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Close collaboration, dialogical thinking and affective regulation

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Abstract. I present aspects of a process model of close collaboration, relating types of dialogical thinking (extensional, accumulative, foundational, interpretative) to the interactive circulation and regulation of affect, conceptualised as tension-relaxation.

1 Purpose

The purpose of this paper is to explore two aspects or 'qualities' of collaborative dialogue and their interrelations: the processes of dialogical thinking, viewed epistemically, and the regulation of the interactive circulation of affect. This exploration is based on previous work on knowledge negotiation (e.g. Baker, 1994), forms of cooperation (Baker, 2002), argumentative interactions and the co-construction of knowledge (e.g. Baker, 1999) and the role of affect in argumentative interaction (Andriessen, Baker & van der Puil, *in press*). The working hypothesis is that important qualities of collaboration processes are situated in the interplay between the ways that people think together in dialogue and how they communicate affects.

The notion of "quality" of collaboration can be understood in terms of the combinations of two dimensions: process/product, and descriptive/normative. Thus, the work of Meier, Spada and Rummel (2007) is normative with respect to both collaboration processes and their products (learning outcomes): good collaboration is that which leads to good learning outcomes. Burkhardt et al. (2009) propose a descriptive model of the quality of collaboration, and show how it varies with characteristics of technology mediation.

I consider collaboration *processes* in *descriptive* terms, with respect to their *potentialities* (rather than outcomes) associated with certain types of dialogical thinking: collaborators may collaborate in a 'close' way without necessarily being efficient with respect to outcomes; they may elaborate new ideas during the collaboration process, that can then be integrated into that process, or learn something incidentally that can not necessarily be apprehended in terms of outcomes of prescribed tasks.

2 Close collaboration

I want to try to sketch out a concept of *closeness* in collaboration that is a property of that process irrespective of its outcomes, in the way that one might say that a football game had been a 'good game' even though no goals were scored. A family of reasons for being interested in quality of collaboration relate essentially to trying to understand what ways of working together lead to better outcomes (e.g. better learning, better problem solutions). By concentrating on collaboration as a process, I am consciously emphasising the creativity of dialogue, its possibility of surprising its participants and observers with respect to the ideas that emerge from it, which is important, for example, in the study of innovation.

In *Phenomenology of Perception* (1945), Merleau-Ponty wrote the following:

> "In the experience of dialogue, a common ground is created between the other and myself, my thinking and the other's are woven into only one cloth, my remarks and those of the interlocutor are called forth by the state of the discussion, they are part of a common operation of which none of us is the creator."
>
> (Merleau-Ponty, 1945, p. 407 [my translation])

Whilst being distinct, dialogue and collaboration depend on each other: collaborating in the achievement of a task usually requires dialogue; dialogue presupposes collaboration in elaborating shared interpretations. I would like to say that what Merleau-Ponty (*ibid.*) writes of dialogue, elevated to the status of an ideal, is also relevant to collaboration. From the participants' points of view, a close collaboration would be associated with such a free-floating shared and personal experience, integrating affective and ideational aspects. Close collaboration is fusion of persons' ideas and selves such that the experience of not knowing who proposed what creative idea is seen in a positive way. The outside observer, researcher, can try to apprehend this, I propose, by trying to analyse the different ways that ideas are co-created, and how such processes relate to the way that affects (anger, (dis)pleasure, boredom, excitement, …) circulate and are regulated in the interaction. That is the approach I want to sketch out here. I shall frame this in terms of types of dialogical thinking, and processes of tension-relaxation in interaction.

3 Dialogical thinking, knowledge co-elaboration

On the most general level, across a wide variety of research approaches, collaborative activity can be understood in terms of three main gradual dimensions (Baker, 2002): (a)symmetry of roles adopted with respect to task elements and collaboration management, degree of (dis)agreement, and degree of alignment (of coordinated actions, problem stages, representations of the problem or "grounding). The articulation of roles is a way of describing patterns of contribution or participation; (dis)agreement relates to consensus building, knowledge co-construction and argumentation dialogue. But these general analytical dimensions do not describe the processes of collaboration themselves, where collaboration is understood as "co-elaboration" or 'working out ideas together' ("*co*"- together; "*e*"-out; *labore* - work).

In previous work (e.g. Baker, 1994; Mephu-Nguifo, Baker & Dillenbourg, 1999), I described knowledge co-elaboration processes in terms of types of cognitive-linguistic operations, or ways of doing cognitive work with language exchanged in dialogue. There are four main classes of such operations: (1) generalisation—specialisation (exploring degree of generality of application of classes); (2) additive—subtractive (conjoining, agglomerating or else subtracting propositions); (3) foundational (arguments, justifications, verifications, explanations); and language-meaning based (repetitions, reformulations, negotiation of meaning). Operations can be applied by speakers within their own interventions, or else to the interventions of their interlocutors (or rather, to the contexts for interpretation created by utterances). One quality of collaboration *on a purely epistemic plane* thus concerns the degree to which cognitive-linguistic operations are applied to others' ideas/utterances (more collaborative/dialogical), or else to a speaker's own utterances (less collaborative, more monological).

With Allwood (1997), I consider dialogue as a form of collective thinking that goes beyond the sum of individuals' expressed thoughts, and that it can be analysed in terms of the dominant types of cognitive-linguistic operations that are mobilised in specific dialogue sequences. I thus define four major types of dialogical thinking as shown in Table I below.

Dialogical thinking	*Definition, cognitive-linguistic operators*
Extensional	Generalising or restricting scope ($\forall$, $\exists$, ι), defining set inclusion of propositions; giving specific examples or instances
Cumulative	Conjoining, agglomerating, synthesizing, making inferences from propositions, exploring other alternatives (disjunction)
Foundational	Expressing (counter-)arguing, justifying, explaining, verifying
Interpretative	Repeating, reformulating, defining, negotiating meaning

Table I. Dialogical thinking and cognitive-linguistic operators.

These categories of dialogical thinking can be compared with Allwood's (*ibid*., p. 6) alternative categorisation (argumentative, consensus oriented, emotional, subconscious collective thinking), closely associated with dialogue types, and also with Mercer's (1995) categories of "talk", as "exploratory", "accumulative", "disputational", etc. Contrary to these authors, I do not identify dialogue types with types of dialogical thinking, since, in my own view, dialogue types always involve a combination of such types of thinking, notably in the case of interpretative thinking (ubiquitous in all communicative interactions) and also in argumentation dialogue, discussed below. Neither do I consider "emotional" as a type of thinking as such (*pace* Allwood, ibid.), given that it is associated with all thinking, action and perception, whether individual or dialogical (also see below).

One dialogue type that is particularly associated with negative affect is argumentation dialogue (cf. work on socio-cognitive conflict, such as Doise & Mugny, 1981), although, as discussed below, it always also involves other types of dialogical thinking.

4 Argumentation dialogue

From a pragma-dialectical point of view (Barth & Krabbe, 1982; van Eemeren & Grootendorst, 1984), argumentation is a dialogue game, with usually implicit rules (e.g. you must defend against an attack; you may not repeat attacks or defenses) aiming at resolving a conflict of avowed opinions (there can be a variety of simple or mixed conflict situations, according to the number of theses and degrees of commitment).

Such a purely dialectical vision would correspond to purely foundational thinking. But in (human) reality, such dialogues almost always also involve the other three types, relating to specific dialectical and rhetorical processes (e.g. Baker, 1999). Foundational-argumentative thinking can also be associated with: (i) extensional thinking, via argument by dissociation ("you are right for class C, but it must be split into C' and C'', and I am right in the latter case"); (ii) cumulative thinking: accumulation of concessions, consensus building as argumentative resolution, making inferences to refute by internal contradiction; (iii) interpretative thinking: deepening the theses debated, redefining underlying notions. Such discursive movements, particularly stimulated by interactive pressures relating to disagreement, can be seen as important manifestations of the *creativity* of dialogue. Argumentation dialogue can, in specific cases, thus be a particularly 'close' form of collaboration, given such creativity. In this case, the role of affect is also particularly salient, as discussed below.

5 Tension-relaxation regulation in dialogue

People who work together over a series of sessions develop what has been termed a "collaborative working relation" (Andriessen, Baker & van der Puil, *in press*), as they develop more extensive mutual knowledge and ability to coordinate. A further aspect of this is regulation of affects, which we (*ibid.*) have analysed in terms of the concept of "tension-relaxation" (cf. Bales, 1950). Thus, for example, verbal conflicts and refusals to accept proposals generally raise tension; humour and acceptance generally lower it (although the effects of such communicative actions are highly contextual: humour in the middle of a bitter highly-charged conflict might raise rather than lower tension!).

Muntig and Turnbull (1998) showed experimentally that affect enters into the very heart of argumentation dialogue, in the guise of the choice of defensive strategy: the greater the degree of aggressiveness of an argumentative attack (n.b. the most aggressive is to claim non-relevance), the more likely it is that the proponent will choose to defend his own thesis (and thereby, 'himself'), rather than to counter-attack. In other words, explaining the way that a debate unfolds requires taking affect and facework into account. We applied a set of tension-relaxation analysis categories to a debate, and compared the variations in it with the extent to which the debate was deepened (i.e. chaining arguments on arguments). This is important given that the deeper the conflict, the more it is potentially face-threatening (Brown & Levinson, 1987) and problematic for the collaborative working relation. We found that tension, following a particular verbal conflict, tended to 'lag' behind the debate; it could take time to subside to relaxation, such that successive debate phases began at a higher tension threshold and were more emotionally charged than they 'should have' been. Although it is thus clear that there are close relations between affective regulation and argumentation dialogue, these relations appear to be highly contextual.

6 Examples

Tables II and III) show extracts from a dialogue collected in a physics classroom; the students (A and B) are 16-17 years old. Their task is to find an equation to represent the properties of balls of different substances (steel, wood, rubber) and sizes that explains their rebound behaviours when they released from the same height (the coefficient of restitution). The examples are presented to illustrate types of dialogical thinking and their relations to tension-relaxation.

Line N	*Loc*	*Dialogue*
56	A	But there there's a soft impact … so that since it's a soft impact … kinetic energy is not conserved … you see I learned my lesson … but … one can already notice that it rebounds higher than we released it
57	B	Well yes but that's necessarily so with the friction, so errr it's not negligible
58	A	Yes well in the end there's a loss yeah there's a loss at impact but we can still…
59	B	as substance … constituant?
60	A	Well right there there's a total loss of speed with means that
61	B	Wait, wait, with their interaction with the ground
62	A	so there the ground absorbs errr
63	B	yes
64	A	absorbs the impact
65	B	yes, it's an errrr soft impact

Table II. Extract 1: cumulative dialogical thinking with low tension.

This first extract (Table II) manifests predominantly cumulative dialogical thinking, in the form of inferences that take the problem solution forward ("since soft impact ➔ kinetic energy not conserved") and the addition of properties (predicates and their arguments) of the object to be explained, with a relatively symmetrical form of cooperation (A: absorbs(ground, _) ==> A: absorbs(ground, impact) ==> B: soft(impact)). Some retroactive foundational thinking takes place, to give validating justifications for the solution under elaboration (line 57). There is no obvious inter-relational tension here, except, perhaps, for the impatience or eagerness shown by B in line 61 ("wait, wait …") who wants to follow the line of thinking with respect to friction.

Line N	*Loc*	*Dialogue*
89	A	look, concerning masses, look, one can see that the steel one is … is heavier
90	B	But it's not a matter of mass
91	A	Well there's potential energy involved, I'm sorry! ((*pause 3 seconds*))
92	B	... ok but if you have ...
93	A	If we have ... ?
94	B	If you had a big steel ball … it would rebound…
95	A	And if we release them at the same height, one with a greater mass than the other, the one with the greater mass would have greater potential energy…
96	B	Yes but
97	A	So there would be more
98	B	Do you think that if … if you had an enormous rubber ball like that, that was a kilogram, you think it would rebound a lot?
99	A	Yes, but that's only valid in the case of an elastic impact
100	B	umm
101	A	well, I think …
102	B	We'd maybe be better off thinking about that since theoretically it's more simple, given that it's a soft impact
103	A	Err yes there is … precisely ((*laughs*))

Table III. Extract 2: foundational dialogical thinking with tension-relaxation.

This second extract is primarily foundational dialogical thinking, associated with argumentation dialogue, beginning from a conflict of avowed opinions according to whether higher mass of a ball does or does not explain its rebounding higher, for which a pro argument is the presence of "m, mass" in the potential energy equation, and a counter-argument is an appeal to intuition, a thought experiment (a very heavy rubber ball would not, it is claimed, rebound much). Interestingly, this verbal conflict is 'dissolved' by some extensional thinking: dividing the universe of discourse and validity into elastic vs. inelastic impacts. There appears to be some increase in tension at the beginning, when A (line 91) defends her view quite adamantly. Yet it is perhaps a sign of the close interpersonal relation between the girls that they were able to quickly dissipate this tension once agreement was reached on the dissolving of the disagreement (the laughter in line 103).

7 Concluding reflexions

I have proposed that the emergence of creative ideas from dialogue and collaboration can be understood in terms of types of dialogical thinking. Since all thinking (perception, action) and social encounters involve an affective dimension, collaboration can be seen as involving a qualitatively different personal and shared experience to working alone (Crook, 1994). The complex relations between affective regulation and types of dialogical thinking depend, at least in part, on the specific combinations of the latter in specific dialogue sequences, and notably on the presence or not of a verbal conflict situation.

What appears to be important in determining the affect/dialogical thinking relations are the *individual and shared goals* of the dialogue type within which they occur, and the existence or not of *conflicting goals*. No type of dialogical thinking appears to be either *necessarily* tension-raising or relaxing in itself, although, as discussed above, affective regulation can influence the type of thinking that occurs in argumentation dialogue. Foundational thinking is not necessarily tension-raising, since explanations and arguments can be produced with a view to cooperatively examining alternative solutions, building consensus (accumulative thinking), just as much as with the goals of winning, refuting, humiliating or claiming intellectual superiority/worth (Walton, 1989). Similar remarks can be made with respect to interpretative thinking: although refining or deepening understanding of the thesis being debated could be mutually experienced as 'constructive' (tension-lowering), with adversarial goals it could also be experienced as an attempt to avoid the issue or to abusively redefine concepts for individual ends (tension-raising). Only accumulative dialogical thinking appears to be special in this respect: it involves making inferences, elaborating proposals, brainstorming alternatives, and consensus-building, which all seem to be irenic or tension-lowering. Yet it is even possible in this case to envisage conflicting interests, where one participant wants to focus discussion on a particular proposal, and experiences the multiplication of alternatives as an annoying digression. And of course, inferences can be made from others' proposals in order to show that they lead to absurdities.

Only two aspects or qualities of collaborative activity have been discussed here, to the exclusion of many others, such as those relating to action coordination and temporality, or "fluidity" of collaboration (Burkhardt et al., 2009). Nevertheless, many of the qualities of collaboration studied with respect to normative evaluation of outcomes are herein reconceptualised, such as "consensus-building", "conflict resolution", and "grounding" (as part of interpretative dialogical thinking). Further work in this direction will aim at pursuing empirical study of relations between types of dialogical thinking in relation to affective regulation, within specific collaborative activities.

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Collaboration as constructive interaction and the jigsaw method as its enhancer

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Abstract. This position paper introduces the theory of "constructive interaction" (Miyake, 1986), claiming that differences between members make a conversational interaction constructive. From this theory, the quality of collaboration depends on how often constructive interactions take place among members and to what degree each member deepens her or his *own* understanding through the interactions. This divergence, individual oriented theory is contrasting to the convergence, group oriented theory (Roschelle, 1992). I will explain that the former is suitable in this knowledge creating society as well as beneficial to clarify fundamental mechanisms of collaboration with some empirical data. In addition, in order to show the benefits of the theory, I compared jigsaw-type collaboration with normal-type one in cognitive science education. As a result, the former outperformed the latter, indicating that the legitimization of differences could promote constructive interactions.

1 Collaboration in the knowledge society

In this knowledge creating society, innovation and creation should be the heart of our knowledge works (ATC21S, 2010). We should take care of not only how to solve present problems in routine ways, but also to identify and solve future problems in creative ways. Aims of the society also change from how to achieve pre-defined goals quickly to how to "go beyond" or *surpass* (Bereiter & Scardamalia, 1993) them deliberately. Collaboration can help this, given that we have adequate theories of collaboration and designs of collaborative environments for this "surpassing ourselves" society. We need theories of collaboration which illuminate ways to push everyone go beyond her or his own present goal. We also need new designs of learning environments for acquiring such collaborative skills. I will explain theories in the second section and designs in the third one.

2 Theory of constructive interaction

When one tackles with a complex problem and reaches her or his own satisfactory solution, s/he often runs out of resources for checking its validity. Yet, if there is someone who monitors solver's explanation of the solution, the monitor can provide with "criticisms," which leads the solver to rethink it and deepen her or his understanding of the task. This is the virtue of collaboration. Thus, we often experience collaboration as precious but laborious, in the sense that it triggers our reflection upon what we once considered as "solved" or "understood."

The *theory of constructive interaction* (Miyake, 1986; Shirouzu *et al.*, 2002) explains these phenomena best. It claims that differences among members are precious sources for collaboration. Differences make a conversational interaction constructive – constructive in the sense that the members can come to understand what was not understood and find the way toward the fuller accomplishment of what they wanted to accomplish.

The differences come from two ways: *initial diversity* and *role exchange*. The former is members' individual differences in prior experience, knowledge, and expertise brought in the situation. The latter speaks to role exchange between task-doing and monitoring in collaborative situations. When one member engages in task-doing like solving a problem, the other member only can monitor that process. Yet, the monitor cannot fully share the task-doer's internal plans, intentions, or interpretations, and thus observe the process from a slightly broader perspective, which contributes to providing with objective comments or criticism. In successful collaboration, two factors, active externalization of the initial solution and the frequent role exchange, interact to generate various solutions differing in the degree of abstraction (Shirouzu *et al.*, 2002).

This theory implies two keys to the quality of collaboration. First, the quality of collaboration depends on how often constructive interactions take place among members by role exchanging. It does not concern collaboration *products*, but *processes* (Baker, 2010). Second, it depends on to what degree each member deepens her or his own understanding through such collaboration. It concerns products, but *non-predefined products*, because s/he pursues her or his own, idiosyncratic goal. This demands new assessments of collaboration:

- analyzing collaborative processes by backtracking from emergent, finally achieved goals,
- focusing on the reflective and deliberate nature of collaborative thinking, instead of the efficiency of how to get at the one, predefined goal,

- tracing diverse processes of understanding, innovation or whatever of participating members, and
- thinking not only of inter-mental interactions, but also of intra-mental interactions between internal knowledge and external cognitive resources of each member.

These proposals, especially the latter two, take a somewhat individualistic view of collaboration. It contrasts with the "co-construction" view shown clearly by Roschelle's (1992) statement as "a crux of collaboration is convergence to the shared, common understanding." This is the prevailing view among various disciplines like CSCW, CSCL, and learning sciences. So, why do I take the former?

The first reason is changing goals of collaboration in this knowledge society, as written above. The second reason is that, even in the shared problem solving or learning situations, we often observe starting points, intermediate processes, and resultant achievements differing from member to member (Forman & McPhail, 1993; Miyake, 1986). We also often witness a well-designed class wherein many children present many different ideas, which push their conversations to more scientific levels. Although it leads them to seemingly "mutual" understanding, we often find dozens of different explanations or expressions in individual reports or interviews after the class (Hatano & Inagaki, 1991).

Learning processes are so diverse that, as we collect finer-grained data or analyze the same data at finer-grained levels, more individual differences appear. Actually, Miyake (2008) and Shirouzu & Miyake (2002) re-analyzed Roschelle's case (1992), especially expressions used by individual students (Carol and Dana), only to find a different pattern other than what Roschelle had found. Roschelle's analysis, taking the pair as a whole and analyze their language as each complementing the other, made the convergent pattern emerge in the targeted direction. Our analysis, however, taking individuals as its unit, showed that the resultant pattern was lopsided: among the 14 key expressions we selected, only three were shared or frequently used by both. Miyake (2008) stated:

> This pattern indicated that each student had held her own model to the very end of their collaboration, where they could complement each other's explanation. While this complemented whole does represent their "common ground," it does not guarantee a shared understanding. It could even be said that the complementing action was possible, because the explanations given by one member were almost never complete, and the incompleteness invited the other member to provide the missing pieces from her repertoire. (Miyake, 2008, p.463)

Taking each individual as a smaller unit of analysis contributes to demonstrating finer mechanisms built in the collaborative process.

3 The jigsaw method for constructive interaction

If we assume that individual differences are precious sources for collaboration, we can design collaborative situations from different perspectives. For example, when the balance or symmetry of individual contributions is taken as a problem (*equity* in Buisine, 2010), co-construction theorists often tend to provide with more chances to share the same information or views among members throughout the collaboration. From our perspective, however, this is not a problem, because monitors can learn much from collaborations even if they talk little (see Hatano & Inagaki, 1991, for empirical data). Yet, if we take this as a problem, we solve it by attributing more differences and greater authority to individuals. It will also contribute to increasing chances of role exchange, because every member has her or his *own* task and can engage in task-doing. This is the concept of *distributed expertise* or *legitimization of differences* (Brown, 1997), and the jigsaw method (Aronson & Patnoe, 1996) is suitable for doing this.

However, there is little research that compares the jigsaw method with the more convergence oriented method directly. Thus, we compared two collaborative activities for college students' learning of cognitive science, specifically integration of classic literature of twelve research pieces. One method is the jigsaw that assigns different pieces to different students and makes them exchange what they learn. The other is a simpler type of collaboration that gives all pieces to all students in a serial order, which should provide members with more shared information and knowledge.

Comparing the results, we found that the jigsaw method promoted integration of research pieces more than the simpler method. Detailed analyses of the students' discussions revealed that distributed expertise promoted each individual's solid understanding of the assigned piece, which also served as a basis for integration. In contrast, the students in the serial-ordered collaboration did not refer to the contents of research pieces, as if they were taken for granted, which led themselves only to vague abstraction of overall themes. Also, the total amount of verbalization is more balanced in the jigsaw method, even though the members often exchanged roles. In the serial-ordered collaboration, strong members often took the floor and forced others to converge to their opinions without serious argumentation of the content material.

These results indicate why the jigsaw worked. In this method, each member engaged in constructing explanations of her or his own assigned material, and when explaining it to the others s/he gained slightly objective comments. In integrating multiple materials, each member actively participated in the conversation, rooting her or his explanation in the assigned material yet utilizing its essence. In this sequence, gradual abstraction could take place from literal reading of the material through sense-making to relation-making among several materials. We also observed that the jigsaw students often changed their axes of integration of research pieces, which implies their deliberate nature of thinking as well as enriched understanding of original materials. We have been collecting and analyzing in details this kind of comparison data, computer-mediated or non-computer-mediated, of various tasks in various domains (lecture comprehension in Shirouzu & Miyake, 2007; mathematical proof in Shirouzu, 2009). I hope future discussions on how to raise and assess the quality of collaboration.

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Understanding collaboration in team design, task-oriented interactions

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Abstract. This paper presents a part of the methodology used in a broader study that aims to describe, analyze and evaluate the face-to-face interactions of teams that co-design online courses. Specifically, team design collaboration is viewed as a co-construction process, during which design content is contributed, co-elaborated, and offered for discussion by the participants. The proposed method has been applied to identify the most co-constructive episodes out of an extensive range of team meetings.

1 Introduction

Team design is both a complex cognitive activity (Visser, 2006) and a social construction process (Bucciarelli, 1998). Presently, many noticeable efforts to evaluate team design discourse have been reported, with (as in Darses, et al., 2001; Stempfle & Badke-Shaub, 2002; D'Astous, et al., 2004; Détienne, et al., 2005; Baker, et al., 2009) or without (as in Bucciarelli, 1998; Valkenburg & Dorst, 1998; Adams, et al., 2009) the further aim of evaluating the team design communication.

Collaboration regarding the inside-team communication processes is strongly context-related (Rigotti & Rocci, 2006) and, in the case of design, is design object-oriented. This thesis leads to two main assumptions: first, that not all communication emerging inside a work team is task-oriented, and, second, that not all task-oriented communication is also collaborative.

2 Research goals

The main goal of this research-in-progress is to understand how collaboration takes place among the members of a design team, with the aim to inform the team members of their own collaborative practices, and to make them reflect on their quality, in order to achieve better collaboration in future projects.

To do that, two main definitions had to take place beforehand: the design task-object, on which the specific team is working on, and the quality of collaboration, as part of this design process.

Regarding the first issue, the design task, three main dimensions have been identified, regarding the task of designing an online course: a) the *course elements,* such as the core-readings, the how-to-exercises, the tutor-marked assignments etc., b) the *elements' relations,* such as the relation between the elements inside a block of activities, the relation between media and instructional goals etc., and, c) the *third-party relations* – such as the interaction among learners, between learners and the course content, or between the designers and other agents.

As the quality of collaboration is concerned, a choice to view team design collaboration as an "expression" of team design communication has been made, according to the research goal mentioned above. Also, considering communication as a process of socio-cognitive construction (Trognon, 1999), collaboration can be seen as a co-construction process (Baker, 1995), when they both take place to a specific level-object (Baker, et al., 1999). Consequently, the quality of collaboration is (also) based on the quality of this co-construction.

Considering the open methodological issues on how to evaluate such co-construction, a second research goal has emerged: to propose a tool of analysis and evaluation of team design communication. This paper presents a part of the methodology applied for the analysis of synchronous communication among the members of a design team, working at an established Distance University, during an 18-month long design of a course.

3 Research questions

To achieve the goals just mentioned, the following questions are addressed:

- Which episodes of a specific team design interaction protocol are more co-constructive than others?
- To which other collaboration functions does this co-construction relate to?
- Which patterns of collaboration emerge as efficient, and thus, are recommended as reusable?

The present paper focuses on the first question, although taking into consideration the other two, mainly on what regards the methodological proposal. Maintaining the focus on the first question, the following sub-questions emerge:

(1) How is co-construction defined in team task-oriented interactions?
(2) How is this definition applied at the time of analyzing an extensive interaction protocol?
(3) How can co-construction be evaluated?

4 Definition of co-construction

In order to define “co-construction” in team, task-oriented interactions, three criteria are proposed: the explicitness of information, namely *informativity*; the elaboration of contributions at an inter-speaker level, namely *co-elaboration*; and the argumentative disposition of the participants, namely *argumentativeness*.

The criterion of *informativity* denotes the need of making explicit as much relevant information as possible, with the assumption that once made explicit, it can further be used for the production of design elements.

The criterion of *co-elaboration* describes the need of extending, clarifying, accepting, evaluating, and/or transforming the content of another speaker’s contribution(s), either by adding information to it (adjunction relations), or by expressing a viewpoint on it (interjunction relations).

The criterion of *argumentativeness* describes the need to evaluate all statements made explicit, both by the others and by the statement “owner” him- or herself. In the analysis proposed, this need is satisfied by the existence of as much addresser-addressee relations as possible, meaning as such the relations of solution presentation, comment, explanation, reformulation, summarization, attribution, antithesis, justification, and (proposal of) action (adapted from Renkema, 2009).

A further step was to define the task and discourse components which could be used as “measures” of co-construction, in the specific context of team design. These components are defined as following:

• *Design-related contributions*. As already mentioned, not all design discourse is design object-oriented, and subsequently, not all speakers’ sayings contribute to the design content. In order to decide which of the contributions are design-related, a design content analysis of the protocol has been first made and a number of design relations emerged, as shown in Table I. To consider a contribution as design-related, a specific relation among its referent(s) and the design object is necessary. Design-related contributions are related to the criterion of informativity.

• *Dialogue moves.* In order to understand the specific discursive function of each elementary discourse segment, and subsequently of the speakers’ contributions, a categorisation of task-oriented dialogue moves (Carletta, et al., 1997) has been adapted to this research protocol. This categorisation supports the identification of main (or initiation) moves and their distinction from secondary (response and preparatory) moves. Statements, questions, and (if any) commands are considered to be the main moves, or those belonging to the presentation phase in Clark's (1999) terms. The identification of dialogue moves allows the identification of inter-speaker relations, which are the basis of co-elaboration.

• *Discourse relations*. Moves are related to one another through discourse relations. Many classifications of discourse relations have been proposed until now, with the most known in the field of Rhetorical Structure Theory (Mann & Thompson, 1988). In this research, I adopt the Connectivity Model proposed by Renkema (2009), for three main reasons: a) it is based on the construction metaphor, making easier its extension to a co-construction context, b) the relations proposed are strongly related to the content of the discourse, especially the ones of the adjunction level, making tagging easier, and c) the notion of interjunction, as the highest level of discourse construction, has direct references to argumentation components, as the author himself argues (Renkema, 2009; pp. 123). Interjunction relations can be used as a basis for the identification of argumentative relations.

All these three components can be treated either quantitatively, as product, or qualitatively, as process. The method followed in this research considers both approaches, based on the following guideline: a quantitative "measurement" of co-construction can lead to a first filtering of the most salient episodes; afterwards, a more thorough qualitative analysis of those can –and should− follow. The present paper is focused on the former.

5 Coding scheme

The coding scheme constructed for the needs of this research is based on three dimensions: the agent, the task, and the discourse dimension[1].

Regarding the task and discourse dimensions, the main components previously described are coded with the categories appearing on Table I.

Coding Category	Sub-categories	Examples
Design Relation (DR)	**Past action** (pa)	*I couldn't download it*
	Action (a)	*We'll incorporate those bits*
	Function (fu)	*This exercise promotes reflection*
	Means (m)	*printing it out on PDF*
	Attribute (at)	*It's not too big*
	Reflective assumption (ra)	*in order to kind of reach that self-wise*
	Requirement (r)	*The tutors will need a kind of marking guidelines*
	Constraint (c)	*Consistently problems are coming up in the forum*
Cognitive	**Design problem** (p)	*If students can't use this tool*

[1] I follow a who-what-how approach to define team design activity, as in Cole & Engeström (1991).

Focus (C)[1]	**Design solution** (s) **Design goal** (g) **Domain rule** (r) **Domain object** (o) **Task-Team** (t)	*What about having different voices?* *That will be a strength of the course* *Students like talking about the assignment* *The language was quite nice and accessible* *I'll work over it over the weekend*
Move (Mv)	**Statement** (S+ID) **Question** (Q+ID) **Command** (C+ID)	*It can be on different levels* *What about the readings?* *So don't send that out*
Relation type (Rt)	**Conjunction** (C) **Adjunction** (A) **Interjunction** (I)	*Yeah we should do that* *Yeah, providing we cut and paste titles* *Yeah, unless it's a very open end* [2]
ID number of related EDU (rID)	**Statement** (S+ID) **Question** (Q+ID) **Command** (C+ID)	

Table I. Coding categories relevant to co-construction.

According to the above categories, design-related contributions are all the moves made within a design cognitive focus, that have a direct (action, past action, function, means, attribute) or indirect (reflective assumption, requirement, constraint) content relation to the design object. Main moves are distinguished from secondary moves by the mere fact of non-marking the latter. Finally if a move is related to a previous move, this is marked with one of the three relation types: conjunction, when the relation is at a "form-to-form" level; adjunction, when it is at an "information-to-information" level; interjunction, when it is at an "addresser-addressee" level (Renkema, 2009).

As far as the agent dimension is concerned, three main components are taken into consideration: the speaker, the enunciator or "other voice" (to whom an action is attributed, e.g. by a reflective assumption), and the agent's epistemic role (also see Baker, et al., 2009). The latter is marked through shifts in domain language, initiated by a speaker alone or after invitation[3] (in this case he/she is considered the "expert" of that language). The sub-categories emerging for each one of the agent categories are based on the specific protocol under analysis, and are the ones appearing on Table II.

[1] The sub-categories used to describe this category are adopted from Darses et al. (2001) and adapted to this protocol's needs.

[2] These three examples are all indicators of consensus expressed in a different type of discourse relation. These cases were selected as examples, because the answer format allows the identification of the relation without necessary referring to the previous moves.

[3] I owe this consideration to Janet McDonnell.

Category	Sub-categories
Speaker (Sp)[1]	Course leader (L), Course manager (M), Course Author 1 (A1), Course Author 2 (A2), Course Author 3 (A3), Collaborator 1 (C1), Collaborator 2 (C2), External 1(E1)…
Enunciator-other voice (E)	the above plus: Course team (CT), Other team (OT), Other person (OP), Students (stu), Tutors (tut)…
Epistemic shift (Es)	Technology (T), Pedagogy (P), Design (D), Management (M), plus an "i" in front when the shift is invited, asked for

Table II. Categories considering the "agent".

Finally, a consideration regarding the amount of new information carried through each contribution is made. This new information is named after as *design referent*; it forms part of the task dimension and it refers to those elements of the contributions through which the design relation is implied. In most cases, this is made explicit through specific words, which are then marked in bold in the protocol. An effort to decide the informative strength of all contributions is currently being carried, with the further aim to indicate by a number how elaborated a contribution is in terms of quantity of new information supplied, always in relation to the rest of contributions. A short excerpt of the coding protocol is shown in Table III.

Speech		Agent			Task			Discourse		
1 D	**Transcription**	**Sp**	**E**	**Es**	**Dr**	**DR**	**C**	**Mv**	**Rt**	**rID**
38	So **that**'s a bit like what I've set up	E1			1	at	o	S38		
39	Yeah () would you prefer it if we were **writing** into this?	M		**iT**	1	a	o	Q39	I	**S38**
40	Ideally but you're **Mac based** and stuff like that	E1			1	c	p	S40	I	**Q39**
41	Yeah that's the thing with **structured content**, it's more **fiddly**	L			2	c	p	S41	I	**S40**
42	it's a bit more like kind of **laying out a webpage** with **code**				2	m	p	S42	A	S41
43	So this is not **Mac friendly**?	M			1	at	o	Q43	A	**S42**
44	No	L, E1					o		C	**Q43**

Table III. An excerpt of the coding protocol. In bold the design referent keywords and the inter-speaker relations.

[1] "Speaker" is not marked by his/her name initials, but by his/her prescribed role in the design team.

6 Discussion

In this paper, an effort to define co-construction in the specific context of the team design of eLearning material has been presented. The components of co-construction discussed, namely *informativity, co-elaboration,* and *argumentativeness,* have been hitherto treated as quantitative measures based on task and discourse components. This need was due to the fact of treating a quite extended protocol, thus qualitative processes of common-grounding, goal sharing, and weighing of arguments could not form objects of analysis for the whole protocol.

As far as the identification of the most co-constructive episodes is concerned, a “filtering” process based on the proportional number of design-related contributions, dialogue moves, and interjunction relations is currently being followed[1]. The next step consists in thoroughly treating the episodes emerging as “most” co-constructive. This can be done through relating the components of co-construction proposed with other functions of team collaboration, such as the roles of the participants at a communication and epistemic level, the inclusion of “other voices” in discourse, and the quality of argumentation expressed at both an individual and a team (inter-speaker) level.

After that, the third research question regarding the identification of patterns of collaboration can be addressed.

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Virtual learning communities and groups dynamics in the overcoming of obstacles.

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Abstract. This paper presents our research work on tracking how activities in distance learning situations organized themselves in spite of brakes and barriers they encounter. A part of this research work is related to the tracking data exploitation during asynchronous communication, it focuses on shapes data analysis, in a quantitative way at the level of a group.

1 Introduction

The virtual campus of the University of Limoges CVTiC is an international distance training platform whose organization relies on the concept of virtual community of learning. The presentation of contents, modalities of exchanges and validation, relationships with the teacher are completely established according to this collaborative training framework between students. For every credit, the students are asked to constitute a workgroup then to determine the strategies of piloting and driving of the activities that the working order suggests. We are interested in demonstrating the existence of stimuli that forced the Virtual Learning Community to work in a collaborative mode. Using primary traces on the forums for two teaching units and converting them in M-Trace (Djouad 2008), we could classify the different stimuli. From the many posts on these forums, we were able to determine the types of operation of CLV. Using the classification of the regulatory action proposed by Mac Grath, we could then see that the CLV naturally tended toward a collaborative work mode face stimuli.

2 Synchronous vs Asynchronous

Because of its openness to international, the virtual campus of the University of Limoges includes some forty nationalities, with the particularity that the student remains in his country and his home environment.

Jet lag, time access to a computer, difficulty with respect to the spoken French, poor connections bring with them the cause of the malfunction attempts synchronous meetings in groups. Finding a good time slot for a particular group for a synchronous meeting takes about a week, which is unrealistic. Therefore, the students favor asynchronous communication (forum or email) to share with their peers or teachers.

This is not without problems: the vocabulary (especially related to the divine) might be misunderstood by others, the isolation of the student, from the response time of the forum can reach twenty-four hours because of jet lag, is reinforced. For example, in a study group, one student felt assaulted by the remarks made by another group of students. She asked the teaching staff to act, what has been done ... without the concerned students can explain their point of view (because of time shift). If tutors can be aware of this situation, it remains difficult for a student. A student, asking for help from a teacher who is sleeping, feels abandoned, as it has not seen the issue of time zones. Human relations are necessarily degraded by this choice of asynchronous communication. This can degrade the quality of collaborative work and therefore requires the establishment of rules accepted and recognized by all.

3 Rules of collaboration.

From a learning unit to another one, from an activity to another one, according to the skills and the motivations of each one, the leadership within a workgroup can change. The group is going to recognize, at any time, the capacity of one of its members to take the leadership, each agreeing on the objectives to work on. In some cases, according to the weaknesses of some of its members (linguistic, technical), some forms of tutoring can appear, the success of the group in the collective realization being a priority.

Our works are carrier of some testimonies of this type. The public interest of the community dominates on the investment which each is brought to supply. From that point of view, when, within a workgroup, this co-support is refused by some of the members, the group disintegrates and does not manage to reach the objectives of expected work, at least in a disrupted way, thus except order.

Generally speaking, this behavior shapes the group and gives substance to itself to develop in a real community of interest: the success in fine to the diploma. The community thinks of obtaining a gain in terms of productivity and fluidity in the training evolution. It is not dependent any more in its progress of the arbitrary and the behavior of a managerial employee but obtains internally all the necessary knowledge and know-how for the realization of its objective.

The virtual campus of Limoges was equipped with a charter to define the group work. This charter insists on the importance of rules and modalities structuring the community. For the main part, let us quote:

- Participating in the exchanges and in the group work according to the advice given in the guide of the collaborative work,
- Contributing to establish a reliable climate, to let never without news (short stories) the rest of a group, to hold its commitments not to put the group in trouble, respect and make the calendar and the terms respected, fill in with honesty the board of follow-up when someone is asked to report his activities;
- Publishing a photo allowing other students and teachers to identify a student on the platform of training of which the access is secured;
- Following working rules indicated by the teaching staff. These can be modified at any time according to the educational or organizational imperatives.

The training guide of this virtual campus insists on four locatable levels of community:

(1) the working community within a credit;

(2) the community that groups together around a credit;

(3) the community of promotion which groups together around a program of training;

(4) the community of the students of CVTIC (students on a longer term).

4 Breaks for optimal operation of the community

From an ecological point of view, the virtual communities of learning that we observe on the Virtual Campus CVTIC of Limoges accentuate several conditions necessary for their smooth running: the exchanges between peers are useful exchanges; the freedom and the flexibility of tone do not compromise the end of the exchanges: Inquiring mutually, progressing collectively; asynchronous exchanges are reagent; every member of a group declares his procedures, choices, and difficulties; the members of a group co-support themselves; every time it is necessary and possible, there is exchange of expertise the leadership turns inside the group. In such a way, we can regard virtual communities as being dissipative system.

However, the functioning of the VLC can be disrupted by the problems of internationalization of the virtual campus and the constraints bound to the training opened remotely. If it is acquired that the emergence of the virtual communities of learning is a long and complex process, several brakes in their birth quickly appear in the practice during the implementation of university trainings via an international virtual campus. It is advisable, at first, to list in a most exhaustive possible way these brakes and barriers before studying more forward their impacts on the life and the survival of the VLC

We are interested in two learning units of four weeks. The first unit (UE303, Nstudents= 40, ngroups = 8) is a unit of three years university degree “Servicetique” which belongs to the core of the diploma. The second unit (UE150, Nstudents = 15, ngroups = 3) is a unit of International iFOAD degree. Both units are based on the same approach and same educational approach: each week is a series of activities to achieve group before the end of the week. The position of these units in the year is irrelevant, their study used primarily to define rules and types of collaborative or cooperative work which will be used in a module of tutoring community. The number of post per day for example is a synthetic indicator that reveals nothing of the kind of exchanged messages. Over time, however, the evolution of this indicator provides a number of lessons that can detect volumetric stimuli by the volume of response associated.

Looking at the forums, at the level group, we could find and classify stimuli such as shown on table I.

Type of stimulus	Nature of stimulus	Exemple
Exogenous	Technical	Unable to read a text because of format
	Societal/cultural/linguistic	Conflict with a teacher
	Organizational	Delay in on-line publishing
Endogenous n/1	Technical	Internet locally collapses
	Societal/cultural/linguistic	Integration of a new member

	Organizational	Jet lag
Endogenous 1/1	Societal/cultural/linguistic	Local war
	Organizational	Simultaneous leadership
Endogenous n/n	Technical	Incompatible OS
	Societal/cultural/linguistic	Religious membership, ethnicity
	Organizational	non agreement on work orientation

Table I. Typologies of brakes/Stimuli

Using the presentation of McGrath task circumplex we can see the arrangements (regulatory function) that have developed between the actors reach the final results.

This classification allows to see the way the VLC has taken to meet the guidelines or to stimuli. We thus follow the approach used for the study forums (Caviale 2008). We have then found that:

- the production and selection dominate the distribution of activities. They are present almost throughout the duration of the project (production activities are negligible at startup).
- trading activities are more limited over time (which does not mean they are less important). The detailed analysis of the trading activity shows that the VLC seeks itself to identify experts it fails to find. Everyone will then be formed individually before they offer new services to VLC (second bounce).
- we can note the absence of messages related to enforcement activities (which reflect the hierarchical relationships or competition). This absence can be explained by the circumstances: it is the beginning of training, the promotion was not structured and the position of dominant / dominated is still regarded as harmful to the group's assessment, what we show analyzing the evolution of group behavior in the EU. This is precisely the absence of strong leaders (dominant) in the group that explains the length of the negotiation before work.

5 Typologies of work

To determine which type of profile is a volumetric mode of operation and if this pairing is structurally feasible, we have identified profiles of outstanding and we have analyzed the types of trade and distribution (Desjardins 2002). We may well have set three basic types of works (Table II).

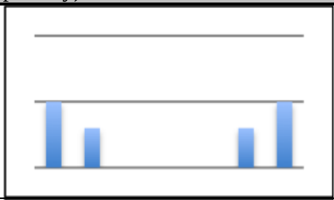
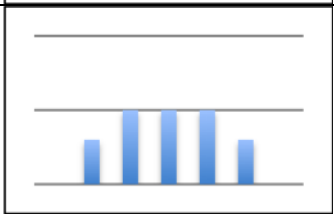
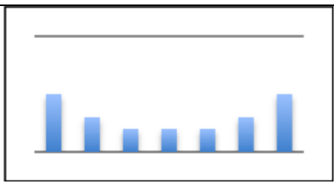
Type of volumetric Profile	Volumetriuc Profile (number of post per day)	Notice	Work typoligy
In « U »		Students exchange at the beginning, the distribution of tasks, act independently of each other and then make a summary of their work.	Cooperative
In « bridge »		Students exchange throughout the week, with peak activity in mid-week for the transfer of knowledge between experts and the group.	Collaborative
In « M »		Students exchange at the beginning of the week to search for experts. Everyone will gather information outside of the community.	Interested collaborative

Table II. Typologies of work.

Table III for example, shows work evolution for a group during UE150 due to breaks. We notice that the team has reached the goal of a collaborative work. Expected answer and given answer use Mac Grath's classification.

N°	Type of stimulus	Expected answer	Given answer	State of the CVL before stimulus	State of the CVL after stimulus
1	Exogenous n/1 technical	T3	T3	Cooperative	Cooperative
2	Exogenous n/1 organisational	T2	T2	Cooperative	Cooperative
3	Exogenous n/1 organisational	T1	T3	Cooperative	Interested collaborative
4	Exogenous n/1 technical	T3	T4	Interested collaborative	Interested collaborative
5	Exogenous n/1 organisational	T8	T8	Interested collaborative	Collaborative
6	Exogenous n/1 organisational	T8	T8	Collaborative	Collaborative
7	Exogenous n/1 technical	T3	T3	Collaborative	Collaborative
8	Endogenous n/1 technical	T2	T2	Interested collaborative	Collaborative
9	Exogenous n/1 technical	T3	T3	Collaborative	Collaborative
10	Endogenous n/1	T2	T2	Collaborative	Collaborative

	societal				
11	Endogenous n/n orga.	T1	T8	Collaborative	Cooperative
12	Endogenous n/1 orga.	T8	T8	Cooperative	Interested collaborative
13	Exogenous n/1 technical	T2	T2	Interested collaborative	Interested collaborative
14	Exogenous n/1 technical	T3	T3	Interested collaborative	Collaborative

Table III – Example of the evolution of work modality during an UE.

6 Conclusion, extension of the work

Looking at the patterns of the forum before the brake and after the brake and with the use of Mac Grath circumplex, we have seen that even with a break, a VLC stays in a collaborative work. Moreover, if it was in a CSCW (Computer Supported Cooperative Work) before the break, it will be after in a more collaborative work. This demonstrates that a virtual community needs, to set up a collaborative work, some stimuli, while they are endogenous or exogenous. It is the succession of these stimuli, due to the indexed answers, which supplies the community. They drive this last one to a collaborative work and\or maintain it in this working modality. We avoid a tunnel effect, which leads towards a purely cooperative work, or towards a destruction of the group. We tried successfully to detect stimuli or answers (or their absences) to define the state of the community. Hence, we will soon propose some skills and rules introduced in the LMS Moodle that will help teachers and tutors to manage the working way of the VLC by using breaks.

Using the theory of fuzzy logic, we will develop a module in Moodle that uses the rules above. We will integrate into a phase fuzification, the rules allow the inference when comparing the behavior of the community with a robust operating said optimum collaboration. This is for the model to predict whether the VLC work effectively in collaborative mode. The expert system issue, when implemented, alerts on degraded operation of VLC in real time during training sessions on the virtual campus and advises, through the proposal of stimuli, the tutor in his approach to animation. The flexibility of a model associated with a fuzzy logic approach can provide a scalable model and open with each additional indicator, regardless of its origin is a layer over the inference.

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Assessing Writing and Collaboration in Learning: Methodological Issues

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Abstract. We describe the main tasks students usually complete when working in an e-learning platform, across five mean features that have to be taken into account in research efforts (writing-based activities, individual/collective level, knowledge/ pedagogy orientation, feedback, multiple stakeholders account). Ways to analyse and assist these tasks by (semi)-automatic assessments using NLP techniques is discussed. Two services aiming to assist writing-based tasks are presented along with their first validation.

1 Introduction

Current e-learning platforms allow rich collaborative learning activities that are now very well detailed and documented (Dillenbourg 2002; Kollar et al. 2006). However, the ways to record, study and analyse these activities yield methodological issues often debated in the literature (Strijbos & Fischer 2007) and theoretical frameworks to tackle these issues are lacking. The learning activities engaged in collaborative e-learning contexts share some specificities. First, they are based on writing. Second, their manifestations are both at individual and collective level. Third, their aim is twofold: at covering (learning) a given knowledge domain but also at leading a pedagogy-related activity. Fourth, they require to be analysed in order to provide an adequate feedback. Fifth and last, the stakeholders to be considered are not only the learners and the teachers, but also the researchers studying the activity.

Taking into account all these specificities requires devising ad hoc methodologies and overcoming research challenges. Strijbos and Fischer (2007) listed five main methodological challenges close to those pointed out in this paper, the goal of which is to present a comprehensive framework drawn from Bakhtin's work and a set of NLP-based tools that can help analyze learners' tasks according to these five points. The following sections shed light on each of them.

2 Five Specificities and Features for E-learning Tasks

The tasks every learner performs in an e-learning platform share five features:

Writing for learning. Every learner engaged in individual and collaborative learning in a virtual platform performs a set of writing-based activities (e.g., abstract writing, note taking, chatting, writing in forums), which are both evidences for, and products of, learning (Emig 1977). We can integrate the different writing-based learning activities in a comprehensive framework, based on Bakhtin's dialogism theory (Bakhtin 1981). As Koschmann (1999) put it, quoting Bakhtin: "[…] the voices of others become woven into what we say, write and think". We thus can take into account all these activities within a unique framework: everything—written, read or spoken—has a dialogic nature, which is expressed through writing and relates to learning.

Multilevel Tasks: from Individual to Collective. Tasks carried out by students are often separated in two independent ones, individual and collective. As Stahl (2006) puts it, learners engaged in a collaborative task in an e-learning platform have to cope with two *recursive and interrelated* main tasks: first, they are involved in an *individual* knowledge-building process; second, they are publicly engaged in a process of *collaborative* discussions about the notions at hand in the first loop. Bakhtin's ideas of dialogism and inter-animation suit with these intertwined and multiple tasks (inner dialogs and debates).

Two aims: knowledge and pedagogy. The multiple tasks in which students are engaged in e-learning do not share the same goals. The complexity of any learning situation is partly due to the fact that two different and often conflicting aims interact with each other (Shulman 1986): learning a knowledge domain and in parallel being confronted with pedagogy-driven activities. On the side of knowledge, learners are given information they process in order to acquire knowledge. On the side of pedagogy, learners' behavior is directed as 'moves' within the classroom environment and pedagogical methods can be inferred from these moves.

Feedback delivery. In an e-learning context, *students* spend lot of time waiting for feedback from teachers or tutors about their writings, whatever are the goals and levels pursued. They encounter some problems: they stagnate themselves in the writing process; the limited feedback opportunities do not stimulate explorative approaches ("what if-trials"), but force them to hand in mainly completed versions; during writing, it is difficult to self-assess ongoing work and understanding. *Teachers* have a limited overview of the learners' processes, and assessments of students' understanding or collaboration are difficult and time-consuming. Feedback is thus necessary in e-learning contexts and can partly be automated by computer-based procedures.

Accounting for stakeholders' viewpoint. E-learning contexts are populated by numerous stakeholders (students, tutors, teachers, researchers) whose tasks may differ, overlap or be contradictory to each other. These tasks can also strongly interfere with the kind of tool used for analysing a given learning situation. Since most of the tools aiming at analysing collaborative software are devised for research purposes, they are more difficult to be used by other stakeholders.

3 NLP-Based Tools

Web-based services using NLP techniques can take into account the five features of e-learning situations presented above:

(1) detection of relations between utterances can be processed to reveal the voices engaged in writing or dialog;
(2) account for both the individual and collective level of knowledge acquisition;
(3) sensitivity to both knowledge (cognitive models) and 'moves' (dynamic situations) (Dessus et al. 2005; Wolfe et al. 1998);
(4) possibility to deliver just-in-time feedback allowing self-paced learning;
(5) deliver generic feedback to account for all the stakeholders' categories.

Let us now present two instances of web-based services designed from this viewpoint, *Pensum* and *PolyCAFe*.

Pensum supports learners at an *individual level* in the automatic assessment of their essays (summaries, syntheses). *Pensum* analyses how well learners understand course texts through their textual productions. It provides different kinds of feedback (see Figure 1) all based on LSA (Latent Semantic Analysis, Landauer & Dumais 1997) on two important features influencing writing quality: topic coverage (semantic links between sentences source texts and synthesis) and inter-sentence coherence.

PolyCAFe (Chat & Forum Analysis and Feedback System, Trausan-Matu & Rebedea 2010) functions at a *collective level* using a NLP pipe (stemming, POS tagging, chunking, etc.), advanced pattern matching, social network analysis and LSA for detecting discussion topics, threads and inter-animation in chat logs. Feedback (textual and graphical) is generated emphasizing collaboration degree, discussed topics and evaluation of the participants' contributions (see Figure 1). The graphical visualization is interactive, that means the tutors and students may choose to see different threads in the conversation, with zooming and other options.

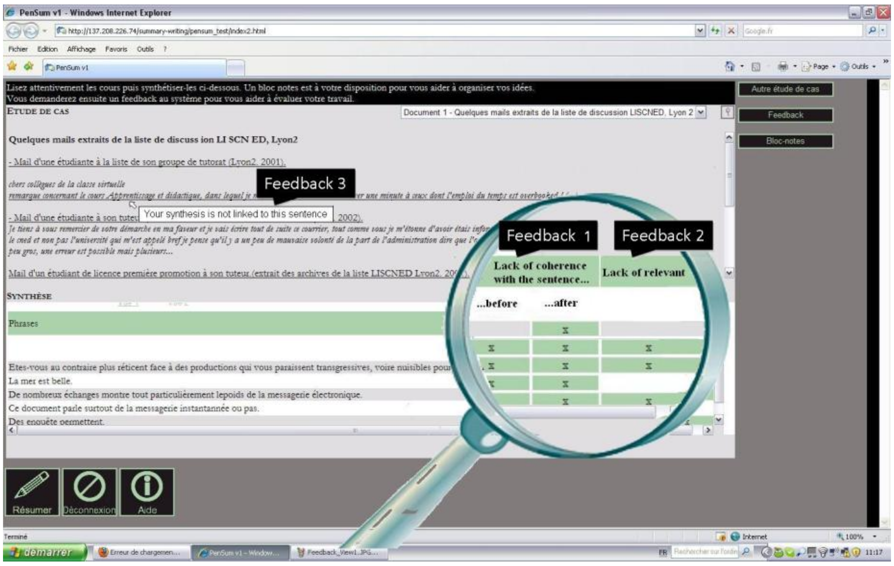

Figure 1. The different pieces of feedback delivered by *Pensum*.

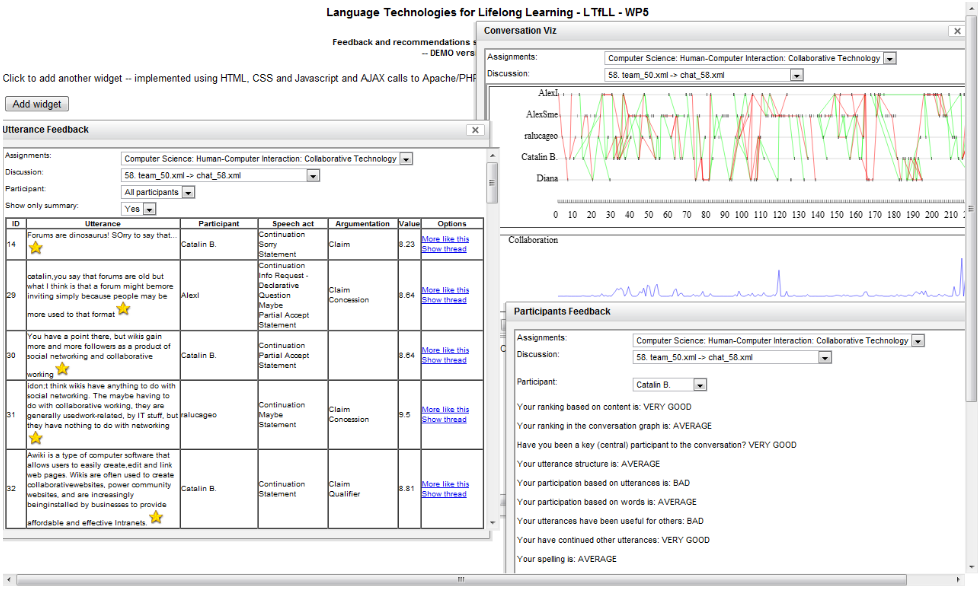

Figure 2. *PolyCAFe* main interface: utterance feedback and conversation visualization.

4 Validation Study

These two services have been subject to a first validation study. The main goal of this study was to have a closer look on the usability of the services for learners in authentic settings, since they provide complex feedback on equally complex tasks.

4.1 *Pensum* Validation

Participants. The students participating to the validation experiment were from three different university courses: Master 2nd year students in educational sciences, (with an ICT focus, $N = 6$); Master 1st year students in linguistics ($N = 3$) or language didactics and pedagogical design ($N = 2$). The average age of the participants was 34.5 ($SD = 12.1$) and 3 of which was male. They were rather proficient in computer use (5.1 h per week of use, $SD = 3.0$), mainly for Internet search and e-mail.

Task Description. Participants were given the following tasks to be performed at distance (ecological settings): to view an on-line screencast (4-minute long) describing the main functionalities of *Pensum*[1]. Then they had to use *Pensum* to write out a synthesis of a given set of two documents on ICT and Internet use in African countries. No length constraints were given and 18 days were left to perform the task. They eventually had to fill in a closed questionnaire on *Pensum*'s use (mixing questions on pedagogical soundness, usability, subjective

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[1] http://www.youtube.com/watch?v=vnKLcmxq5hw

cognitive load, and overall satisfaction) and to participate to a phone interview with more qualitative questions.

Quantitative Results. The completion of the activity (i.e., writing a synthesis) took between 1 to 4 days ($M = 2$; $SD = 1.4$). They asked for feedback between 0 to 10 times ($M = 4.27$; $SD = 2.97$). The syntheses written by the participants were from 4 to 28 sentence-long ($M = 15$; $SD = 8.32$), and were modified 0 to 16 times ($M = 5.09$; $SD = 4.91$). The students made a very variable number of textual modifications: $M = 27.46$; $SD = 23.73$ (one student performed 83 modifications). Table 1 shows students' opinions on *Pensum*'s use (from closed questions). Overall, most of the answers are in the middle of the range (item 3 answer for a scale from 1 to 5), indicating a mixed opinion. For three questions, students expressed opinions were statistically different from the mid one. They think that *Pensum* gives feedback and guiding different from humans, but also that *Pensum* is rather easy to use and that errors are easy to recover. Briefly, this questionnaire showed that students had a better opinion on the usability of *Pensum* than on its effects on learning or its pedagogical capabilities. Eventually, we analysed data related to participants' subjective cognitive workload (from NASA-TLX, Hart & Staveland 1988). Their most important efforts were in trying to understand how to get a better use of *Pensum* and how to use it, and the frustration level compared to the four other factors (mental pressure, physical pressure, time pressure, achievement). These points appear to be normal considering it was the very first uses of the software.

Qualitative Results. The analysis of the open questions (interviews) showed that the students found that *Pensum* was useful for revising courses and helped them focus on the gist of the course text they read. However, their opinion on feedback quality was mixed: some of them complained that *Pensum*'s feedback was confusing because too many sentences were underlined, without sufficient explanations.

Overall, whereas the opinion of *Pensum*'s first users was mixed, this first validation study provides some indications to improve its usability further; first, in enhancing the quality of the feedback (particularly with regard to the inter-sentence coherence), second, in enabling teachers to put comments on the synthesis and to enrich the kinds of feedback given by the system (teachers may set the severity degree of the feedback themselves), third, in giving students control over the system (self-assessment and synthesis annotations).

Table 1. Usability data from the validation study.

Software service	Pedagogic effectiveness	Cognitive load*	Usability	Satisfaction
Pensum	2.4/5	3.9/5	n/a	2.1/5
PolyCAFe	3.9/5	3.6/5	4.1/5	3.9/5

*Scores measuring the users' cognitive load are not comparable across the two systems, since the questions from which they were processed are not similar (an aggregated score from NASA-TLX was used for *Pensum* whereas *PolyCAFe*'s score used answers to closed questions).

4.2 *PolyCAFe* Validation

Participants. A group of 9 students and 4 tutors participated to the validation of the service. The students were enrolled at the Human Computer Interaction course (4^{th}, senior undergraduate year) at the Department of Computer Science and Engineering at the “Politehnica” University of Bucharest. Their average age was 23 years without having an important deviation. All of them have very good computer skills as they will be graduating with an engineering degree in computer science.

Task Description. The learning scenario consisted of the following tasks:

- Tutors grouped students in teams of 4-5 participants. Each student has been assigned a topic to study individually and afterwards to support it during an online chat debate with the colleagues from the same team. The subject of the chat discussion at the HCI course was “collaborative tools available on the web”. The four topics assigned to the four members of the teams were: ‘discussion forum’, ‘chat’, ‘wiki’ and ‘blog’. The team that had 5 members received an extra topic: ‘google wave’.
- Students scheduled by themselves a date for the chat. As they were instructed, they stayed online and discussed for about two hours, structuring the conversation in two steps. In the first part, each of them had to support his/her assigned topic by presenting its features and advantages and criticize the others’ topics by invoking their flaws and drawbacks. In the final part of the chat, they had to discuss on how they could integrate all these tools in a software environment.
- Students met with the validation team, watched a screen-cast describing *PolyCAFe* and then used the software in order to get feedback about their participation in the chat conversation. During their use of the software, they were encouraged to think-aloud about the usability of the tools.
- Students filled in a questionnaire on *PolyCAFe*’s use and participated in a focus group conducted by the validation team.

Quantitative Results. Due to the nature of the instant messaging technology, each student participated to the conversation only once, for 90–120 minutes. Then, they consulted the results provided by *PolyCAFe* once for each chat, for a period of about 60–90 minutes. It should be taken into account that this was also the first time when they used the software. The questionnaire that each student had to answer consisted of 32 items: 13 general questions related to the use of *PolyCAFe* as a whole and 19 questions related to specific functionality of the system’s components. Table 1 offers an overview of the results to the generic questions grouped by category. There was a further category of questions not displayed in the table that considered the efficiency of the implemented solution which has an average score of 4.2/5. As can be seen from this data, the students considered the system to be effective, efficient and easy to use, with an average score of slightly above 4/5. They were also satisfied by the results provided by the system and the cognitive load was not very high taken into consideration the fact that it was the first time they have seen the system. The highest scores were obtained for the following items:

- The students considered that *PolyCAFe* provides adequate support for their learning activities (*M* = 4.33; *SD* = 0.47).
- They considered that it takes less time to complete learning tasks using *PolyCAFe* than without the system (*M* = 4.22; *SD* = 0.79).
- The system was easy to learn to use (*M* = 4.56; *SD* = 0.50).

However, there were questions that received lower scores; the lowest one being when they were asked to compare the support provided by *PolyCAFe* compared to the current support provided by humans, which received an average score just above 3 (*M* = 3.11; *SD* = 1.10). However, it should be noted that the system is not designed to replace human feedback, but just to enhance it and provide a quicker alternative. On the other hand, there were 3 questions related to specific functionality of the system that had an average score below 3. This points out that although the system has been validated as a whole, specific modules should be improved in the next version of *PolyCAFe*.

Qualitative Results. The focus group results show that the students considered the system to be very useful for understanding their role in the chat conversation and the degree of collaboration, as well as the coverage of the concepts related to the topic of the discussion. As the feedback provided by the tutors for each chat is usually late and quite poor, the alternative of receiving preliminary results from *PolyCAFe* was received with enthusiasm. However, they pointed out that the usability of the system can be improved in order to provide a better guide to using the software and understanding how to use the results, indicators and textual feedback returned by the system. Moreover, not all the components were considered to be equally effective: the conversation visualization and the utterance feedback widgets were considered the most effective, while the conversation and participant feedback widgets were considered the least effective and more error prone. Several improvements to these components were suggested by students in order to be more relevant for their learning activities.

5 Conclusion and Future Work

We presented a theoretical framework arguing that learning tasks in collaborative platforms share five main features. We also designed and tested two web services supporting these tasks and accounting for these features. Our services (1) are focused on writing activities; (2) are both on individual and collective levels (3) can embed pedagogical facets through the use of web widgets; (3) propose high-level and automated feedback; (5) can be used by various stakeholders. A first validation study of these two services has been undertaken and shows promising results. Further work is planned to cross the results of these tools to uncover patterns of efficient individual or collaborative forms of writing.

6 Acknowledgments

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Assessing the quality of collaborative activity in open, online, calculus help forums

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Abstract. Open, online help forums allow students to anonymously post queries (usually problem-specific questions from assignments) that are then visible to others with Internet access. These forums are especially popular for homework-intensive subjects, such as calculus, and are not affiliated with any educational institution or a particular course offering. The organic nature of these forums affords researchers the opportunity to study naturally occurring collaborative activity between students and helpers, especially in forums that exhibit a strong sense of community. Quality can be assessed first through quantitative metrics and then through qualitative analyses of student and helper contributions. Based on observational studies conducted over the last several years, I propose three markers of student activity: the presence of assertions and proposals for mathematical actions, questions and challenges of others' proposals, and indicators of resolution. Likewise, I propose three ways that helpers contribute to quality: bringing mathematical practices to life, fostering alternative perspectives, and supporting mathematical accuracy. I believe that studying these exchanges will give insight into how to improve the design of communication interfaces and how to better assess the quality of collaborative activity in more regulated, structured contexts. Future work includes relating the nature of forum collaborative help to learning outcomes.

1 Introduction

Open, online help forums are found on websites and allow students to anonymously post queries (usually problem-specific questions from assignments) that are then visible to others. These forums are "open" in the sense that, unlike other asynchronous communication tools (such as course forums or discussion boards), access is not restricted to any particular course or institution. Also, instead of hosting discussions based on the curriculum from a particular course, the forums cover broad school subject areas (such as mathematics, science, and business) at a range of course levels (from elementary to graduate). These forums are a help-seeking resource that democratizes education through technology (Larreamendy-Joerns & Leinhardt, 2006) and is currently available free of charge to any student who has Internet access.

Students from around the world access these forums when they are in need of help completing assignments or understanding course material, and this is particularly true for subject areas such as mathematics that are homework intensive and require students to construct solutions to exercises. For example, one such site (www.mathhelpforum.com) that offers help in arithmetic through higher mathematics, has over 29,000 members and received an average of 152 queries daily in 2009.

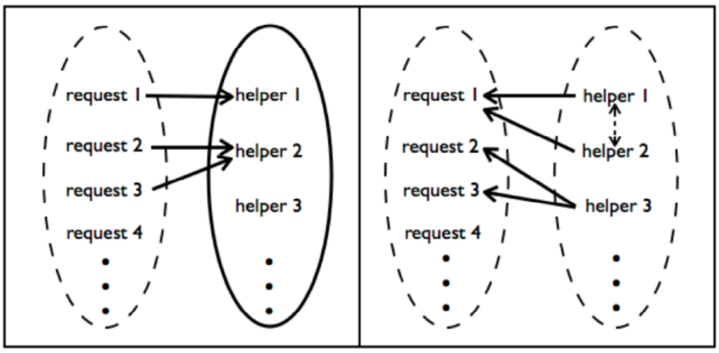

Figure 1. Alternative forum participation structures: AOH (left) and SOH (right)

Open, online, homework help forums belong to a genre of technology-assisted education called 'networked learning' (Goodyear, Jones, Asensio, Hodgson, & Steeples, 2005). The extent of the network and hence the affordance for collaboration depends, in part, on the structure of the forum (Figure 1). Some forums have a pool of select, vetted helpers to whom incoming queries are assigned, for example on the basis of expertise or availability (Assigned Online Help or AOH). Forums with this structure support one-to-one, computer-mediated help seeking between students and a restricted set of others who have met certain qualifications. Other forums, however, allow any member to respond to a query or contribute to an ongoing thread (Spontaneous Online Help or SOH). SOH forums provide a much more extensive help-seeking network with richer opportunities for collaboration (van de Sande & Leinhardt, 2007). In SOH forums, for example, helpers can dialogue with each other within a thread. A third possible forum structure, that is currently being researched (Puustinen, Volckaert-Legrier, Coquin, & Bernicot, 2009) is a blend of AOH and SOH in that the set of helpers is more-or-less restricted and subject to approval (like AOH) but helpers can pick up any thread and interact with one another within threads (like SOH).

During our studies of calculus forums (van de Sande, 2008; 2010; van de Sande & Leinhardt, 2007; 2008), we have developed and applied several quantitative and qualitative metrics to assess the nature of engaging in homework help as a collaborative activity. In the following paragraphs, we introduce these metrics that address the quality of activity on the part of both students and helpers with the understanding that these are by no means independent.

2 Quantitative Metrics

For each thread, we define a *conversation code* that tracks the number of participants, the sequencing of turns, and the number of contributions in an exchange (van de Sande & Leinhardt, 2007). Although these codes do not address conversational content or timing, they provide a means for comparing participation over large numbers of exchanges. For example, the codes reveal how the design and structure of a site influence exchange participation: sites with an AOH structure favor brief exchanges between single student-tutor pairs (low complexity), whereas sites with an SOH structure (and minimal delay for publishing postings) may contain extended exchanges between multiple participants (high complexity).

In addition to highlighting the effects of forum structure on participation, complex conversational codes are positively related to the quality of exchanges, in terms of mathematical depth and pedagogical sophistication (Figure 2). Exchanges with a low complexity are generally communications of sparse fragments of mathematical information (low quality), whereas exchanges with higher complexity may contain elaborated mathematical discussions with sophisticated pedagogical elements (high quality). In exemplary exchanges, mathematical principles are invoked and the problem-solving activity contains valued elements of instructional practice (such as Socratic dialogue).

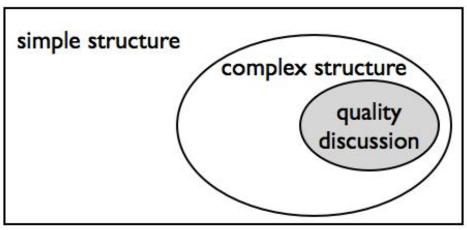

Figure 2. Relationship between quality of discussion and conversation “complexity.”

Another quantitative assessment of quality involves timing. Because students are using the forums for homework help and have assignments that are due, successful forums provide quick responses to student queries. We define *response latency* to be the time from initial student post to first response. For more successful forums, the response latency can be a few hours or as low as thirty minutes.

3 Student Activity

Clearly, if a forum is affording collaborative opportunities rather than serving as a cheat site, then this should be evident from qualitative analyses of student contributions. Three markers of student activity, grounded in research on face-to-face interaction (Greeno, 2006), are the presence of assertions and proposals for mathematical actions, questions and challenges of others' proposals, and indicators of resolution (van de Sande, 2008). In terms of making assertions and proposals for action, there are two locations within each thread in which a student has opportunity to contribute to the construction of the solution to the problem: the initial post and in post(s) following helper intervention. Thus, there are four descriptive characterizations of student activity: coasting (absence of assertions), slacking (assertions in initial post), ramping (assertions following intervention), and sustaining (assertions throughout) (van de Sande, 2010). In terms of establishing common ground, students may either accept or question the contributions of helpers (Clark, 1996) to establish mutual understanding. Questioning may be part of a self-regulatory learning strategy to repair knowledge deficits. Finally, students initiate forum exchanges and are therefore positioned to initiate resolution (specifying if and how the exchange was helpful). This can take be done in either a weak (unsubstantiated) or strong (reflective) manner.

4 Helper Activity

One can also examine the nature of helpers' contributions in the exchanges. Helpers can adopt various pedagogical strategies, ranging from providing (partial) worked solutions to initiating a dialogue. The choice of strategy sets the tone for the ensuing exchange with the student in terms of expectations and, more generally, instantiates community norms for help seeking (Nelson-Le Gall, 1985). In addition to interacting with students, helpers in some forums exhibit a strong sense of community (van de Sande & Leinhardt, 2007). For example, they share explicit and implicit goals, identify themselves as members of the community, and assume shared responsibility for participation. SOH forums afford opportunities for members to interact with one another that are manifest in distinctive patterns of participation. In order to describe these patterns of participation, it is useful to view forum helpers as "Good Samaritans," who come to the aid of students in mathematical distress (van de Sande & Leinhardt, 2008). For instance, there is a sense in which help becomes contagious as proposed solutions or perspectives on a problem prompt other forum helpers to contribute their ideas with the goal of improving and augmenting the discussion. There are three ways that helpers contribute to the quality of help as a collaborative activity: bringing mathematical practices to life, fostering alternative perspectives, and supporting mathematical accuracy (van de Sande, 2008).

5 An example

Table I is a reconstruction of a thread that shows what activity on an open, online, mathematics help forum can look like. This thread was taken from www.maths-forum.com, a French site, and involves a student (Tomi) and three helpers (Erico, Dan314, and Scare) discussing polynomial factorization and division. In order to protect the identity of forum participants, names have been altered in this paper.

Posted by [member] **at** [time]	**Text**
Tomi @ 12h09 	**Polynôme de degré 3** Bonjours à toutes & tous, J'ai un problème sur une question d'un exercice, **Question de l'exo :** On considère le polynôme $P(x)=2x^3+3x^2-5$. Calculer $P(1)$. En déduire une factorisation de $P(x)$ et le signe de $P(x)$ suivant les valeurs de x. **Mes résultats :** Évidemment je trouve $P(1)=0$. Mais ensuite je bloque complètement, je ne comprend pas le système de division pour $\frac{2x^3+3x^2-5}{x-1}$. J'ai cherché et trouvé des méthodes que je n'est jamais étudié en classe bizarrement. On parle de soit faire une division du type : $\frac{2x^3+3x^2-5}{x-1}$ ou alors procédé par division synthétique, mais dans les deux cas je reste à coter de la plaque. J'ai cru comprendre que la division synthétique est plus simple, j'ai donc cherché à procédé par division synthétique mais, impossible pour moi de comprendre sont fonctionnement. =>Si quelqu'un pourrait m'éclaircir tout ça, je le remercie d'avance.

	Tomi. ________ ... => => => => => => => => => => !!
Erico @ 12h13	il te suffit de mettre (x-1) en facteur dans $2x^3+3x^2-5$ tu as plein de façons de faire ça. Soit directement en déduisant chaque terme, la division euclidienne des polynômes ou bien si tu ne sais pas tu poses $2x^3+3x^2-5 = (x-1)(2x^2+ax+b)$ tu développes le second membre et tu identifies chaque terme avec le membre de gauche (pour la division euclidienne regardes wikipedia : ici)
Dan314 @ 12h19 	Salut, Si t'est vraiment flemmard (ce qui est une trés bonne chose pour un matheux), tu peut même constater que, de la même façon qu'Ericovitchi a directement mis un '2' devant le x² pour que, quand on le multiplie par le 'x' du premier terme on obtienne bien le 2x^3 désiré, on peut directement mettre un 5 à la place du 'b' pour que, quand on le multiplie par le -1 du premier terme, ça fasse bien le -5 désiré. Il ne reste donc que le 'a' à trouver...
Tomi @ 12h26 	Tout d'abord merci de ta réponse, J'ai donc procédé de la manière suivante : $2x^3+3x^2-5=(x-1)(2x^2+ax+b)=2x^3+ax^2+bx-2x^2-ax-b=2x^3+(a-2)x^2+(b-a)x-b$ Et par identification des termes j'obtiens : $\begin{cases}a-2=3\\ b=5\end{cases}$ $\begin{cases}a=5\\ b=5\end{cases}$ Donc la forme factoriser de $P(x)$ est: $P(x)=(x-1)(2x^2+5x+5)$ Est-ce bien ça ? Merci. ________ ... => => => => => => => => => => !!
Tomi @ 12h36	Bonjour Dan, Citation:

	Posté par **Dan314** *Si t'est vraiment flemmard* tout à fait , J'approuve totalement ton supplément, mais du faite que cette année j'ai changé pour la 5ème fois de prof de math..., j'ai une nouvelle prof depuis 2 semaines et donc je préfère faire tout point par point de peur que la méthode dite "flémarde" ne lui convienne pas ne sachant pas sa façon exacte de fonctionné. Je te remercie de ta réponse. Tomi. ________ ... => => => => => => => => => => !!
Tomi @ 13h21 	Un petit up pour me confirmer la réponse svp ________ ... => => => => => => => => => => !!
Scare @13h24	Salut ! La factorization est bonne
Tomi @ 13h24 	merci beaucoup ! ________ ... => => => => => => => => => => !!

Table I. Reconstruction of thread on polynomial factorization and division from French mathematics SOH site.

This thread, titled Polynôme de degré 3, has a relatively complex conversation code of 12311141, where each 1 in the code represents a contribution from Tomi and subsequent numbers represent contributions from the three helpers (2 for Erico, 3 for Dan314, and 4 for Scare). From this code, we can see that the student remains a contributor throughout the thread, and that the three helpers appear to be working cooperatively with Tomi. The timing also reveals a tight-knit help-seeking interaction. The response latency is only 4 minutes and all of the interaction takes place within 1.25 hours.

In terms of student activity, we see that Tomi contributes initially to the construction of the solution by showing the work done on the exercise (Row 1 of

Table I) and following helper intervention (Row 4). Tomi also shares details of her/his classroom experience with the forum (Row 5), indicating that the collaborative activity embedded in the forum extends beyond the purely cognitive. We also see this in the sequence of emoticons that is Tomi's signature (Rows 1, 4-6, and 8): learning (head in book) leading to impasse (head banging on brick wall) and frustration (tears) that is gradually transformed to understanding (wide eyes), happiness (smiles), and victory (thumbs up!).

In terms of helper activity, we see how three helpers cooperatively work to support Tomi. In a manifestation of cumulative thinking (Baker, 2010), Erico, the first to respond, does not give a solution but suggests and outlines an alternative method to what Tomi suggested, while at the same time providing an external reference if Tomi wished to pursue her/his line of thought (Row 2). When the second helper enters, we see extensional activity (Row 3) together with the way in which mathematical dispositions of study (here, laziness) can enter naturally into the flow of forum experience. The third helper, Scare, contributes by verifying Tomi's work (Row 7) and thereby alleviating the built up tension (Row 6) from waiting for a response. The final contribution from Tomi (Row 8) demonstrates closure; the problem has been resolved and the interaction helpful.

6 Conclusions

By identifying features of 'good' and 'bad' forum threads, we are better positioned to help students and helpers effectively work together as students seek homework help outside of the classroom and helpers seek communities of practice. The CSCL community has recognized the importance of connecting measures of quality to concrete learning gains. Thus, for this research, future work includes refining assessments of quality, followed by relating the nature of forum interactions to student learning outcomes.

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Task-oriented collaboration: not just what is inside the task, but what the task is inside of

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Abstract. In this paper a case is made to extend concern for the quality of collaboration to include more serendipitous and intermittent exchanges. An overarching goal of such a concern is to loosen the boundary between the formality of learning as 'study' and the informality of learning as it occurs within the 'everyday'. The relevance of new, open format learning spaces in higher education is considered in relation to this ambition.

1 Introduction

The computer-supported collaborative learning (CSCL) community have helpfully brought about a vigorous interest in understanding collaboration as a social-psychological process. In the early days of CSCL (e.g., Crook, 1994; Koschmann, 1996, O'Malley, 1994), the learning encounters that were of special interest were those that involved small groups (or simply pairs) of students working together at a computer screen. As the networking of computers become more widespread, interest in collaboration expanded to embrace forms of synchronously or asynchronously networked discussion. In both of these contexts – face to face and networked – the object of study was generally a circumscribed 'task'. Face to face collaborators might engage in a short episode of joint problem solving. Networked collaborators might pursue a similar focus, although they would do so in the more distributed organization that must be managed within spatial separation of temporal asynchrony.

Of course, such designs do usefully reproduce commonplace conditions of classroom life. However, sometimes in classrooms - and often in the world outside - collaboration is experienced in a more fragmented, serendipitous, and improvisational way. Moreover, it may not be directed towards goals that are precise or goals that perfectly overlap for participants. Yet these social interchanges – these ‘co-ordinations’ of shared interests - may still be termed ‘collaborative’. If, for example, an institution makes an effort to provide designs and resources that encourage such social co-ordinations, then we might say that institution is offering “a collaborative experience of learning” (Crook, 1994).

The task-orientation of traditional CSCL research is poorly prepared for making sense of collaborations that occur within such loose couplings. If those are to be better theorized, what is needed is less an understanding of social processes that are strongly task-oriented and more an understanding of the contexts in which putative and sometimes disconnected tasks interleave and take shape. Or put another way, research is less a matter of what is ‘inside’ tasks (as circumscribed shared goals) and more an understanding of what tasks (overlapping, multiple goals) are inside of. To define the nature of such contexts it helps to highlight the nature of ‘study’ as a species of learning and to acknowledge a continuum of in/formality that can be constructed around it. Having done that, an example will be explored of a ‘collaborative context’: that is, a setting within which ‘tasks’ (and ‘interests’ and ‘trajectories’) may be addressed collaboratively.

2 Study as a species of learning

The English terms “learning” and “study” are not always clearly distinguished. Yet they express a distinction that is worth protecting. “Learning” is perhaps the parent term. It covers a whole range of circumstances – incidental and accidental, as well as the more intentional – circumstances whereby we are changed in ways that shape how will tend to act in the future. “Study”, on the other hand, is a distinctive kind of learning that is more narrowly defined: in particular, it is typically deliberate. It suggests the learner embarking on something more contrived: a specific scenario-for-learning. Such a scenario will usually involve an engagement with resources in a manner that is decoupled from circumstances of relevant use, appropriate place, or immediate need. Such relatively de-contextualised learning is, of course, a characteristic of schooling.

Human beings are good at study. It calls upon our important and shared ability to achieve learning through actions that are un-situated (Bereiter, 1997), or out of natural context. When institutions design such circumstances for learning, one significant challenge is to arrange that the products of un-situated study can be effectively coordinated with experiences of authentic practice from the relevant subject-matter domain. Real depth of knowing surely depends upon how education orchestrates such a balance of situated and un-situated experience. However, that particular variety of blend is not the subject of the present paper. Instead, concern here is with a different sort of balance: namely, how the various familiar states of studying (especially talk) can be more seamlessly integrated into a background that we might simply call ‘everyday life’.

This concern can be put another way: namely, in terms of bringing about shifts in ‘learner identity’. To become a student of, say, History or Psychology is a matter of individuals allowing the dispositions of study to enter naturally into the ongoing flow of their lived experience. The discourse of these academic subjects thereby comes to penetrate their everyday life. To be a Historian or a Psychologist is – to some extent at least – a matter of interrogating ones world through the modes of inquiry that those disciplines invite. It involves living out the subject in that sense.

3 Designs for enculturing study into the everyday

Yet, in practice, such shifts in personal identity are not easy to achieve. How is the motive for study to be made more continuous with the student’s more everyday concerns and fancies? How might personal identity be shaped to accommodate more comfortably the demands of thinking through the lens of some academic discipline?

Education’s engagement with new technologies could be regarded as a recurring ambition to mediate this transformation. Here the vision is one of appropriating new media: taking media that enjoy popular appeal and aligning them with content or practice that relates to some curriculum (Cuban, 1986). Thus, television affords ‘educational broadcasting’, handheld personal devices afford ‘mobile learning’, and – most compelling of all perhaps – the Internet affords ‘personal inquiry learning’ or participation in ‘communities of practice’. Undoubtedly, these technologies make valuable contributions to the experience of education. Moreover, they have evolved to be increasingly powerful in that respect. So, whilst watching the Discovery Channel is quite a long way from being a Zoologist, the learner who uses the internet to explore animal migration patterns in relation to climate change data is surely is getting a lot closer.

Typically, developing technology as an educational opportunity in this sense is achieved by arranging that both recreational and study resources should converge within the space of a single medium – television, mobile phone, internet etc. This simple proximity of resources then may prompt the learner to enter into the educational sector of this shared space. Moreover, learners’ confidence in manipulating that shared medium for recreational motives is potentially recruited into more educational purposes. However, using technology to lever such convivial engagement with curriculum content is not without problems. The proximity of resources may encourage a pattern of time investment that is not balanced in the direction desired. It may be more towards the recreational than the academic. Educational resources that were previously segregated from recreation (for example, in libraries, classrooms, and other contexts) are now more closely integrated with resources that may be powerful distracters from study. The consequences of this may be made apparent in the well-documented student habits of intense multitasking in personal computer settings (Crook and Barrowcliff, 2001).

4 Enculturing collaboration as a form of study

The pursuit of effective study is partly a matter of the learner seeking the most productive interactions with relevant disciplinary material – symbolic resources as well as physical artefacts, or more concrete material. But effective study is also a matter of interacting socially. That is, study will involve periods of collaboration with other students. Moreover, doing so involves a parallel challenge to the one sketched above. It is a challenge of enculturing the curricular into the everyday. The process of becoming a historian (or psychologist, or whatever) is a matter of allowing the collaborative talk of a discipline to more often penetrate the discourse of everyday life. Not necessarily to overpower other discourses, but to become a comfortable and versatile part of an individual's discursive repertoire. At the very least one would hope to find that such collaborative talk no longer always needed to be segregated into places and occasions where it was formally orchestrated as 'study'

There is a design challenge here – one that echoes the ambition of having new technologies lever curricular material into the breadth of lived experience. Just as we seek media that allow an interleaving of curricular materials into the playful arena of everyday life, so we need spaces whereby talk that has a curricular focus can be accommodated more comfortably into the everyday. Accordingly, any research concern for the 'quality of collaborations' ought to include attention to the design of environments that stimulate this enculturation of study-oriented conversations. However, research on collaborative learning has tended to concentrate on more traditional arrangements for such talk. The iconic arrangement for a researchable collaboration is a short, self-contained episode of joint problem solving: probably around a problem that is of limited relevance to the participants - who themselves may have no authentic agenda of shared needs. The idea of collaborative talk as something that might arise in a less choreographed manner seems to attract scarce interest. And yet working to embed such conversation into the routine exchanges of 'everyday life' might be an important step for loosening the segregated nature of study as a distinct species of learning.

The present discussion is particularly concerned with the circumstances of higher education. A starting point for the necessary research interest in that context must be a recognition that spontaneous collaborative learning is relatively rare among undergraduates (e.g., Crook and Light, 2002). Those self-report accounts of study practices are complemented by recent records we have collected in the form of audio diaries. Here, students keep a running commentary of their study and reveal it is rarely organised as a collaborative experience.

In some part, this pattern of preference may reflect the competitive and divisive nature of prevailing assessment regimes. However, it may also reflect the way in which out-of-classroom study is encouraged to migrate to solitary and silent spaces (cf. 'private' study) – such as libraries or study bedrooms. Yet this version of extra-classroom learning spaces is being challenged by new designs for libraries and resource centres. At the heart of this new design agenda is an interest in collaborative learning. This may be in some part inspired by a modern move of theory towards 'social constructivism'. But it will also be inspired by a contemporary political imperative for cultivating '21st century learning skills' – a package of competences that prioritises the ability to work comfortably in teams.

5 New spaces for social learning

These forms of learning space remain relatively unusual and data concerning the way in which they are used is rare. However, our own fieldwork suggests a mixed picture. For many students, spaces for study that actively cultivate unmanaged conversation are a source of distraction. Not simply by virtue of exposure to other people's noise (this is often deflected by the insertion of MP3 headphones – ironically isolating the learner from their social space). It is distracting because the form of conversation that too readily develops can be more recreational than curricular. In which case, any visit to a study space for the purposes of managing learning ambitions may be too quickly de-railed. And yet for other learners, the availability of this space has created the only condition in which they would have chosen to engage in any study at all out of class. However, this is less because of its potential for sustaining collaborative (study) conversation, and more because the space creates a kind of generic but welcome social ambiance.

Such ambiance is 'co-labour' in surely only the broadest sense. Certainly it identifies a concealed form of the social as it arises in relation to the support of learning. However, if an attraction to such ambiance is researched as part of a trajectory – one heading towards interactions that are more actively collaborative, then it becomes an important phenomenon to understand in relation to the emergence of quality collaborative exchanges. It also becomes an important step in the design of learning environments that encourage a more productive synergy between the curriculum and the everyday.

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Report on discussion group 1

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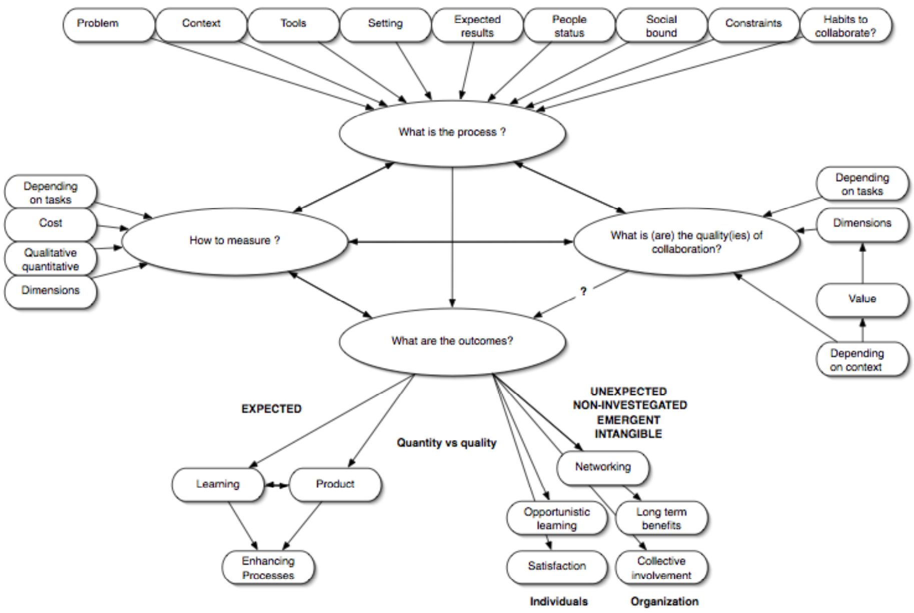
1 Introduction

Exchanges and discussion started by examining the various approaches to assess the “quality of collaboration” among the participants in the subgroup. We quickly agreed on viewing collaboration as a set of (dynamic) processes that emerge between participants when they work together to achieve an objective/a task. By the way, we also pointed that tasks may have a different status in CSL and CSCW. In CSL, task performance *per se* is usually of less importance compared to the (collaborative) processes associated to the acquisition of specific learning objectives by collaborators. Inversely in CSCW, task outcomes are usually of a primary importance while no specific learning outcomes are expected. The discussion also underlined that the quality (of collaboration) could be assessed in a quantitative or qualitative fashion based on the process itself or some of its dimensions, depending on the authors.

These points lead us to distinguish between (at least) 4 classes of issues that would be interesting to address in order to gain a deepened understanding of (the notion of) quality of collaboration. These classes are:

- What is (are) the determinant(s) of collaboration viewed as a process. Discussion elicited several factors (either intrinsic or extrinsic) that could determine the collaborative process related to the task at hand, both at the content and at the dynamics levels.

- What is (meant by) quality (or qualities) of collaboration? Quality of collaboration seems to refer primarily to a normative view of collaboration, where expected norms are confronted to data collected in the assessed situation? For example, Buisine (this workshop) defines the quality of collaboration as the equity of contributions between collaborators. She described "equity" as "the ideal collaborative situation". Other approaches like those of Kahrimanis & al. (this workshop) and Safin & al. (this workshop) have emphasized that collaborative processes have multiple and highly situated dimensions that assessment method should take into account, i.e. enabling to reflect these multiple "qualities".
- What can be expected/analysed in terms of outcomes when a "good" collaboration occurred? Although processes and their outcomes should not be confused, the discussion showed that the relationships between them are complex and probably not univocal. Depending on their relationships and their nature, outcomes can indeed provide or not the basis for assessing in an indirect manner the quality of collaboration.
- How then can we measure quality, process and its outcomes.



Schema 1. Conceptual map of issues discussed in group 1. Directed arrow from A to B denote that Element A (be it a concept, an issue) potentially influence /modify Element B.

In the following part, we refine what were discussed regarding these issues during the work done within the subgroup. In parallel to our discussion, we have attempted to reify it on a conceptual map (schema 1).

2 Quality(ies) of collaboration associated issues

2.1 Collaboration processes are situated

Processes are situated, that is collaboration processes can take a huge variety of ways and forms contingently to the history, actors, expectations and environment in its more extended sense. These forms depend indeed on several factors (intrinsic vs. extrinsic to group and individuals) describing the considered situation that may affect the process of collaborating itself. For example, the task as well as the phase related to the task in progress have an effect on the form and nature of emerging collaboration processes at a specific point in time (see e.g Safin & al. this workshop). Ergonomics studies have been interested for a long time in evaluating how tools and settings are modifying collaboration, in general terms (e.g. effect of distance as synthesized by Olson and Olson, 2000) as well as at the very concrete level of features of a specific computer-mediated system (see e.g. Burkhardt & al. 2008). We made an attempt to list some of these factors in Figure X. A first obvious consequence is that while collaboration processes are probably changing depending on values of the several factors identified in a specific situation, both investigated dimensions of the process and measurements approaches should be tailored to fit the situation as well. Furthermore, different collaboration processes imply to some extend that different measures of quality(ies) should be derived.

Among the set of issues that can be discussed from the "process" view, complex one deals with the overlapping between "production process" and "collaborative process" when a real group of participants collaborate to achieve a goal/task. Has the process of collaborating have to be considered, observed and measured independently of the process of achieving a goal (e.g. designing)? Or is collaboration intrinsically linked to the tasks, making comparisons between domains more difficult?

We finlly identify the necessity of carrying more longitudinal studies, examining the effect of the several factors previously listed, in order to complete the picture of collaboration processes. Indeed, most of studies are currently mostly constructed on the basis of short-scale and/or punctual observations of activities, which undermine both habits and social bounds determinants of collaboration.

2.2 Quality, qualities and collaboration (processes)

Collaboration is often seen from a normative perspective in CSCW as well as in CSCL studies. Specifically in CSL, there are dimensions described as indicators of "good collaboration". These indicators are usually associated to the same valence, i.e. a better score in those dimensions would mean a better quality. As an illustration, it is often stated in learning situations that reaching a consensus among all participants is a key factors for experiencing a good collaboration and achieving goals.

During the discussion, this normative view have been partially questioned and the following alternate view has been proposed : depending on the situations situation (for example at work), the various dimensions do not necessarily have the same kind of valence: depending on the context, on the participants and on the tasks, some dimensions may be not important, or even negative. For example, it may be more efficient to have decisions taken quickly by the most experienced participant in highly time-constrained situations, like in emergency interventions.

2.3 Measures

There are several ways to measure, to assess and to describe collaboration processes, qualitative or quantitative, mono- or multi-factorial, depending obviously on resources, but also strongly on observed tasks. Indeed, in the workshop, two studies were based on the same paradigm (Spada's model of collaboration) but the method has been adapted to the specific tasks (architectural design and algorithmic) to be efficient. It seems thus that that no method is universal and, therefore, it raises the issue of the comparability of the results, their cost and efficiency, their adequacy to the (evaluation) contexts as well as to the specific form and nature of the assessed collaboration processes, etc.

2.4 Expected vs. less (or even non) considered outcomes

Rather unexpectedly, the main group reflections were about the outcome of the collaborative activities.
A first line of issue dealt with a real difficulty in linking the quality of collaboration and the quality of the outcomes. For example, the issue raised in several examples was "does a "good" collaboration leads automatically to a "good" result? Depending on the situations, the answer was sometime yes as in design situations or sometime no, the latter meaning that both dimensions are mostly independents.

A second line of issue was that the collaboration processes outcomes are much more diversified that what is usually measured. Some of the outcomes are those expected and in some extent measurable: the product, the amount of learning and possibly the gain in process effectiveness. But several other outcomes exist, which are less expected, less measurable, and thus far less investigated by scientists. These emergent outcomes may affect the individuals and/or the organization. The collaboration is strongly related to the satisfaction of the users : we can expect that a good collaboration increases the feeling of democracy in organizations. The individuals may also experience "opportunistic learning", i.e. learning of new knowledge or competencies through the other participants competencies an expertises. The organizations can gain in collective involvement from their employees throughout an efficient culture of collaboration. Long-term benefits (organizational learning for instance) can also been expected in collaborative organizations. Finally, the networking as an outcome from collaboration is a positive aspects for individuals and organizations.

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Report on discussion group 2 (“collaborative processes in groups”)

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Abstract. This is a short report on the discussions that took place during the COOP 2010 “Quality of collaboration” workshop, within the group constituted by the presenters of the second paper session, “collaborative processes in groups”. Three main issues were discussed: contextuality, power in social interaction, and corpus analysis. It was concluded that more collaborative studies of ‘real-life’ collaboration are needed.

1 Contextuality

Nearly all research presented during the workshop has identified a number of specific qualities, factors or dimensions of collaboration that are relevant to assessing its quality. In certain cases, the aim is to quantify these factors automatically, within an approach that sees quality of collaboration as a sum or product of individual factors. Examples of such factors include:

- degree of symmetry, quantified in terms of numbers of interventions per participant;
- paralinguistics, e.g. laughter, pauses;
- degree of co-elaboration of ideas, e.g. by identifying use of phrases introduced by one participant by another;
- frequencies of discourse types, such as argumentation, knowledge building;
- … .

In spite of the usefulness of this approach, we argued that these factors can not be considered outside of *context* — interactive context and task-context —, by which we simply mean “con-text”, or what ‘comes with’ discourse and contributes to its meaning. For example, quantity of interventions, and their symmetry, mean little without considering the contextual meaning of interventions: one participant could make ‘high quality’, significant contributions whilst saying relatively little (see Hatano & Inagaki, 1991). Similarly, a pause can be seen positively, as giving the group time to think or being an invitation to question or elaborate (McDonnell, 2010), or else (negatively) as a sign of some interactional problem. Humour does not necessarily lower tension: it could in fact raise it, if produced in a context of high interpersonal tension (Baker, 2010). In other words, it is the *function*(s) of interventions in context that needs to be considered in the examination of quality of collaboration. Although interventionists may be tempted to design collaborative situations on an ‘engineering model’ by which fruitful *outputs* are aggregated from *input* factors, interactions between the factors and the context are so complex that they should always consider these interactions as a whole. Currently many apparently quantified (implied ‘objective’) measures actually rest at the micro-level on aggregations of what are essentially potentially entirely different elements – from a semantic perspective.

2 Power

All exchanged discourse between persons, in specific situations, necessarily involves relations of *power*, and this has been little addressed so far in the workshop.

In certain situations, power relations can be institutionalised, in the form of specific roles, such as “manager”, “assistant”, “captain”, “professor”, etc.; yet, although, for example, a “manager” has legitimised power over an “employee”, this does not totally specify how such a role will be concretely played out in interaction. In such cases, questions are raised concerning the very definition of collaboration: is it really compatible with such hierarchically structured situations? Can a manager really speak of his or her subordinates as “collaborators”, or is this a convenient way of masking objective power relations? What would “quality of collaboration” be, here? What is the degree of adequation between what is ordered and what is understood to have been ordered? The subordinate understanding what the manager wants before he or she in fact asks it? There could be some aspect of ‘team spirit’ here, even with such asymmetry.

Or does collaboration rather presuppose more horizontal structures and relations, with a greater degree of equality of rights to intervene in various ways? Dunbar (1995) traced four research laboratories of biology during several years, and found that research teams with more horizontal structure and heterogeneous backgrounds tended to make scientific discoveries, rather than the others. Does it imply that members had better ignore and reset the predefined structure between roles (e.g. principal investigator, PIs), or that a PI should deliberately build the culture of egalitarianism in her or his team?

If we consider groups of students within a same class working together, *a priori*, institutional roles and rights as "students" are equal. Asymmetry will subsist nevertheless in terms of task-related competence, in terms of the self and other-images that are projected (intersubjectivity), and in terms of dominance, exclusion, and other common characteristics of groups described by social psychology. How do such power/dominance relations relate to quality of collaboration? Could it involve a notion of equality of participation?

A relevant level or unit of analysis here is that of roles, institutionalised and/or interactively negotiated. The degrees of fluidity of exchange of roles between participants, and the flexibility of ways of playing out those roles themselves, are relevant to quality of collaboration (Rapanta, 2010; Shirouzu, 2010). We need to address complex interactions between institutionalised roles and emergent ones, and how such interactions lead to quality of 'dynamic' collaboration.

3 Corpus analysis

We believe that one of the reasons why the dimensions mentioned above (contextuality, power) have not been sufficiently addressed in research, is that much research on CSCW and co-design has in fact been carried out with students, in laboratory-designed situations. In this case, real-life socio-institutional constraints and stakes will not be involved (other than those where a graduate-student-participant wishes to play out that role well before others of the same status, as well as the experimenter-colleagues).

We propose a greater focus on the context of the interaction. This implies a methodological preference for studies in the work-field. Interactions among students can bring great insights regarding the process of task-oriented interaction, but we miss institutional and "real"[1] task contexts, which, as we already argued, are essential at the time of evaluating the quality of collaboration. Anthropologists like Hutchins (1995) have already clarified mechanisms of various *institutionalised* collaborations in the field of work, but in this case, little is known about how these institutions change their structure or practices to deal with emergent tasks.

A second implication-proposal for further investigation in the field is the organisation of research workshops oriented on specific datasets. This either means that each researcher brings each own data and works on them adopting other researcher's methods-suggestions, or that there is a shared dataset, prepared

1 "Real" here does not only mean not experimental, but also coming from the *wild* professional world in Hutchin's (1995) words.

for the needs of the workshop, but based on a professional field study (as it was done with the two Design Research workshops, i.e. the Delft protocol and the DTRS7 dataset). In this way, we believe that a constructive interaction of different focuses can emerge.

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Report on discussion group 3

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Carla van de Sande

The discussion was wide ranging and particular shaped by the participants shared interest in more loosely coupled forms of collaboration – such as are apparent in online discussion forums and within the new design of learning spaces for private study. The discussion evolved around the following issues: How to circumscribe situations as "collaborative" and then what the activity of collaboration is that needs to be assessed (for quality) and finally, what sorts of things we believed that such quality of collaboration depended upon.

Main points were as follows:

1) Quality can refer to experienced arising in a particular occasion of collaboration (an episode) or it can involve something that is cultivated through sustained engagement with a broader culture (of collaboration).
2) It is tempting to make an operationalisation of quality in terms of learning outcomes. This causes us to miss gains associated with collaborating that are not visible in the particular product that does get produced. Moreover, it may in particular cause us to miss gains that are associated with difficulties that are experienced in reaching an outcome but which serve to sharpen the thinking of participants in ways that may not be evident in a particular local product
3) Quality will include features that are inherently possible with some media for communication and lacking in others. For example the anonymity of discussion forums may empower the disabled and marginalised learner.
4) Quality depends upon the social structure that we are interested in. What needs to be measured might be events in a single episode (a collaboration) but

it might be cumulative events that take place when individuals are in learning cultures that are collaborative in general terms.

5) What you seek as "quality" depends on your goals as an educator. It depends on what particular cognitive, social, or affective experiences you are attempting to cultivate.
6) Measures of quality will be different according to whether it's the group that is the focus of concern or the individual participant. An episode can have collaborative quality for a group (as the unit of concern) but not for all the individuals participating.
7) Quality may need to be measured outside of the temporal and spatial limits on an episode. So, for instance, the structure of a collaboration may resource participants to continue thinking about a problem after the collaboration is over. But the design affords openings to do this (as in revisiting the records of what was done and said)
8) Quality may not always be picked up in our observations of spoken and written communication. High quality collaboration can often arise because of participants realising they DON'T need to communicate.
9) Why are we asking these questions. Because, to some extent, we might want to engineer experiences with "higher quality". What would be involved as levers to achieve this. Perhaps… Training, structuring an institutional ecology for group activity, particular mediating tools, scripts, rewards?

Mobile Collaboration Systems: challenges for design, work practice, infrastructure and business

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1 Introduction

Mobile devices are expected to soon become the "primary computer" and tool for sharing and connecting with others. In our thriving world of mobile communication, technological advances have brought a number of novel and improved ways of collaboration: in business, commerce, healthcare, education, and society in general. Collaboration can help to overcome the limitations of a single user, device, and network. However, creating mobile collaborative applications and systems requires careful consideration and design.

How does mobilization influence collaboration? This question was of paramount interest to the workshop participants who shared and discussed theories, understandings, experiences, and lessons learned in the field of mobile collaboration systems.

The workshop papers focus on different levels of mobile collaboration such as application, usage and technical level; social and interface aspects as well as conceptual frameworks were also presented and discussed. Presented application areas for mobile computing are: mobile building site and maintenance management using AR technology, urban areas as an arena for mobile learning, social software, resource reservation for optimized mobile performance, and mobile decision support systems. Enjoy reading the papers!

Supporting Mobile Maintenance in Construction Industry

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Abstract. This workshop paper presents a system to support mobile maintenance in construction industry. Using mobile augmented reality (AR) technology combined with a web-based collaboration system, the proposed system helps to improve the communication and collaboration processes. The cooperation between workers and remote experts will be supported. The paper describes also the results of a user study to evaluate the system.

2 Introduction

The construction industry is faced with a dilemma that until a building is in progress some problems are not foreseen and this has impact on the handover time to the customer. This invariably implies default and penalty clauses that affect the profitability and the return on investment for the builder.

As building realization necessarily uses local labour, plans and construction information is not always interpreted correctly in line with the design intent and the architect's vision. This leads to on site operative being faced with unforeseen problems that are potential job stoppers. In view of the above, it is envisaged that an improvement in the communication and collaboration processes is likely to have considerable impact on the success of the construction project which is measured in terms of project total cost, duration and quality. Furthermore, the

introduction of the collaboration technology may result in reengineering of the problem solving process, this leading to further increase in productivity.
For this reason we developed a mobile service application, which can be used by construction site workers or maintenance engineers to collaborate with remote experts to solve complex engineering tasks. Using mobile computing and augmented reality technology collaboration between mobile workers and experts at remote locations will be supported.
After giving a short overview of related work, the next section explains the scenario, the platform and the tasks of the user tests. The evaluation methodology and the results of this user test will be presented in section 4. The paper closes with a conclusion in section 5.

3 Related Work

There has been already some work for mobile augmented reality applications in industrial settings. Each one follows different approaches and is applied to several industrial sectors. The work presented in [7] introduces an approach for the aerospace sector. The focus of this paper is on usability engineering, ergonomic questions on the system and the user interface and their evaluation. The test scenario for the described prototype includes assembling tasks in production of airplanes. The system presented in this paper consists of a standard PC and a head-mounted display.
A more mobile approach is described in [6]. Two different prototypes are compared. The first prototype is a tablet PC and the second prototype is a laptop-based AR system with a video-see-through display. The paper discusses different evaluation methods. This prototype is applied to service and maintenance tasks for machines.
Koch et al. [4] present a mobile AR system for maintenance tasks in the automotive industry. Their system contains a mobile PC connected to a backend server. This server will be used to take over the computational tasks for the tracking.
In contrast to the related work presented in this section, the approach described in this paper offers new possibilities of accessing the entire building information model on-site using a remote server. It provides a tailor made solution for site supervisors and workers in the construction area to collaborate with partners and stakeholder.

4 User Collaboration and Interaction

The main purpose of the mobile AR system is to enable site workers or site supervisors to access the digital building information model which is stored on a remote repository. Using this information unforeseen problems, like a missing element or a wrongly installed component, can be detected by comparing the real and the virtual model.

Furthermore, additional information can be displayed by clicking on appropriate parts of a model. This way for site supervision important dates like last inspection date or responsible persons can be shown on the screen of the mobile device.

An integrated media streaming function guarantees a distributed collaboration between the site workers and remote colleagues.

A knowledge repository is essential for collaboration because it comprises all necessary data for a construction project from the different stakeholders. This facilitates the process of various construction steps due to the list of involved partners could be very long. Table 1 shows an example of the involved stakeholders for the scenario described in section V.

	Stakeholder	*Role*
1	Project Manager (PM)	Representing the Main Contractor and the client-based on site
2	Architect	Producing the architectural design and drawings
3	Structural Engineer (SE)	Producing the structural design and drawings
4	ME Engineer	Producing the Mechanical Engineering design and drawings
5	Plumbing Sub-Contractor (SME1 foreman)	Plumbing work-based in the office
6	SME1 operator	In-charge of installing plumbing work on site
7	HVAC sub-contractor (SME2 foreman)	Heating, ventilation and air conditioning work-based in the office
8	SME2 operator	In-charge of installing HVAC work on site
9	Quantity Surveyor	Cost estimates
10	Contractor Senior Manager (CSM)	PM reports to- based in the company
11	Commercial Director	Costing implication
12	Authorities	Examples: fire, environment, police, planning, etc.

Table 1 Involved Stakeholders for the described scenario in section V

Due to the limited storage of the mobile device, it is not possible to have the complete data of a construction project stored on one device. Therefore using an identification approach, the currently required data will be downloaded from the repository on demand. Without the downloaded data and model from the knowledge repository, there is no interaction and overlay. According to the detected ID, the appropriate data is loaded. With the downloaded 3D model, the virtual model will be displayed superimposed and the site worker is able to interaction with the scene.

5 System Overview

The overall system for mobile maintenance consists of three main components. The first component is the remote knowledge repository, where the required data is stored. The second component is responsible for identification and tracking tasks and the third components is the mobile AR system.

5.1 Knowledge repository

The Knowledge repository is based on the BSCW Shared Workspace system [2]. The BSCW ("Basic Support for Cooperative Work") is an extended web server, which provides basic facilities for (primarily asynchronous) collaborative information sharing, activity awareness and integration of external applications. The BSCW server provides a web-based access to documents, contacts, appointments and resources (s. 0). The digital building information model (BIM) is represented by the stored data on the server. Background information of resources, specifications, pictures, reports, good practice reports and other building related content are stored in a context-aware manner, which makes it easy to access the appropriate data and interaction possibilities for users in specific working situation.

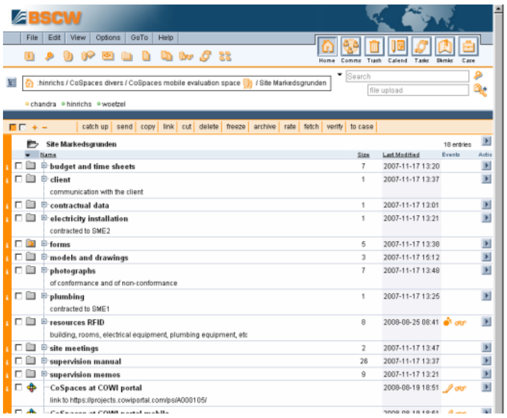

Figure 1 Screenshot of a digital building inforamtion model based on a BSCW system

Providing an interface to the mobile AR system using web services, the remote worker on site is able to having access to the complete data set. In case of unforeseen problems, he can get in touch with the responsible expert using the contact data of co-workers and experts stored in the system.

5.2 Positioning and Identification

The second component of the system is the positioning and identification component. This component is responsible for several tasks. On the one hand, identification techniques like RFID or fiducial markers [3] allow to determine specific parts of a building thus only the required data is selected and downloaded from the remote repository. On the other hand, the estimation of the current camera position and orientation (camera pose) of the AR system is important for augmentation issues. The camera pose is required to display a virtual overlay (s. 0).

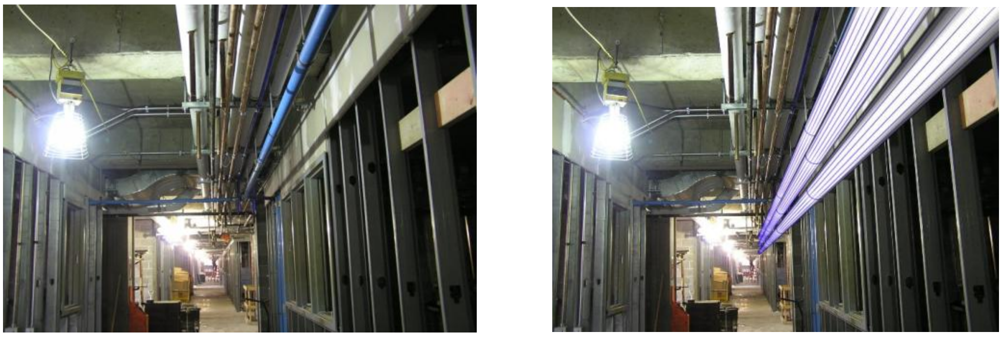

Figure 2 Augmentation of a real scene (left image) with a virtual overlay (right image). The appropriate placement of the virtual object was determined by the identification and positioning component.

There are several approaches for computer vision based pose estimation. Some of these approaches make use of further 3D knowledge of the environment. One kind of these approaches are marker-based tracking techniques.
Artificially designed fiducials, so called markers, are added to the scene. These markers, typically rectangular patterns with a black/white texture, need to be detected by basic image processing algorithms. The disadvantage of this method is, that the environment has to be prepared by attaching markers to e.g. walls or doors.
In contrast to fiducial-based approaches, image-based information can also be extracted by the mean of natural features detected in the image. These detected natural features can be combined with a priori 3D knowledge. The 3D knowledge can be obtained by CAD models of the scene object, a set of planar parts, or even a rough 3D model such as a cube. To this category belong also model-based techniques [8].
The third category considers natural features without any other 3D knowledge [1]. The estimation of the camera pose is based on camera images only, without any other knowledge of the environment.
Regarding the usage within the mobile maintenance system, the question of the most suitable positioning technique depends on the current working situation.

5.3 Mobile Augmented Reality System

The mobile AR system consists of a mobile device suitable for mobile AR applications on construction sites and the appropriate software functionalities.

As mobile device, an Ultra-Mobile PC (UMPC) is used. It is used with a so called "Magic Lens"-metaphor, which means that an AR application running on this device enables to enhance the reality by superimposing the live video image with virtual objects. In our case we use a Sony Vaio VGN-UX280 (0). The device is equipped with an in-built camera at the back which provides the live video for augmentation. The screen size is 4,5`` and the weight without any attached sensors is 0,6 kg.

Figure 3 The mobile device: A Sony Vaio VGN-UX280

The device provides several buttons which could be used for interaction. In our case only the left mouse button is used. It is represented by a button on the upper left of the device, thus it can be used conveniently with the left thumb. This UMPC is running Windows XP 32bit. It is equipped with 1GB RAM and an Intel Core Solo U1400 1.20GHz.

For the special purpose of detecting unforeseen problems, the superimposed virtual model of a building or parts of a building will be compared with the real situation.

The enabling software is the VR/AR framework MORGAN [5]. The 3D rendering capability is one of the major parts of MORGAN. Its own render engine has been particularly designed to meet the requirements of distributed multi-user VR and AR applications, providing native support for different file formats and scene graph structures. This is achieved by the MORGAN specific approach of using internal and external scene graphs. The underlying concept separates application or file format specific information from pure rendering information.

Following the concept of external scenegraphs, such a scenegraph supports the IFC file format. IFC – Industrial Foundation Classes – is the international standard for digital building information model (BIM). Supporting the IFC file format, the AR interface enables to visualize the digital building information model on-site.

All components such as the render scenegraph are integrated into MORGAN by a specific plug-in mechanism. Using this plug-in mechanism other components like a media handler can be included. This media handler for instance could be used for audio and video streaming for distributed and mobile collaboration. Figure 4 shows an example of a streamed video from remote site supervision.

Figure 4 A site supervisor streams a live video to a remote expert

6 Use Case and Evaluation

6.1 Scenario

The scenario corresponds to a realistic vision of the European industries concerning the innovative way technology could be used to improve future collaboration, based on workshops and interviews with construction companies. Within these workshops concrete work areas and working environments which are most suited for technological support by the Mobile AR application has been identified.

The resulting scenario considers the situation of a small or medium enterprise (SME) who is attempting to install piping services to a previously installed heating and ventilation air conditioning system. This system is being installed by a second SME. The problem created is that there is insufficient space and access to install the supply pipe as well previous holes access has been utilized.

The scenario is a derivative of a more generic case associated with the occurrence of “Unforeseen Events”, where there is a need for information and a decision from a variety of stakeholders to resolve the problem as early and efficiently as possible.

For this situation the main objective is to reach a resolution in the most efficient way and in the minimum of time, without excessive cost implications. This is to be achieved through better means of communication in an efficient collaborative setting.

6.2 User study

The approach used in the evaluation is the Living Lab approach. The user study was carried out two times. One study was conducted with experts at a construction company with people from the construction area and another one was staged at our research institutes with IT experts. For the participants (six in total) it was at most the second time they had contact with the mobile AR interface.

As user tests, a simulation of a real scenario was performed. The workflow of the mobile application scenario comprises several tasks, which have to be executed by the participants. To follow the described scenario in section A, the users were asked to conduct the following tasks:

- Login to knowledge repository and access the appropriate building information model workspace
- Start interacting with the scene. The user has to figure out that without the downloaded model from the repository, there is no interaction and overlay
- Select the necessary data by identification of room using an optical marker attached to the door. According to the ID, the appropriate model will be downloaded from the remote repository
- Compare the virtual 3D model superimposed on the real environment and figure out the difference
- Since the interaction is enabled, the user has to get some information by selecting a scene item.

6.3 Results

The evaluation method for the mobile maintenance system is subdivided into two parts.

The first part is a questionnaire which consists of two types of questions. The first set of questions is closed questions with semantic scales to test the usability of the user interface, the likeability and the system utility. The second set of questions was open questions to collect the participants' views on the process itself.

The second part is a verbal protocol. As participants vocalize thoughts, goals, feelings and talk about their actions whilst performing a task, this method was selected to validate the usability of the system and to also understand the users' reasoning when interacting with the system. The first part of the questions was about the overall system. It contains the impression of the entire framework. The results of user tests regarding the overall system are shown in table II.

	Question	*Mean*
1	I would like to use this system frequently	3
2	I found the system is unnecessarily complex	4,2

	Question	Mean
3	The system is easy to use	2,8
4	I need technical support to use this system	4,4
5	There is too much inconsistency in this system	3,6
6	The system is very uncomfortable to use	3,4
7	I needed to learn a lot of things before I could get going with this system	3,6
8	I found the system very awkward and uncomfortable to use	2,6
9	I felt very confident using the system	3,2
10	I enjoyed using the system	2,4

Table 2 Overall System

After a short introduction to the user test, the participants got a manual on how to use the system and what to do within this test. All participants succeeded the test and fulfilled the required tasks.

In some cases the setup of the system and the creation of the meeting have to be repeated due to technical problems. This could be one reason why some participants stated their opinion of the complexity and inconsistency of the system as very high.

The second part of the questions was about the mobile AR interface based on the MORGAN framework. The results of user tests regarding the mobile AR interface are shown in table III

	Question	Mean
1	Importing / converting of 3D files is simple	3,8
2	The layout and design of the GUI is appealing	4
3	The GUI needs to be revised further	3,2
4	It was difficult to navigate in the 3D scene	2,6
5	The quality of the model display was sufficient	3,4
6	The rendering quality needs to be improved	3
7	The response time on user interaction was short	3
8	The different layers (of each discipline, i.e. structural, electrical, plumbing) of the model were not clearly visible	3,4
9	The image quality was poor	2,4
10	The system facilitated decision making	2,8
11	The system can help to detect unforeseen problems	4
12	Using the system would not help companies to reduce cost	2,8
13	The device was easy to carry around	4
14	The device made interacting with the content easy	4
15	I found the interface confusing	2,2
16	I found the device confusing	2,4
17	Using the device was a natural way to interact with the real environment	3,8

Table 3 Mobile AR Interface

Regarding the overall impression of the mobile AR interface, the users didn't had problems using the device and interact with the scene.

Sometimes some irritation occurred when selecting an item. This could be explained by temporal inaccuracies of the tracking. For the test scenario, a marker based approach was used. For this approach it is very important that the marker is always visible and the light condition is sufficient.

The users agreed, that the layers according to each disciplines are not differentiated clearly. It is not visible which part of a building is actually selected, for instance plumbing or electricity.

The interaction with the device was no problem. The users described the way using the device to interact with the real environment as natural and intuitive.

7 Conclusion

To summarize the results of this final user test for a mobile maintenance system, the prototype was well accepted by the experts.

After analyzing the results we got a positive impression. But we have to mention that the evaluation was done by very supportive project partners with a positive attitude towards the project.

Besides the mostly positive feedback, the participants remarked also some critical points. First of all they commented the complexity of installation and preparation of the entire system. They recommend a more user-friendly approach.

Regarding the AR interface, they missed a clear distinction in visualization between the different disciplines. A more sophisticated and powerful user interface would even more support the site workers.

But generally speaking, all participants agreed, that the system facilitates maintenance work and supervision and it has a big potential to save time and money when employed in industry.

One participant has seen the mobile maintenance system as even more: "This will be the killer application!"

8 Acknowledgements

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Considering the Design of Mobile Applications for City-wide Learning

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Abstract. This paper outlines a number of open issues to be considered for the design of mobile, collaborative technologies for informal learning. The design reflections presented stem from a central concern to envision technological support for long-term visitors' experience of learning a city by living it.

1 Introduction

It seems that the whole world is on the move (Urry, 2007). On the one hand, complex, organizational factors – i.e. outsourcing, dislocation of production, movements of information and capital – have determined the emergence of different type of mobilities. On the other hand, being physically mobile has become a way of life adopted by various individuals and heterogeneous social groups (e.g. business people, commuters, but also sport stars, travellers, international students, asylum seekers, holidaymakers, etc.). It is against this social backdrop that understanding, learning, making sense of, and appropriating different locations and cities might become a central concern for the people involved. On a technological level, this opens up a space of opportunities for the role that mobile technologies could play to support the exploration of cities, and the possibility to share with others related stories and experiences.

This paper explores the potential of mobile and ubiquitous technologies to enable new-comers and long-term visitors – as opposite to tourists – to learn a city by living and dwelling in it. The city is here regarded as a network of places, whose granularity might change depending on individuals' experience and appropriation of it. Moreover, it is considered as the intertwinement of cultural, social historical and spatial aspects. Thus to learn a city entails to understand and internalize various issues related to the above-mentioned dimensions.

The mobile setting discussed in this paper concerns an informal, collaborative, learning context. Nevertheless, we believe the design of technologies for such settings draws attention to a number of issues (i.e. tension between the use of applications for private and work-related purposes, managing ensembles of technologies) that are also relevant to the latest wave of CSCW research (Pipek et al., 2007).

2 The Fabula Project

The work presented herein is being carried out within the FABULA Project (http://fabula.idi.ntnu.no/). FABULA aims at developing novel principles and technical solutions for a platform of services supporting city-wide collaborative learning. We envision a dynamic city that, with the support of wireless networks and portable technologies, becomes a learning place for its inhabitants, with services and applications that enable them to explore its social, cultural, historical and spatial dimensions. More specifically, we intend to investigate how new-comers and long-term visitors learn and make sense of a city by being there, by exploring its different places and actively participating in the life of its various communities. The research will, thus, seek to understand and explore the main concerns and needs of these heterogeneous cohorts of people, and to identify the most common practices whereby individuals seek to learn a new city. This analysis is instrumental to the design of mobile technologies and services enabling the type of mobile learning we are interested in.

Through the adoption of qualitative studies, we are now investigating: (a) the techniques and personal strategies people adopt in order to get to know a city, and feel part of a specific social context and community; (b) what technological artifacts and other type of resources support the experience of learning a city and becoming part of it (both on a social and cultural level); (c) what events can be regarded as learning moments, where do they occur, and who are the people involved in it; (d) what are the aspects of the learning activities and experience we want to design for, and what type of mobile technologies and applications better support it.

The learning situations considered are informal, thus neither specific learning activities nor pre-defined educational curricula are investigated within the project. This means that rather than supporting a range of pre-defined learning tasks, we seek to foster exploration and interactions that could lead to serendipitous and informal learning experiences. A main challenge inherent in this approach regards the definition of what constitutes learning. It becomes, in fact, problematic to identify a priori a set of learning moments, the people involved in them and the artefacts used. Moreover, it is difficult to predict where they will occur, and how they will unfold.

On a design level, this aspect underlies the decision to shift attention from the design of applications supporting specific tasks, towards a service-oriented architecture enabling the development and the adoption of applications for multiple, interleaved and dynamic learning experiences. Concerning this point, the exploration of possible design spaces raises a number of interesting challenges. On the one hand, designing new applications draws attention to issues of appropriation and integration of the technology under design into the constellation of artefacts people might already be using. On the other hand, re-designing and adapting applications already available (i.e. social media and Web 2.0) bring to the fore issues of overlapping functionalities, or of integration and communication between different devices and applications.

3 Issues for analysis

Within the city-wide context we have set out to explore, we are particularly interested in 'third places' for learning (Oldenburg, 1999) – i.e. places other than home, work or school, like, for instance a public square. Such places, enhanced by in situ resources and technologies, may provide augmented learning opportunities and interactions. They may support people's active participation in the life of a community, offer multiple opportunities for interaction, and serendipitous occasions for situated and informal, learning experience (Lave et al., 1991). However, before exploring the potential offered by such locales, we will seek to understand what constitutes learning within these locations. More specifically, what is actually learned through the informal, serendipitous situations afforded by these places? As Vavoula and Sharples (Vavoula et al., 2008) outline:

> "Mobile, informal learning can be both personal and elusive […] it is not possible to determine in advance where the learning may occur, nor how it progresses or what outcomes it produces. It may also be difficult to track the progress of learning if it occurs across multiple settings and technologies."(Ibidem, 297).

Furthermore, the focus on collaboration draws attention to aspects such as: (a) meaningful and persisting shared interactions in public space, (b) awareness of shared, learning experiences, (c) visibility of learning – that is how to make other people and their activities visible to others (Willis et al., 2010). Another issue we regard as central to our current investigation relates to *ephemeral interactions*. As people dwell in various places, different and changing configurations of individuals might be involved in their learning experiences at hand. While some interactions might come to an end as participants move to other locations, other ones might continue, or start anew.

3.1 Open questions

The following are a number of questions raising from the analytical issues introduced above.

What are the main issues involved in learning a city? What aspects of this informal learning could be enhanced by technological artefacts? How do people share their knowledge and experiences? How is it possible to create a sense of continuity between different groups of new-comers and visitors? What makes a shared experience meaningful for people (i.e. a common interest, a shared place, a community)? What trails of experience are relevant and how should they be supported? What type of knowledge and experience do people share with each other?

4 Issues for design

The recent proliferation of portable and broadband technologies (e.g. multifunctional phones, PDAs, pocket PCs, WLAN, Bluetooth, etc.) and related data services has contributed to a partial migration of work outside of traditional workplaces and working hours. The increasing interest in *nomadic work* (Brodie et al., 2001; Brown et al., 2003; Kakihara et al., 2002; Su et al., 2008; Wiberg, 2001) has revealed a shift of focus towards settings that do not assume stable working hours or working places, but still retain essential, collaborative aspects. The panel discussion (Pipek et al., 2007) at the 2007 European Conference on Computer Supported Cooperative Work (ECSCW) – tackling issues such as the usage of mobile devices, work-life balance and the blurry barriers between private and working hours or private and working usage of technologies – reflects the partial, ongoing migration of work outside traditional, well-defined workplaces that have traditionally been analyzed by CSCW research (Hughes et al., 1995). Research on mobility is also broadening analytical and design concerns from one technology–one user (or group of users) to ecologies of interactive artefacts, and to how to design for humans-computers interactions (Oulasvirta et al., 2008).

In past work (Rossitto, 2009; Rossitto et al., 2007), we have explored how the use of constellations of technologies is orchestrated in the context of university student engaged in group work. The research concentrated on the spatial, social, cultural and contextual factors that reflected on the situated use of mobile technologies. In so doing, particular attention was devoted to the interactions between individuals, the use of specific technological artefacts, activities involved and particular places at which they occur. A few issues stemming from the data analysis are introduced below, since they constitute a background to start thinking of the design of mobile technologies for non-professional settings.

The same technology can be used for different purposes within different groups. Within some of the groups studied, for instance, mobile phones were seldom used for communicative purposes. When participants were asked about this issue, they explained it was too expensive and that, because of this reason, they preferred to use instant messaging or email if they needed to talk to each other. Nevertheless, other groups strongly relied on it. Some of the workshop participants, for instance, considered communicating by mobile phone as more reliable, because one can almost be certain that messages, both verbal and textual, reach other people at once. This concern becomes particularly central as deadlines approach, or the closer one gets to a meeting.

Appropriating technologies. There seems to be a fundamental difference between student nomadic settings and professional nomadic workers, whose technological artifacts (e.g. smart phones, PDAs, etc.) are often provided by the companies they work for. This point bears important consequences for students' work practices, as an essential concern for the groups is to agree, implicitly or explicitly, on the technologies and tools to be used throughout the project. Different persons have different personal preferences with respect to the use of particular technologies, and they often seek to convince other peers to adopt the ones they are fond of. However, several episodes observed also illustrated that the same enthusiasm is not always shared by all of the group members, for a number of different reasons. Students, like other people, certainly have their own preferences and range of choices, so that they may choose certain technologies rather than others. Another possible reason is that the short life of a group hinders a comprehensive appropriation within the group's practices. To get acquainted with new technologies may, in fact, require efforts that are not necessarily worthwhile, especially if an application is going to be used only in the context of one course. The analysis also showed that the same student may use different technologies and applications within different groups, both with regard to past and present projects. One of the informants explained, for instance, that it would be hard to convince new project peers to use a micro-blogging application such as Jaiku. As it was explained, it is not enough to use a certain tool, but it is important to use it in the *"right way"*. Specifically to this case, "the right way": (i) is a way commonly acknowledged by all the group members; (ii) it encompasses both working and, like in this case, non-working practices; (iii) it concerns the student's experience of himself in relation to the social groups he belongs to. For all these reasons, it is not enough to update someone's own status every now and then, but it is also important that others can rely on the fact that this is done regularly.

Difficulties in keeping track of every tool. Another issue to be addressed here are the difficulties in keeping track of every tool. One of the consequences of using various tools to collaborate and communicate with each other often resulted in the fact that working files were scattered all over, and *this made it problematic to keep track of where resources were stored.* This issue is also related to the appropriation of a given technology within the individual and the group practices.

Supporting integration of information and applications. As also discussed elsewhere (Rossitto et al., 2010), a central design issue concerns the integration of existing technological artefacts in order to make different type of information – e.g. comments, notes, working documents, pictures, sketches, stories, etc. – shareable among different technologies and applications. Because of the ever-increasing number of new technologies, physical devices and applications continuously made available, the problems of managing multiple devices are unlikely to disappear.

4.1 Open questions

The following are a number of questions regarding design we would like to further discuss at the workshop.

How is it possible to integrate new technologies and devices into the existing constellation of the tools already adopted by people? How do we address issues related to overlapping functionalities available in different applications? How can we support discontinuity between technologies and places? How is it possible to support the changing configuration of people who might participate in different learning experiences, at a number of different locations? Is it possible to establish a correlation between a given service and a certain location? Should a system proactively provide such correlation? What actions should be delegated to the system and what has to be actively performed by the user?

Contextual Relevance. A starting point to answer the questions introduced above is to consider the design of mobile devices as tools to be used *here* and *now,* rather than *anywhere* at *anytime*. This brings into the picture, an understanding of contextual and situated aspects such as: (a) how to take advantage of the environments people inhabit temporarily; (b) how the physical resources available in there may support a particular experience; (c) how the people present there could provide unforeseen opportunities for collaboration; (d) how relevant digital resources supplied by technologies can be accessed and used.

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Separating Friends from Spitters

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Abstract. Undesired mail, such as commercials, is called spam in mail services. Spit is what spam is for mail services, unsolicited communications. The difference in spit and spam is that spam can be checked before the delivery to the recipient and spit can be reliably detected only after the call is made.
Voice over IP (VoIP) community has adopted a more peer-to-peer approach, in which the registrars and proxies are located on the participating nodes, rather than on separate servers. Industry has also been quite keen in the development of such approach, especially ones that use identifier-locator split protocols. The lack of centralized authorities and the usage of long trust paths make detecting spit even harder a task.
In this paper we describe a system to disseminate information of friendships that are based on an end-host based identifier-locator split protocol. In our solution the existing *buddy lists* are used to introduce one-hop connections in the system.
In our system we rather detect friends than spit or spitters. Moreover, our solution can be generalized for situations where the before-hand inspection of the content is impossible or otherwise hard to implement.

1 Introduction

Everyone knows how annoying it is to open a mailbox and see it littered with unsolicited mail. We have seen this problem grow in proportion over the years and now we see how it spreads across different mediums. Everything that draws in large crowds of users will eventually draw in hordes of spammers in a form or another.

VoIP is one of many new technologies that draw in users as well as spammers. Spam over Internet Telephony (SPIT), the equivalent to spam in VoIP, is more intrusive as a call effectively disrupts whatever the user was doing at the moment and the spam does not. Blacklisting is the most prominent way to fight against spam but it has its downsides and there is no sure way of knowing is the call SPIT before answering it.

In VoIP, Session Initiation Protocol (SIP) is the signalling protocol used to create the sessions between clients. In order to get a more scalable and less vulnerable SIP has Internet Engineering Task Force and networking industry been designing a pure peer-to-peer alternative that does not need any centralized servers, i.e. peer-to-peer SIP (P2PSIP). As the architecture moves away from the centralization, the research community has proposed the usage of trust paths in order to identify friends (Heikkilä 2009)

In our paper we argue that trust paths longer than one-hop are too long to retain trust. Moreover, we argue that hiding of the path structure from the search result, for privacy reasons, enables Sybil attacks without any fear of retaliation for the attackers.

Our solution is based on host based identifier-locator split with self-certifying cryptographic identities. These identities are used as the entities in the certificates that are used to communicate the one-hop paths between participants. Moreover, we show how this information can be used in the GUI to provide more information for the users to make better trust decisions.

It should be noted that the solution is also valid for other situations where the before-hand inspection of the content is impossible or inconvenient. First, the content such as live audio and video streams cannot be inspected before receiving it as it does not exist prior to the receival. Second, the inspection of a large file transfer can be impossible, difficult or even unwanted waste of resources as the file has to be transferred and stored on the inspecting host or middlebox.

Rest of this paper is structured as follows; In the Section 2 we describe the basics of P2PSIP, identifier-locator split protocols, and in more details a host-based approach, i.e. Host Identity Protocol (HIP). In the Section 3 we discuss about the usage of trust paths to identify friends amongst spitters. In Section 4 we describe the overall system including what is distributed and by what means. Also the flow of control is described in the system when a connection is made between participants unknown to each other. In Section 5 we evaluate the behaviour of the system, i.e. latencies of how long it takes to gather the one-hop trust path information, and how much space on the wire does the trust information take. Section 6 concludes the paper.

2 Background

SIP is a signalling protocol for conferencing, telephony, instant messaging and presence. SIP can create, modify and terminate two- or multi-party sessions. In SIP the user equipment (user agent, UA) is the network endpoint that creates or receives the calls. The actual architecture comprises of three elements: proxy servers, registrars, and redirect servers. Proxies handle the routing of SIP messages between UAs and they can implement access control. Registrars maintain the location information for the UAs, i.e. registrars translate SIP URIs into one or more IP addresses. Redirect servers can be used to redirect SIP session invitations to external domains.

For scalability and security reasons the SIP research community has introduced a peer-to-peer alternative for SIP called the P2PSIP (Jennings 2010). The infrastructure elements in SIP are defined as logical entities and are usually co-located on the same hardware. This distinction makes it easier to move the infrastructure elements to the UAs as P2PSIP does. The host Identity Protocol (HIP) (IETF RFC 4423, IETF RFC 5201, Gurtov 2008) has been proposed to be used for the connection maintenance and transport protocol for the P2PSIP because of its support for mobility, multihoming, NAT traversal, and security features (Keränen 2010). For VoIP applications NAT traversal is a major concern and by offloading it to HIP the connection management in VoIP applications becomes simpler. Moreover, by using HIP VoIP applications gain support for transparent mobility without any modification to the application.

It could be argued that why to use host identities in access controlling, as the modern operating systems are multi-user systems. First, in our opinion most of the machines, such as laptops, smart phones, etc. are more personal than ever and they even require additional authentication methods, such as PIN codes on smart phones, and account passwords on laptops, etc. Second, the usage of lower level identifiers to access control the connection avoids the need for deep packet inspection on higher layers. For example, using SIP URIs for access control would need inspection of SIP URIs in the SIP messages.

HIP introduces a new cryptographic namespace between the transport and the IP-layer. The namespace is based on public-key cryptography and consists of so-called Host Identities, which are RSA and DSA public keys. Using full-length public-keys in packet headers can produce too much overhead and would be incompatible with unmodified (legacy) applications. For this reason public-keys in HIP are also represented in a shorter 128-bit (IPv6-compatible) format, called the Host Identity Tag. HITs can be used directly with IPv6-enabled applications because of their size and format. Since HIP uses cryptographic keys as identifiers, host authentication and the establishment of a secure channel between HIP hosts is very simple. Moreover, HIP is designed to be extensible. A modular packet and parameter concept allows the addition of new functionality to HIP easily. In essence, the HIP Base EXchange (BEX) is a four-way handshake and key negotiation phase to create IPsec security associations between hosts HIP has an update procedure that is used to maintain the ongoing connection.

Digital certificates bind a piece of information to a public key by means of a digital signature, and thus, enable the holder of a private key to generate cryptographically verifiable statements. HIP has a container to transport X.509.v3 and SPKI certificates (Heer 2010). This container is an organizational parameter that can be grouped to transmit semantically grouped certificates in a systematic way.

HIP has support for the XML-RPC interface (Ahrenholz 2009). The XML-RPC interface provides basic features, such as *put*, *put-rm*, *rm* and *get* operations. Put operation inserts a key and a value to the storage and get retrieves the value, matching the key, from the storage. Remove operation is protected by a hash of a secret that is inserted with the value and revealed in plain text when removed. The XML-RPC uses also a time-to-live value in order to remove stale information from the storage.

HIP for Linux[1] implementation has an identity management GUI that filters all HIP based control traffic through it. Incoming connections are filtered upon receival of I1 control packets. Incoming connection prompts the user to make a decision on accepting or dropping the connection. The GUI is used also used to group known HIs in to groups and give them group based attributes. GUI can also be used to show dropped HIs.

3 Requirements for the trust paths

Web of trust (WOT) originates from the Pretty Good Privacy and is the starting point for most trust path related solutions. WOT is a decentralised trust model that represents the trust that the users have for each other. A path through the WOT from the initiator to the responder of the communication is presented as a token of trust to the responder. We argue that long trust paths are: complicated and do not represent real trust.

First, long trust paths increase complexity of the solutions and can have unforeseen problems. Heikkilä et al. allow long trust paths scheme in their Pathfinder (Heikkilä 2009) approach for protection against spit. Pathfinder uses one or more centralized servers as privacy protected search engines. The information that the pathfinder servers use is protected with a hash scheme. However, we argue that by protecting the privacy of the links the Pathfinder allows Sybil attacks.

A malicious user can set up a node that acts trustworthily among other nodes. While, acting nice, the node then links the real spitters to the WOT. Now, when

[1] http://www.infrahip.net/

the spitter tells the Pathfinder to search for a path from itself to the target, the path is found. What makes this effective is the fact that the malicious user connecting the spitters to the network does not have to fear of punishment as the path is hidden along the responsible node.

Second, long trust paths do not represent real trust. To be trustworthy, long trust paths require that every node on the path are honest and do not lie in their statements. The longer the path grows, the harder it becomes to trust every nodes decision on the path. In a country, such as Finland, it may be possible to connect the authors to the President with a reasonably short path. However, it does not say anything about the trust between the President and the authors in either way. In our opinion trust degrades quite fast, in the matter of few hops.

We propose based on the discussion above that one-hop trust paths are sufficient.

4 Our Solution

HIP BEX creates an IPsec tunnel between the participating hosts and the traffic is transported inside the tunnel between the hosts. Due to the nature of IPsec being a host-to-host connection, we access control the traffic coming from the tunnel by using the HITs from the packet headers. This way we bind the tunnel for certain usage, VoIP in our case.

In our prototype we used OpenLookup v2 as our credential storage system. Although, any storage that implements anonymous key-value storage service with the XML-RPC interface can be used, such as Bamboo DHT[1] or OpenLookup v1[2]. The replacement does not have to be a DHT but could be a centralized system or even less centralized system than DHT. But it should be noted that by using a centralized system it may become bottleneck for the system and in less centralized systems the revocation of the certificates may become overly complicated.

Upon an incoming connection from an unknown host the user is prompted with a dialogue, in which a question is asked, whether to accept or drop the new connection. If the connection is accepted, a certificate is created and uploaded into the storage system. This certificates semantic statement is that the subject has trusted the host enough to accept a connection from the host. Upon subsequent connections from the subject, the certificate's can be checked and the user is not bothered with the dialog.

The certificate contains the HITs of the participants as the issuer and subject. Moskowitz et al. (IETF RFC 5201) say that HIT collision maybe possible, while improbable. For this reason the certificates contain also the full HIs. The certificate contains also a short time frame in which the certificate is valid. This

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1 http://bamboo-dht.org/

2 http://code.google.com/appengine/

makes the revocation easier, as the issuer can just stop renewing and uploading the certificate. For the host the information contained in the certificate is enough but in the *new HIT* dialogue of HIPL the HITs are also presented to the user. Long HEX strings are hard for the user to recognize and for this reason we added an issuer given name into the certificate. Moreover, we believe that because the names are given by first-hop friends they most probably have a meaning for the receiver. As the certificates do not contain any location information they are also suitable for mobile clients as there is no need to update the certificates in the system upon mobility events.

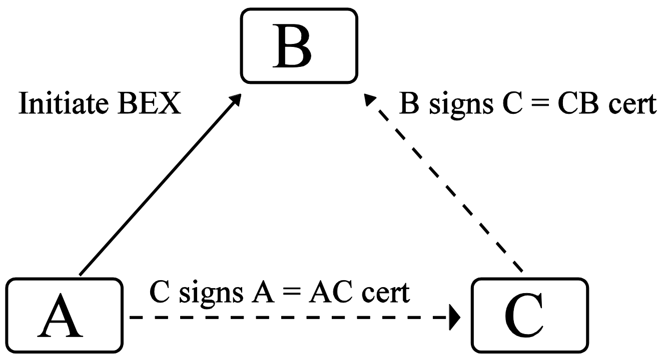

Figure 1 Forming of a trust relation ship between host A and host B by presenting the certificate given to host C to host A.

In our system malicious users can try to lie about their trust but the lying would be noticed easily and the lying friend could be punished. Moreover, the system could have an additional rating (e.g. a floating point value from 0 to 1, where 1 is complete trust) for the trust that could be increased or decreased based on the observed behaviour. In practice this rating could be enforced by increasing the puzzle sizes and/or by throttling the connection by limiting the bandwidth of host with low ratings and vice versa for hosts with high ratings. In the end, the meaning of the rating is left as a local policy, this way the hosts can make independent choices on the level of enforcement. In the worst case the host could deny all connections from the subject and remove its certificate from the system. By tying the used puzzle size in the BEX to the used trust rating, the responder could also choose the puzzle sizes for the initiators based on their ratings. The used computational cycles to solve the puzzle would constitute a payment for the service needed by the initiator of the connection.

During our implementation efforts we changed the triggering point for the access control of incoming HIP control packets. Previously the trigger point was in the receiving of I1 control packets and we moved the trigger point after the handling of I2 control packet. At this stage the user would not see prompts for all easily forged I1 control packets. Instead the responder will see the incoming connection prompt only after the initiator has solved the puzzle successfully. Moreover, the signature in the I2 control packet has proofed that the initiator actually owns the corresponding private key, from which the used HIT was created.

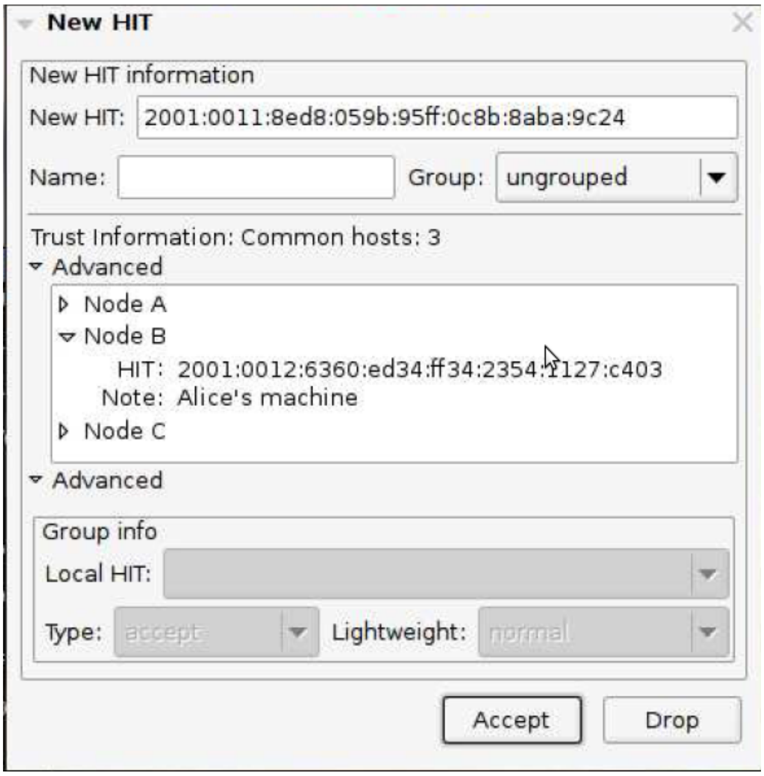

Figure 2 Dialogue presented upon an incoming connection with our modifications.

In the initialization phase, i.e. when the host starts the identity management GUI, the hosts upload the certificates to the used storage service. The upload can happen sequentially or in parallel but for our purposes uploading sequentially was adequate. In the example, host B has previously accepted a connection from the host C and uploaded the certificate to the storage system (CB cert in the Fig 1.). Moreover, host C has previously accepted a connection from host A and has uploaded the certificate to the storage system (AC cert in the Fig 1.) When the initiator starts the connection it queries all the possible concatenations of its own HIT used in I1 and I2 control packets as the destination HIT and its friends HITs and tries to find one or more suitable certificates to be presented to the responder in the BEX. The certificates are stored by using the hash of the concatenation of the issuer and subject HITs from the certificate as the key. This way we retain some privacy as the key cannot be directly guessed. If only the issuers HIT was used the malicious host could easily gather the friend list of a host. Using the hash of the concatenation of HITs the key is obfuscated so the malicious user has to guess what the HITs of the friends are and while the malicious user would guess one friend it would not reveal other friends of the host.

In our example, the host A finds two certificates: one given by host B for host C, and one given by host C for host A. Host A transports the certificate AC in the BEX to the host B. There is no need to transport the certificate CB as the host C is already in the friend list of host B and is trusted.

Upon receiving the I2 control packet host B verifies its signature and checks that the puzzle is solved correctly. If these checks were performed successfully the identity management GUI prompts the user asking to accept or drop the connection (see Fig. 2.). In this prompt, in addition to the used HITs, the user is presented with the user friendly name of host A given to it by host C.

5 Evaluation

We measured the mean latency of OpenLookup v2, using both IPv4 and IPv6, to determine the query performance of the system. We used a quad core Intel Xeon 5130 running at 2 GHz with 2 GB of main memory as the server and we used a laptop with Intel Core 2, 2 GHz CPU processor with 2 GB of main memory as the client. All machines involved in our measurements were located in our local Gigabit network with a mean round-trip latency of 0.88 ms (std.dev. 0.03 ms). We concentrated more on the query performance and not on the update performance, since the friendships seldom change and the frequency to refresh the credentials in the storage can be even a week. The measurements were done by querying random keys with values containing certificates of varying sizes.

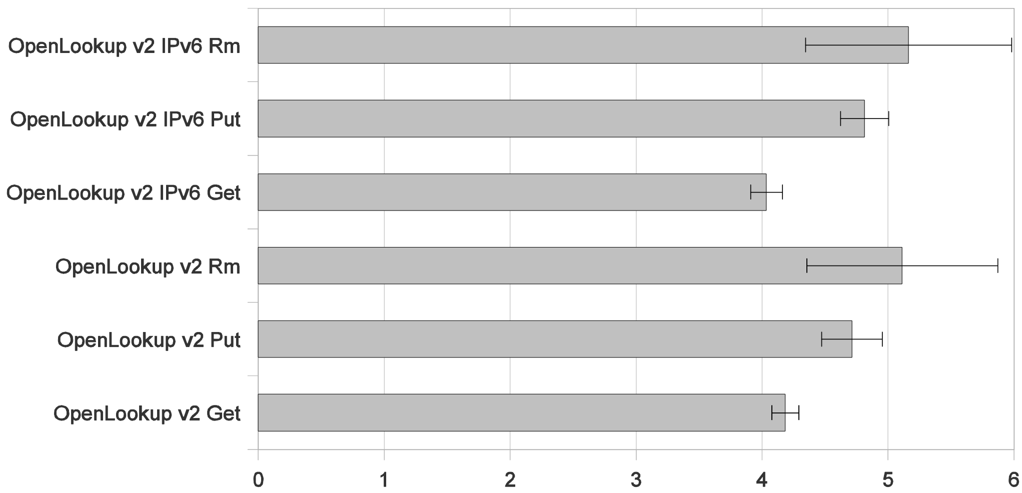

Figure 3 Average latencies measured from the storage systems in milliseconds.

From the results depicted in the Figure 3 it can be easily calculated that an initiator, with 100 friends, can sequentially query the system in maximum of circa 418 milliseconds. In the Internet the RTT times between the client and the server increase the latency. With RTT of, for example, 70 milliseconds between the client and the server will the total time be circa 7418 milliseconds. In our opinion even the longer latencies are acceptable because it bothers only the initiator of the connection. Moreover, the query performance can be optimized by querying in parallel and by caching the results locally on the client and thus avoiding subsequent queries of credentials.

In our experiments we noticed that certificates can pose a size problem for the control packets. If multiple suitable certificates are found, we could send multiple certificates in the control packets to the responder so that the information could be prompted to the user. However, the average size of a I2 control packet, using 1024 bit RSA keys, is circa 850 bytes and it occupies most of the minimum MTU of IPv6 (1024 bytes) and exceeds the minimum MTU of IPv4 (512 bytes). When we add one or more certificates to the I2 control packet will exceed even the IPv6 minimum MTU. This makes it very probable that the packets are fragmented on the wire. The solution for the size problem is left for further study.

6 Conclusions

In this paper we presented a discussion on how to separate friends from spitters, using SIP as an example. Based on our observations, the discussion identifies two problems in the proposed trust path solutions: a) trust path solutions that hide the path details from the users allows Sybil attacks, b) real life trust does not extend over multiple hops.

We addressed these problems by using the self-certifying cryptographic identities of Host Identity Protocols (HIP) to create one-hop trust paths to be used to access control the incoming calls. Our solution is in a sense a distributed white list based on host identifiers that identify the incoming connections from friends. We also provided measurements from live storage systems in order to estimate the time required to gather sufficient trust information and discussed about the size issue caused by the addition of certificates to the control packets.

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A Proposal for QoE in Cooperative Wireless Local Networks

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Abstract. Cooperative Wireless Networks (CWN) have become an attractive alternative for providing ubiquitous and inexpensive connectivity to mobile users. In a CWN, some hot-spot areas may experience the problem of sporadic congestions. The appearance of this localized congestion adversely impacts the network performance in terms of effective throughput, leading to a Quality of User Experience (QoE) degradation.

The challenge then is how to ensure the QoE for the access to services, in this unplanned type of networks.

This paper proposes a QoE for CWN with no centralized entities, which is based on the IEEE 802.11e amendment to the IEEE 802.11 Standard, and employs a game theory approach. The proposed scheme permits the distribution of the load between different Access Points. It also provides to the users a mechanism for the selection of the best Access Point in order to satisfy their requirements, and to guarantee the equilibrium in the network.

1 Introduction

A permanent connection is a desirable feature for any user. Besides of the advantages of being always available, a permanent connectivity allows users to have the information at their fingertips. Nowadays, the users want to use their WLAN mobile devices to become accessible and to obtain data of interest related to the location and the context where they are. The service should be available from just about anywhere, and at any time.

Under these circumstances, and to ensure a universal coverage, it would be necessary to install a large number of access points (APs) that would give full connectivity to a city. This is a very improbable solution, taking into account the installation, operation, and maintenance costs associated to an infrastructure of this magnitude.

The CWN appears as a solution to the problem of ubiquitous access to online services for citizens and visitors in a city. The CWN is a low-cost alternative that, at some extent, satisfies this high degree of connectivity requirement. An example of a CWN is depicted in Fig. 1. In this example, users have access to online services through APs that are participating in the CWN. There is no central entity to manage and coordinate the resources available in such scheme.

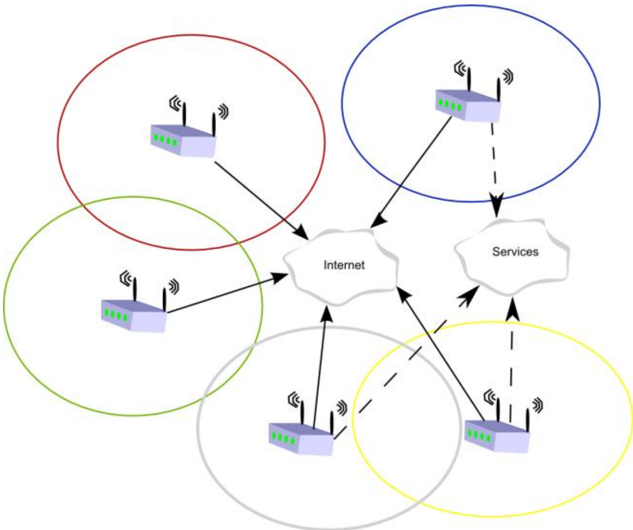

Fig. 1. Wireless Cooperative Network

Despite that the CWN are an attractive alternative to meet the current connectivity requirements, the lack of a planned growth of the network, and the use of a decentralized management, make the network components to be vulnerable to saturation. For example, if one access point is overloaded, then it is expected to look for a neighboring under-utilized AP for the balancing of traffic. However, this is a challenging task, because there are unexpected factors which may interfere with the load balancing and the AP selection mechanism. Some of these factors are: the new traffic patterns in the WLAN, the different types of user applications, the variable number of users in the network, the current load conditions at the AP, the handover latency, the unplanned growth process, and the mobility patterns of the user.

Another issue, if we consider a decentralized approach, is how to find an efficient and secure way to allow for the exchange of information about the network characteristics between APs in different domains.

Consequently, this paper focuses on how to improve and optimize the throughput of user applications, by means of the implementation of APs that comply with the 802.11e Standard (IEEE 802.11, 2005, in order to ensure QoS at the MAC layer. It is also proposed a dynamic resource management scheme for CWN in which the available resources are efficiently exploited to select the AP that offers the best service, based on the user requirements. This selection may occur during horizontal handovers or in those cases when the user requirements have changed during a connection.

To achieve the AP selection, it is necessary for the client to know the current traffic patterns, and for the AP to manage the existent user connections, especially when the resources are scarce.

The AP selection mechanism is based on an algorithm that combines the IEEE 802.11e Standard with game theory. The latter has been extensively used to model the behavior of the user in environments where they have to compete for scarce resources. As a result, the AP selection algorithm will increase the QoE.

The remainder of this paper is organized as follows: Section II gives an overview of the related work. Section III describes the scope of the problem. Section IV introduces the proposed scheme. Finally, we conclude this paper in Section IV.

2 Related Work

In this section, we provide a brief description of previous work dedicated to the enhancement of QoE in wireless networks. Ognenoski et al. (Ognenoski et al., 2009) propose an enhanced QoE in Wireless Heterogeneous Networks, by means of using the parameters of the MAC layer of the WIMAX Technology. Piamrat et al. (Piamrat et al., 2006) provide another example of a solution that employs a QoE-aware Admission Control. The admission control mechanism proposed in this solution is based on a Pseudo- Subjective Quality Assessment (PSQA) tool, which provides a statistic learning tool that uses a random neural network to learn about the level of QoE in the network. Then, the APs can use the information learned by the tool and communicate it to the other APs in an infrastructure-based mode.

A different approach called Effective Access Point selection is proposed in (Chen et al., 2006). Moreover, an AP selection strategy suitable for an office environment interconnected with a WLAN is presented by Du et al. (Du et al., 2008). This strategy uses a new field, called Information Element (IE), in the frames advertised by the APs. The IE allows balancing the stations (STAs) when they want to be associated with a particular AP. On the other hand, in Lee et al. (Lee et al., 2004) propose an AP selection method that uses a reserved field of the IEEE 802.11 frame. This field includes information about the number of connected stations and the amount of traffic currently processed by the AP. After the information is sent, the stations can decide which AP they prefer based on the information received.

Several authors have also considered the use of a game theory approach problem to tackle the problem of load balancing. Suri, Tóth and Zhou (Suri et al., 2004) applied an atomic congestion game for selfish load balancing in order to choose the server with minimum latency. According to Niyato and Hossain users (Niyato and Hossain, 2009), it is possible to use a game-theory approach for solving the problem of network selection in heterogeneous wireless access networks, and with different types of.

The scheme proposed in this paper differs from the aforementioned solutions in the fact that our users are part of a WCN, and thus each AP belongs to a different domain. In addition, those approaches do not consider the QoE requirements in an environment devoid of planning or structure.

Our study aims to cope with the QoE in a WCN. To achieve that, the problem is treated in three different fronts:

Firstly, we formulate the problem of finding the subset of preferred APs. The Qos facilities defined in the IEEE 802.11e Standard are employed to solve this problem.

In the second front, we formulate the AP selection problem using a game theory approach. To ensure a certain level of QoE means to carry out an optimal allocation of the network resources according to the current requirements of the user. Therefore, we aim to determine the user behavior and to define the best strategy to be applied for those users.

Finally, in the third front we formulate the QoS problem. Parameters such as: throughput, jitter, delay, probability of packet loss and the network round trip time (RTT) are the metrics used to ensure certain level of quality of the user experience. The traffic flows then will be transmitted according to the required priority.

Note that we do not consider any centralized entity in our proposed scheme.

3 Problem Statement

Define a Wireless Cooperative Network as a set V of N APs $\{n_1, \dots, n_N\}$ each of which provides access to different types of services such as Internet-based or context-based services. Every AP $n_i \in V$ provides coverage in a particular area for a set U of users, though not exclusively. As WCN are unplanned networks, a user can potentially associate to any of the APs $n_i \in V$ that offer redundant coverage in that site.

Fig. 2 shows an example of a CWN with five different domains. Suppose that User 1 moves in a city from a place of interest A to another place of interest B, in which a different set of APs, excluding AP1, offers connectivity.

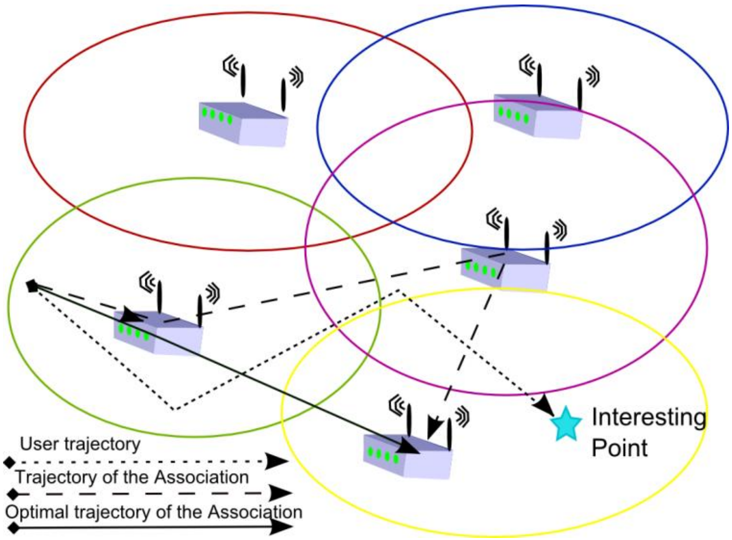

Fig. 2. WCN topology in the example

Due to the architectural conditions of the city, User 1 has to pass near to the AP1, but there are other APs that may also offer coverage to User 1. Nowadays, the mechanism used to choose an AP in the majority of the existent wireless clients is based on signal strength measurements. If that were the case in our example, User 1 will immediately try to associate to AP1. However, a decision based on signal strength does not always lead to an efficient approach, nor guarantees the end-user QoE.

Furthermore, User 1 may have strict requirements in terms of the treatment for its generated traffic, and AP1 may not be able to meet those requirements. It is also necessary to take into account that the performance of an AP decreases proportional to the number of associated users, and the amount of traffic it has to process. Consequently, it is desirable to make a careful selection of the AP, in a way that allows the user to experience the maximum performance and to ensure an efficient balancing of the traffic loads among the APs.

The objective of our proposed QoE scheme is then to guarantee, for a finite number of users $N \geq 1$, the best possible association with the APs. In turn, these users - competitors can share the bandwidth in the assigned AP according to their QoS requirements. To meet this need, we formulate the load balancing problem as a cooperative game among the APs and the users. With the application of game theory, we can model the dynamic behavior of users and can select the AP that meets the current requirements of the user, but without neglecting a network driven approach.

4 Proposed QoE Scheme

In this section, we describe the proposed mechanism for improving the QoE in CWN.

4.1 IEEE 802.11e Background

The proposed scheme is designed based on our analysis of the IEEE 802.11e Standard.

The IEEE 802.11e Standard provides enhancements in the MAC layer, in order to satisfy the QoS requirements of user applications.

Therefore, we use those QoS implementations are locate them in the QoS enhanced Access Points (QAP) and the QoS enhanced station (QSTA). The QoS enhanced Cooperative Wireless Local Area Networks (QCWN) uses some of the QoS facilities, as a supporting mechanism for the selection of the QAP that meets the user requirements as well as the load balancing between the APs.

In order to support the QoS requirements of user applications, IEEE 802.11e employs a mechanism called Enhanced Distributed Channel Access (EDCA). The mechanism is described as follows.

1) Enhanced Distributed Channel Access: According to the IEEE 802.11e Standard, entities in the network that are QoS enabled implement the Hybrid Coordination Function (HCF). The HCF can use both EDCA and HCF controlled channel access (HCCA) mechanisms. On the former, a contention based channel method, unlike HCCA, that uses a centralized control to guarantee contention-free transfer.
   The EDCA mechanism is based on the CSMA/CA scheme. It provides a differentiated access for each MAC Service Data Unit (MSDU) transmitted by the QSTAs, and uses the User Priority (UP) information. EDCA defines eight different UPs, those are support by four Access Categories (AC).
   Each of the AC permits to classify the services in: best-effort (AC BE), background (AC BK), video (AC VI) and voice traffic (AC VO). This classification ensures the prioritization of the traffic.
   Both EDCA and HCCA use a Transmission Opportunity (TXOP), as the interval of time in which a QSTA can transmit information. This value is acquired by the QSTA during a previous handshake with the QAP, and finally is reported to the QAP in the Parameter Set Information field, which is defined in the Beacon and Probe Response frames. On receiving this information, the AP can know the requirements about the priority function for the applications.
   An important consideration to ensure the QoS is the proper configuration of the different parameters defined in EDCA (Jun, 2009). This configuration may determine that a maximum performance could be reached.
2) QoS facility: When an STA is in the coverage area of an AP, it receives beacon frames1 from the AP, in which the information about the

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[1] Management frames defined in IEEE 802.11

operational capabilities available at the AP are included. Then, the STA compares those capabilities with its own requirements. If there is a match, the STA requests the establishment of the association with the chosen AP by means of the invocation of the association service.
The Beacon Frame sent by QAP also includes a QoS Basic Station Set (QBSS) Load Element. This is a 56-bit element that allows knowing the amount of associated users and the level of traffic at the QBSS. Since our system model corresponds to a CWN, the QBSS is the equivalent of a QAP in our scheme.
The QBSS Load element is defined by the following fields: Element ID, Length, Station Count, Channel Utilization and Available Admission Capacity. The Station Count Field represents the total number of STAs associated to the QAP, the Channel Utilization field represents the time percentage in which the QAP is busy, and the Available Admission Capacity field specifies the remaining amount of time that can be used by explicit admission control.
Using the information in the QBSS Load element, the QSTA selects a group of QAPs according to which offer the better features for the user. This group would correspond to the potential APs for the association. We do not use the default AP-selection mechanism defined in IEEE 802.11e, because it does not always lead to an association with the best AP (Simsek, 2006).
For the case of data frames, there is a Subtype field in which the most significant bit represents the QoS subfield. This subfield permits to identify if the data corresponds to a QoS data flow. When the data frame is a QoS data flow (QoS field=1), it means that the data frame also contains QoS Control fields in its MAC header. The control fields are listed as follows: Traffic Identifier (TID) (bits 0-3), End of Service Period (EOSP) (bit 4), ACK Policy (bits 5-6), the 7-bit is reserved. The values between the bits 8 to 15 vary depending of the frame subtype. The possible subtypes of the frame are: TXOP Limit, QAP PS Buffer State, TXOP Duration Requested, and Queue Size.
The TID control field differentiates the available services for each MAC Service Data Unit (MSDU). Based on the TID, the entity that implements the MAC layer at the STA determines the UPs for each MSDU1. Then, the MSDUs are grouped per AC or Traffic Stream (TS). In this way, the IEEE 802.11e controls the medium-access in a differentiated manner, based on the QoS requirements of each dataflow. The differentiation is achieved through the MSDU traffic class and the Traffic Specification (TSPEC) negotiation.
Additionally, by using the UP value included in the QoS control field, it

[1] This usage is when the Access Point subfield specifies a Contention-based channel access (EDCA).

is possible to know in advance the type of traffic that the user is handling. When this value is configured, it is later used in the TID subfield to facilitate the management of QoS in the network. In this way, the QAP knows the type of user traffic by reading the TID subfield (a numerical value between 0 and 7) in the QoS Control field. In the event that there is no value assigned in TID, the AP may infer the type of user traffic by reading the UP subfield of the TS Info field in the associated TSPEC.

After the APs are grouped, the game theory algorithm can be used to decide which AP of the set of preferred APs is the best choice in our WCN scenario.

4.2 Game Theory approach

Consider a decentralized system with a set U of N users. Each user must select one AP out of P APs in a set V. Each element in U is connected to an element in V, thus forming a bipartite graph $G, G = (U; V; E)$. Fig. 3 illustrates the relation between the elements.

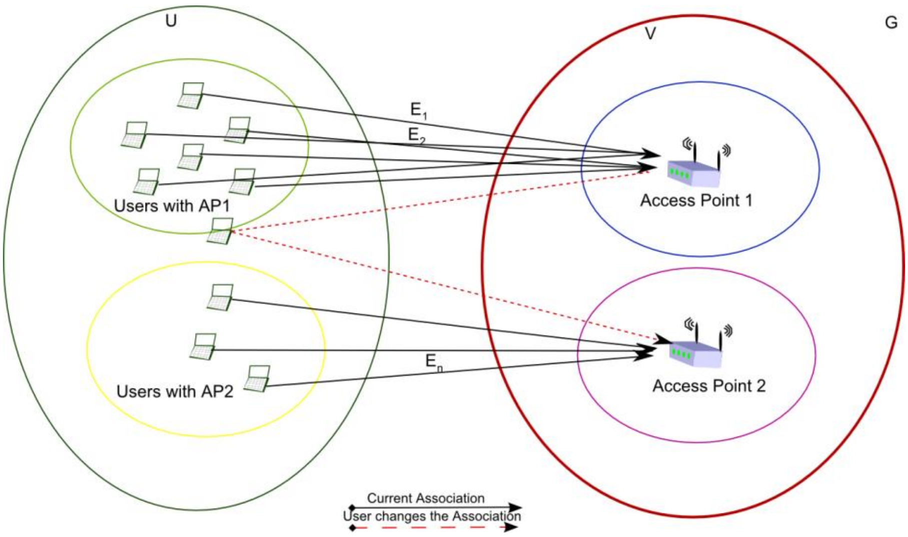

Fig. 3. Bigraph represents the example

The set V represents the group of APs that offers the best features for some users of in set U. At time t, a certain number of users in U associate with a specific AP, AP1. This association is denoted by n (t)i, where $1 \leq i \leq P$. Therefore, $\sum_{i=1}^{P} n(t)_i = N$. Since scenario is dynamic, the relation $n(t)_i$, may change continuously over time.

In this game each QSTA has a set of E strategies; those correspond to the association of the AP. The decisions made towards the association of users to each of the QAP in the QCWN, affect the total load in the other APs. Therefore, it is extremely important to find a balance. The aforementioned game theory model is used to describe this type of scenario. The reason for using a game theory approach is because the set of users in the CWN have a selfish behavior. Every user wants to select the AP that offers the less workload, the highest performance, and the best coverage.

One of the challenges of our scheme is the selection of the best AP during an inter-domain handover, i.e., when a user leaves the area of coverage of an AP and switches its connection to a different AP. During the handover process, it is necessary to evaluate what AP has the best features of connection according with the user/applications requirements. Thus, we require an online mechanism that can respond to the dynamic environment of the CWN.

At the beginning each QSTA should estimate his current game state. The balance or strategic equilibrium (also called Nash Equilibrium) consists on every QSTA chooses his individual optimal strategy during the AP scanning process. In this way, the QSTA could identify the network that provides it the best service or price in this context before joining it.

To find the Nash equilibrium, it is necessary that the players have information about of other players (referred to as a population), one alternative to avoid the lack of information, is to permit the interplayer communication, that means, the player periodically carry his optimal strategy and deliver it to the other players. In this way, the other QSTAs from there calculate the best strategy, this leads to the QSTAs gradually learn and calculate the game again, therefore, adjust their equilibrium strategies to get the maximum QoE. It should be noted that each QSTA estimates his game and the correspond equilibrium strategy, based on information received through the beacon frames and the partial information receive from other QSTAs (distributed approach). Additionally be too considered, that these QSTAs not have full knowledge of the game, due to the dynamic represented by the CWN.

Another important factor in a CWN is the social cost. The idea behind this social cost is the optimization in the use of the common resources, if every STA chooses his Nash equilibrium strategy, no player would benefit by changing its own strategy. That way, it is possible to have a network socially efficient. This of course is not a user target, but it is a requisite to have a CWN that is socially viable for these greedy users.

Going back to the game theory model, every time that a user in U wants to establish an association with an AP in V, it has to pay a cost for it. The cost of this relation is associated with the user requirements that have to be satisfied and the current load of the AP (e.g., an AP that has a high workload would have a higher cost of association for a user that wants to associate with it). The cost has relation with the income level that each AP has, in order to maximize their net income.

As a consequence, it is important to find the different strategies that the users may use to obtain their connectivity at a lower price. The strategy (E) would be based on the information received through the beacon/probe frames by each AP, and the signal strength measurement. Similarly, each user strategy also depends on the other user's strategies. For this reason, it is of high importance that type of information that a QSTA can carry in order to balance the network.

4.3 Access-Selection Resolution

The AP selection problem consists of a series of decisions that have to be made in a repetitive manner. The decisions are influenced by the location and the bandwidth requirements of the mobile users. The system dynamics involves multiple players: APs and mobile WLAN users. The mobile WLAN users have a random behavior in this kind of scenarios (Bachalandran, 2002). To satisfy this constraint, we use a greedy algorithm that intends to assess if the AP selected is indeed the best element in the set of APs. Otherwise, the STA is disassociated from the AP and the evaluation is performed again with the next AP.

5 Conclusion and Future Work

We have proposed a way to exploit the IEEE 802.11e amendment to the IEEE 802.11 Standard to provide a fair and balancing access to the user in a Wireless Community Network. Through the management frames can be selected the AP that has the optimal condition to avoid the congestion, and with a right strategy the user can select the best AP agree with his/her requirements to avoid the performance degradation in the user applications. This proposal for QoE is full compatible with the IEEE 802.11e Standard.

The described work is in progress, and has as goal deployed through simulation the proposal mechanism, in order evaluate the performance In the future, we want to extend this proposal to a secure scheme of QoE in WCN.

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A Mobile Collaborative Decision Support Architecture

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Abstract Advances in the mobile communication technology has increased the possibility of linking interdependent or individual decision making units together in an organization, and providing them with tools to facilitate decision support and problem solving. This paper explores how we align a mobile system with collaborative decision support as a critical enhancement. The designer of mobile collaborative decision support architecture (MoCoDSA) should consider making the communication patterns and protocols in different ways, thus creating realistic system architecture for decision support and problem solving within the resource constraints. The effectiveness of a MoCoDSA system depends upon a number of factors such as the task characteristics, the decision maker characteristics, the nature of the system, and application environment. This study explores to develop a design framework of a general collaborative decision support system in a mobile environment.

Keywords Collaborative decision making, system architecture, task characteristics, mobile system

1 Introduction

As mobile system technologies advance and the market becomes mature, users also find that a mobile system becomes an integral part of their professional life. However, contributions on developing their applications suitable and effective for decision support, especially involving multiple participants, have relatively been sparse (Danninger, et al., 2007). We need to consider a general system modeling in order to have a balanced and holistic perspective on application design, decision support and problem solving process and should also focus on its effectiveness as well as assessment.

We plan to develop a theoretical framework as a basis of a future mobile decision support system. In doing so, the study explores the following questions: can we build a foundation of effective mobile decision support system architecture? How do we create an adaptive architecture in a constantly changing technology environment? How do we relate the effective decision support proposition with operational efficiency?

A mobile collaborative decision support system encompasses a domain application structure and context, information technology infrastructure, and task and group/organizational considerations in achieving the decision makers' goals and strategies (Chung, 2005). It should be made clear that building an advanced system that focuses on the communication aspect--typically text, audio, or video—does not address the essence of collaborative decision support. At the same time, designing a system that would serve all aspects of such a comprehensive need is neither feasible nor realistic.

In this paper, we focus on building a mobile collaborative decision support system model that can play a critical role of translating decision support and problem solving strategies into an architectural arrangement. More specifically, we discuss several issues. First, we explore the mobile system architecture from a task, application domain, and group collaboration perspective. Second, we emphasize the design consideration and implementation issues from a resource management perspective. Third, by delineating the characteristics of the design alternatives, the study examines the parameters that determine the appropriate choice for a specific implementation.

2 Collaborative Decision Support

Organizational decision support typically requires communication and coordination among multiple organizational units involved in a problem solving task. Based on the task characteristics, Hackathorn and Keen (1981) have identified three types of support needed for problem solving and decision making in an organization: personal support, group support, and organizational support. Personal support is necessary for tasks that are independent. A single decision maker independently conducts a task in interaction with a counterpart, either a mobile device or another person. For this, typical communication components and standalone decision support tools might serve the purpose well. Most individual decision support applications using a cellular system are typical examples of such personal support. Group support is required for a task in which a group of decision makers jointly learn or solve problems. Group technology provides support to this kind of tasks. The conference call capability of a cellular phone is an example of a communication component. A multi-person game is another example. A task comprising multiple interdependent subtasks and involving several decision support units in a specific sequence requires group or organization-wide support in a collaborative setting. Deiglmayr and Spada (2010) focused on collaborative inferences in group problem solving. Based on information sharing in a distributed environment, they examined whether such collaborative inferences could generate new information beyond individual inference of each participant. Braun and Graether (2007) designed a portal for mobile devices that includes a social interaction function.

Therefore, it is necessary to consider the tools to support decision support and problem solving as well as the tools for communication and coordination among these separate but interdependent units. A typical mobile system does not address such collaborative decision support and problem solving requirement yet.

3 A Mobile Collaborative Decision Support Architecture (MoCoDSA)

In a collaborative application environment, a mobile system model that focuses on decision support and problem solving involving multiple participants is termed as mobile collaborative decision support architecture (MoCoDSA). In this paper, the term MoCoDSA is used to denote a mobile system that supports decision making, problem solving, communication, collaboration, and coordination among a network of decision support and problem solving nodes in a group or an organization.

Each node in the network is a decision support unit that may comprise a single person using a task/person specific device independently or a group of decision makers using a group technology offered by a mobile unit. In the latter case, each node is responsible for some part of a larger and more complex decision support and problem solving. These tasks can be characterized by having the following attributes: they are complex and require diverse skills and knowledge for decision support and problem solving. They can be broken down into a number of subtasks each of which can be solved by one or a group of participants. Their subtasks are interrelated. The outcome or process in one subtask may become input to other subtasks, and, thus, may constrain the next process or outcome generated in these dependent subtasks. There may be an orderly relationship among the subtasks although they are not necessarily aligned to a hierarchy. Some of the subtasks may involve synthesis and refinement of decision support passed on by prior subtasks. The decision support and problem solving process for such tasks may span more than one level in the task hierarchy and/or more than one application area. Examples of tasks that satisfy these criteria are emergency response training or an integrated product design.

In the MoCoDSA, it is necessary to facilitate horizontal integration (cross-functional) and vertical integration (different levels of the organizational hierarchy) of a mobile system used by various participants to support collaborative decision support and problem solving. Thus, the design consideration of a mobile system needs to address these issues.

The topology of such a MoCoDSA is a "graph" in which the "nodes" represent the decision support and participating units and the "arcs" represent the communication channels connecting these units. A MoCoDSA can be viewed as a graph comprised of a set of nodes and a set of arcs that connect the nodes. In the MoCoDSA, each node is supported by three components: (1) decision support and problem solving support and information services, 2) a set of decision support and problem solving tools in each unit and 3) a communicator which handles communication with other nodes. See Figure 1.

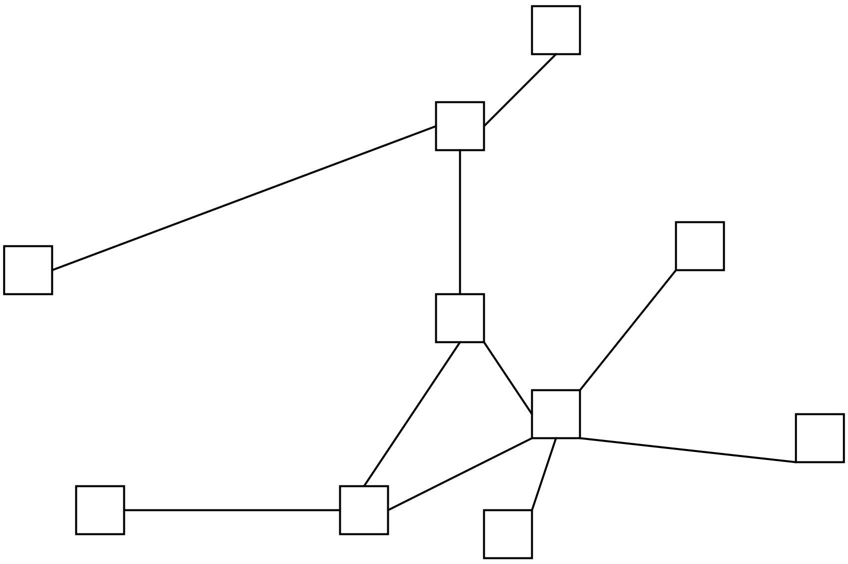

Figure 1 A Graph

Mathematically, a graph G is a set of vertex (nodes) v connected by edges (links) e. Thus $G= (v, e)$ (Rodrigue, et al., 2006). A node v is a terminal point or an intersection point of a graph. It is the abstraction of a location such as a user, decision-maker, or a computing device. An edge e is a link between two nodes.

The link (i, j) is of initial extremity i and of terminal extremity j. A link is the abstraction of a transport infrastructure supporting movements between nodes. It has a direction that is commonly represented as an arrow. When an arrow is not used, it is assumed the link is bi-directional.

A collaborative system as a network enables flow of communications, information, or decisions which are occurring along its links. The graph theory thus offers the possibility of representing collaboration as linkages. For example, a set of two nodes as every node is linked to the other.

4 Design Considerations of a MoCoDSA

Silver (1990) provides a relevant discussion for understanding differences in problem solving and decision support resulting from the designer's attitudes toward change. He uses two attributes, "system restrictiveness" and "decisional guidance," to distinguish different strategies for support system design. These attributes are extended to address the communication and coordination mechanisms used in a MoCoDSA. As the problems faced by an organization become increasingly complex, the organization tends to exhibit division of labor and a greater specialization of roles (Bonczek, et al., 1979). As a result, organizations incorporate a structure of communication and authority to enable them to perform efficiently in the environment. The structure of an organization is supposed to determine, or at least ease, the problem of task decomposition. The structure of roles in an organization serves as a guide to determine who is knowledgeable to address which part of problem solving. Rathwell and Burns (1985) envisioned the distributed decision making as a loosely coupled dynamic network of nodes without any central controlling node. In such cases, decision support and problem solving process consists of well defined, formal procedures that regulate the interaction among the nodes of a MoCoDSA. With this type of a MoCoDSA, the process is institutionalized and aligned with the architecture of an organization, i.e., it follows the problem solving and organizational control structure (Linthicum, 1999).

Detienne (2006) describes the specific characteristics of cooperative work interdependencies related to the nature of a design problem and the fundamental function of design cooperative work arrangement. The study exemplifies these two characteristics of the design work stress specific cooperative processes: coordination processes in order to manage task interdependencies, establishment of common ground and negotiation mechanisms in order to manage the integration of multiple perspectives.

In the base level of MoCoDSA, only communication support, such as electronic mail, instant messaging, or voice communication, is provided. A cell phone system is an example. In this case, MoCoDSA functions are simply to provide the communication channels among the nodes. In this sense, a communication medium by itself is passive and does not provide much structuring or support to the process. However, decision support and problem solving based on process structuring favors an active, yet constraining, involvement in the process. The decision support nodes supported by a comprehensive MoCoDSA implementation have latitude to select among different decision support and problem solving support tools. Thus, a MoCoDSA can be designed to provide guidance to the process. Guidance constitutes an active, yet flexible, involvement in the process.

We view the design of MoCoDSA is primarily contingent upon a number of factors including the technology constraints, infrastructure management, and task/application characteristics, among others. See Figure 2.

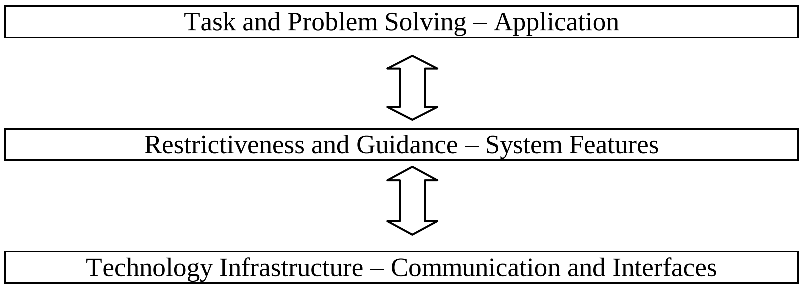

Figure 2. An Architectural Sketch

The appropriate design alternative for a particular MoCoDSA will be situation specific. In fact, designing a particular system involves three interrelated criteria: (1) the trade-off between efficiency and effectiveness, (2) the boundary of decision support and problem solving, and (3) the degree of alignment of the decision support and problem solving process with the architecture (Chung, et al, 1993, 2005, 2009).

5 Toward Operationalization and Evaluation

A real MoCoDSA falls somewhere in between the extremes of these criteria. An appropriate design alternative for a specific MoCoDSA depends upon a number of factors such as the task characteristics, the decision maker characteristics, the system capacity, and the environmental factors. These factors, to a great extent, determine the goodness of fit of a sophisticated a comprehensive mobile system. At the operational level, planning, designing, operating, and controlling such a sophisticated collaboration system to ensure achieving the intended goals of mobile decision support task is difficult to manage. It is because they are often challenged and defeated by the immediacy of decision support and problem solving caused by the factors often outside the control of decision makers. Decentralization of network services, diverse architectural arrangement, internal application demand, and mobility make coherent and coordinated infrastructure management more difficult. Moreover, a multi vendor environment as well as the rapidly advancing technologies further complicate the problem.

Spada, et al. (2005) study exemplify assessing collaborative process by defining characteristic dimension of collaboration. Burkhadrt, et al. (2009) measure and compare the quality of collaboration in a technology-mediated design domain. Their dimensions of communication process include grounding, coordination processes, task-related processes, symmetry of individual contributions and motivational processes.

6 Conclusion

Advances in the mobile communication technology have increased the possibility of linking interdependent decision support and problem solving units together in an organization, and providing them with communication, decision support and problem solving tools to facilitate the decision support process. This model is termed a MoCoDSA. The designer of a MoCoDSA has the choice of making the communication patterns and protocols in different ways, thus creating a realistic MoCoDSA for practical decision support. The kind of a MoCoDSA that will be effective in a particular setting depends upon a number of factors such as the task characteristics, the decision maker characteristics, and the nature of the system and application environment. The success of a MoCoDSA is also dependent on the designer's sensitivity to the nature of the interdependent tasks, feedback, synthesis and refinement of multiple subtasks and their processes, decision support and problem solving tools, and communication capabilities, among others. In this paper we tried to elaborate on the concept of the MoCoDSA, and described some alternative design choices.

The next research steps will further identify and examine various MoCoDSA design features, and experimentally investigate the effectiveness of alternative MoCoDSA designs in different settings. Future research efforts will be directed towards the development of a MoCoDSA prototype and empirically verify the validity of the framework proposed.

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The Mediation Role of Shared Representations in Cooperative Activities: A Workshop Report

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Abstract. The notion of boundary objects has been a significant topic within the field of Computer-Supported Cooperative Work for some time. The idea that certain shared objects, artefacts, or representations may mediate between or serve the purposes of different communities of practice has been a powerful notion and has been useful in understanding discovered phenomena in field and case studies and in designing technologies and applications. *Boundary objects* has travelled far and wide as a concept. However, its success in its mobility has also been its problem – inexactitude. Boundary objects may be digital, textual or material, they may be static or dynamic, they may be shared amongst local or distal practitioners, they may be used by distinct groups or simply collaborators with different perspectives or access to information, and they may be used for distinct activities or be part of a workflow. Their range is large. Other concepts like mediating or intermediary objects also occupy this territory. In light of this background a workshop was held at Coop 2010 in order to examine the territory covered by these concepts and to see whether we could loosely classify such research under different dimensions or whether it was important to refine or discard these concepts. The workshop

had empirical, theoretical and technology contributions and was productive in mapping out the territory and finding ways to compare and contrast a diverse range of work within this domain.

1 Introduction

In a globalized world, where cooperation happens more and more across boundaries, the need for mediation in cooperative work is growing. In focusing on mediation we are highlighting the fact that cooperative work takes place in contexts where the different collaborators have different access to context and resources, different perspectives, different knowledge and skills and often different priorities. In carrying out an activity, aligning elements of a workflow or providing a customer service, often there is considerable human effort involved to reach a shared orientation and understanding. The question that this raises is that of whether alignment between participants and support for the shared activity can be facilitated by digital, material or textual artefacts? In the field of Computer Supported Cooperative Work (CSCW) there has been a tradition of research that speaks to this topic – that around boundary objects. This term was coined in the writings of Star and Greismer (cf. Star and Greimer, 1989; Star 1989). They originally described a museum classification scheme as a boundary object in that it was used successfully by different groups to carry out their work and to communicate around even though they had quite different perspectives and priorities. Since then it has proved a fruitful concept in CSCW and related disciplines in terms of empirical research and design work (e.g. Bowker and Star 1999; Lee 2005; Lutters et al., 2007; Phelps and Reddy 2009; Trompette and Vinck, 2009). Other work in CSCW and related disciplines has discussed similar types of digital objects or representations in terms of the *mediation* they can provide in assisting organisations and customers in achieving service encounters (Castellani et al., 2009; this issue) and for cooperating (but often not collocated) designers and engineers in managing and developing *intermediary* (design) *objects* (Boujut and Blanco, 2003). In relation to this rich and somewhat diverse background we believe that there is an opportunity as well as a challenge to think about the design of (inter)mediation support or of boundary objects, particularly as objects instantiated in CSCW systems. It seems a propitious moment to reflect on the topic of study and consider the landscape of studies and systems that broadly fall under this topic – are there useful ways in which we can map out this landscape in terms of dimensions? Should we draw distinctions between types of boundary objects or boundary objects and mediating and intermediating objects? Our personal interest was very much about digital objects or representations that had active components and functions that facilitated better sharing of orientations, assistance, translation, clarification, explanations and so forth and as such we wondered whether this made these systems distinct from a more general idea of boundary objects. The workshop was the perfect opportunity to explore these ideas with a wide range of practitioners however our theme necessarily spoke more directly to our interests than boundary objects in the widest sense.

2 Workshop Theme

In many cooperative activities related to problem framing or solving, shared representations of the object of the work are manipulated by the participants. Status and history information is often central to the activities. Examples of such cooperative activities include remote troubleshooting, collaborative product design or diagnostics in healthcare. In a remote device troubleshooting context, the participants may for instance collaborate using a virtual 3D shared representation of the broken device. In a collaborative product design environment, designers can interact through CAD models of the product during distant design meetings. Many other examples can be found in every domain where an activity can be carried out remotely and collectively.

Shared representations not only represent the problem to be solved but they also constitute the medium for building the solution through cooperation among actors that may have different points of view and may be separated across location, time, organisation and expertise. Thus the design of the shared representations strongly affects the way in which the cooperation will take place. A good design of a cooperative system should therefore carefully consider the mediation role of shared representations in supporting the interaction among users. We believe that this dimension is often neglected or underestimated in system design. The design of a cooperative system centred on cooperative interactions through objects goes beyond a usual HCI design where the designers only consider the interactions between the system and the user. Here the user/system interaction is considered as part of a wider activity where HCI is only one element among others and therefore the interactions between remote users must be primarily considered and therefore the form, the status, and the role of the medium should be carefully studied. We think the CSCW community is the relevant community to discuss these points.

This workshop was aimed at contributing to characterize the dimensions related to mediation that should be considered when designing new cooperative systems involving representations of shared objects. One example of a dimension related to mediation could be the degree of guidance offered through the shared representation to the users to perform a task.

We were therefore interested in gathering a wide number of points of view and interdisciplinary approaches related to the study of mediation needs or roles in cooperative systems.

Consequently our guidance on topics was for the following:

- Discussions and theoretical speculations on the concepts of shared representation, boundary objects, intermediary objects, etc.
- Ethnographic work on team interactions through objects
- Case studies or applications of new forms of representations for interacting (3D, annotations, voice, etc.)
- Case studies or applications of new media for interacting (touch tables/screens, haptic devices, etc.)
- Cognitive studies on the role of objects as shared representations

3 Workshop Course and Results

The workshop attracted around 20 researchers from across Europe coming from diverse domains such as Computer Supported Cooperative Work, Design Studies, Human-Computer Interaction, Computer Science, Cognitive Ergonomics and so forth. We had a broad range of contributions; from ethnographic studies to theoretical perspectives, and from assessments of mediating or boundary objects to novel systems and design inspirations within this field. There was a lot of interesting work and perspectives.

It was interesting to revisit the field of air traffic control (ATC) and to get a novel perspective that particularly looked at how personnel in different locations with different jobs within an airport tightly coordinated their separate tasks through a series of shared representations or boundary objects (Nellani and Fields). Another paper provided a case study looking at an engineering education ‘game’ and a semiotic take on the topic of shared representations involved in collaborative engineering design work (De Vries and Masclet). A series of papers looked at the use of annotations and annotation systems in the work of engineering and design pointing out the dialogic dimension of design and the need for specific open mediating supports (Boujut, Vyas & Nijholt, Elsen & Leclercq). Another paper (Krogstie) looked at the construction and use of timeline representations to aid participants in software development projects to reflect upon and refocus their efforts. The work presented by Pär-Ola Zander provided an interesting turn in that it was based on trying to classify different types of citizen-government interaction around shared artefacts – it pointed out that collaboration can have different forms and that mediation, too, can be for many different purposes from simple clarification to negotiation over contrasting positions. The work of Bottoni, Kanev and Mirenkov presented various innovative tagging technologies that could be layered on top of web pages and then could enable paper-digital interactions via links embedded in machine readable barcodes. Bugeaud, Giboin and Soulier focused on the efforts to provide shared representations to foster teamwork in the innovation process within two different projects – the first, taking a service science approach provided a representation of 'the service system' for stakeholders involved in innovation projects within a French telecom company, and the second a 'unified framework' to assist business users with web 2.0 and semantic web technologies to facilitate business intelligence and technical watch. Simone and Cabitza provided a review of a some systems that have been developed at the University of Milan that are designed to enable knowledge work and knowledge sharing whether enabling cooperative problem solving in tyre design or via tagging to elaborate and share knowledge and best practice in medicine and archaeology. The final paper to discuss briefly was that presented by Castellani et al. that discussed a particular image of cooperative systems incorporating mediating helpers – mutually orienting, guiding and assisting components integrated with representations within cooperative systems designed to facilitate working across organisational boundaries in service encounters where technical understanding problems could otherwise hinder success.

As well as the presentation of papers and lively involved discussions during the workshop we asked participants to create post-it notes based upon their impressions and understandings of the work presented. It was to be our shared representation of the workshop. We decided on 4 basic dimensions for this representation 'Application/Domain', 'Type of Representation', 'Mediation Role' and 'Design (approach)'. During the workshop we collected a fair number of post-its and at the end had a brainstorming, produced more post-its and re-arranged the existing to try and agree how they fitted the dimensions. As with often in workshops the results are of an exploratory nature rather than representing any final position. However, we feel that considering the systems and studies along these dimensions has given us a richer understanding of the boundary objects/mediation landscape and hope to take this work further in the near future.

Below is a breakdown of the classificatory schema. We believe we had fewest post-its for 'Design' because we had not made clear it was 'Design Approach' but also because almost all participants came from a background where some form of participatory design, user studies or ethnography was involved in the process. Interestingly, a number of concepts were seen to fall in the middle of the two categories 'Type of Representation' and 'Mediation Role', e.g. Emerging vs Existing. Clearly this is because these can be tied together quite closely. Another interesting feature is that within the dimensions of 'type' and 'role' many concepts were presented as binary opposites. It is not the case that one opposite is 'correct' or 'better', rather it simply depends on features such as purpose, user group and other aspects of context which one is most appropriate in terms of scoping or design.

Application/Domain

Collaborative remote troubleshooting
Innovation creation
Healthcare
Archaeology

E-government
Color management workflow
Air traffic control
Product design
Collective construction of information on products
Design of truck tyres
Engineering design
Preliminary design and Creative design

Type of representation

Ontology + Animation
Representation of argumentation in design
Shared representation = external representation
Mental vs external
Traditional vs digital
Individual vs collective
Standard/local (idiosyncratic)
3D view
Univocal vs polymorphic (polyphonic??)
Open vs closed
Web document annotation
Attachable boundary objects
Design artifacts as intermediate states of a product
Static vs dynamic
Generic vs specific
Interacting with the representation

Mediation role

Support to co-design
Monosemic/polysemic and unambiguity/creativity
Role of information artifacts: intermediating global/local articulation; interpretative articulation; organising coordination
Global/local articulation; work ~ expert=local and cross expert=global?
Emergent vs existing
What is shared? (object, information, meaning, something else?)
Value of under-specification
Vehicular vs vernacular language
Shared rep => collection objectification
Clarification and elaboration
Adversarial collaboration
Constructing common understanding
Pacification/harmonization
Shared interpretation
Negotiation
Evoking knowledge
Coordination + articulation
"this community"
Roles of users? Stakeholders
Responsibility for maintaining and designing

Design

Imposed vs grass roots
Representations as a mixture of tools for design
Complexity vs availability
Participatory design and co-design
Ethnography

4 Acknowledgements

We would like to acknowledge Susan Leigh Star first of all, as she was important in inspiring much of the work presented here, and it was very sad to know she passed away this year.

We would also like to thank the organisers of Coop 2010 for assisting us ably in setting up and holding this workshop, particularly Gunnar Stevens and Myriam Lewkowicz. And of course to all the participants who helped make the workshop a fun and interesting day!

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Improving shared representations by linking discursive and graphical aspects of design

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Abstract. In this paper we will focus on distant collaborative design activities. In design graphic representations has always play an important role. If one look back in the history of engineering, graphic representations has always been strongly present. Drawings, sketches, mock-ups, and more recently digital representations (CAD, virtual reality, etc.) are commonly shared in design teams. For many years we have been studying the role of mediating objects in design teams, facilitating common understanding, knowledge elicitation and sharing. More recently we have focused on the argumentative side of design. Indeed, the discursive aspect of design is almost as important as the graphic one. In relation to these observations we discuss the concept of intermediary object, boundary object and transactive memory as a good theoretical framework. Today new technologies enable to rethink the mediating structures in distant collaborative work. Particularly we have studied the role of annotations for linking discursive and graphical aspects of design. This led us to develop an annotation plate-form we will present and propose to the discussion.

1 Collaborative work in design

Design as an art, as an activity or as a science has been studied for a long time. This is a fascinating human activity that is at the origin of most of our material welfare, allowing the creation of a huge variety of artifacts that assist the human beings in their everyday life. Herbert Simon even raised design to the level of a science (Simon, 1969): Design is a science of the artificial, therefore allowing the study of a great number of human activities under this new paradigm. Because the act of designing is everywhere in our life it is certainly not limited to the design offices or the architects' studios.

After these works we know that cannot think design into a finite and closed world of an existing reality. Which means that studying design requires to adopt a constructivist point of view on the observed phenomenon. From a philosophical point of view, design is a teleology where designers invent new artifacts in relation to an end and a given purpose. But designers must shape a future object on the basis of an unknown future, this future being influenced by the object that is being designed. This is a recursive process requiring the co-definition of the object and the environment (industrial, social, etc.). Creativity and design are consubstantial.

But design is also a social process (Eckert et al., 2005) and therefore considering design as only being a cognitive and personal activity appears to be too limited, especially regarding what is happening in the companies today. A wide variety of experts must cooperate in order to deal with the growing complexity of the designed artifacts. Being they called designers, experts, participants, stakeholders, etc., these people are involved in the collective effort towards producing a new artifact. Therefore the collaborative dimension of design cannot be avoided as well.

In companies the design work is mostly organized around multidisciplinary teams that are partially co-located. Most of the time some developments are realized by distant sub-teams belonging to sub-contractors or partners. The paper deals with problems encountered by these teams in their everyday and mostly informal communication. This communication is of course widely mediated through various computer and digital representations. In the following we will investigate the role of these representations and their status in the collaborative process.

2 Design communication

On the one hand, design representation must tend to be unambiguous and precise in order to support design reasoning and evaluation, while on the other hand, communication requires redundancy, overlapping, meaning negotiation, etc. These two aspects are clearly conflicting (Giordano, 2002). Besides ambiguity is often raised as an important factor that fosters creativity. So the communication needs will be different if we consider creative fuzzy front end phases or if we consider down stream development phases. The level of definition of the product is supposed to increase as well as the ambiguity is supposed to reduce as the design process goes on.

Communication is a relational process that encompasses at least two partners that are involved in this process. We will adopt here a constructivist point of view on communication in design considering that communication is a process of creating a shared understanding between the partners and is the consequence of complex interrelation between the subjects and the world. Communication requires shared rules, language, and a goal. Design experts are very aware of the importance of the traces and the content of the messages they share. This is why an approach purely concentrated on the information flow is not relevant for us. We argue that the context and the form of the media play a fundamental role in design communication. Therefore we concentrate also on the vehicle of the information, especially because in the digital era most of our interactions are mediated by digital artifacts. Because most of the industrial efforts concentrate on information flow structuring, there is a clear need of proper digital supports for mediating design communication and particularly its discursive dimension.

2.1 The effect of distance on design communication

Distance clearly affects design communication and distributed design is a growing field of interest. However most of the efforts concentrate on the physical distance between designers. We propose to distinguish between three kinds of distances that affect design communication:

The physical distance, that refers to the places where the designers sit. They can be spread around the world, in different companies or in different departments of the same company, etc. This physical distance materially affects the communication by reducing the channels of communication (i.e. verbal, visual, tactile, etc.)

The cognitive distance is an important issue as it may affect also co-located partners. This cognitive distance is related to the fact that the specialists have different references, objectives, values, etc. depending on their domain. For example a design expert may have a different educational background than a marketing expert and therefore they may attach different values to the same thing. We commonly say that they have a different point of view on the same object.

The cultural distance currently appears when the participants do not belong to the same country (this is the most obvious case, but not the only one). This is obvious when Western companies work with Asia for example, but it is also true between Western countries. Even if the participants speak the same language (e.g. English), the underlying traditions may affect the understanding of the participants to a meeting and all the cultural implicit may become a barrier to a good communication.

These three dimensions must be addressed for achieving a good communication. In this paper we will more particularly concentrate on the cognitive aspects and the good vehicles (mediating artifacts) for the creation of a shared understanding in design teams.

2.2 Artifacts and intermediary objects in the process of creating a shared understanding

In this section we will discuss the cognitive dimension of the artifacts involved in design. We call them design artifacts as these artifacts are part of the product during the course of design. They are the intermediate states of a product that still does not exist. But their materiality (including digital objects) allows them to evolve in the external world and to be grasped by various stakeholders. By cognitive dimension, we mean that design artifacts provide a support to the memory of the participants just as a part of the group's transactive memory (Wegner, 1986). And as the artifacts are shared among the group, this memory allows group members to quickly identify knowledge sources, expertise and abilities of the others in order to improve the efficiency of the communication between the members. This cognitive dimension allows the participants to create shared understanding and make decisions. For us the artifact is tightly related to the subject that created it and to the group that will use it. A mock-up or a bit of product has no sense out of the context of its creation or its usage.

Studying experts' work Bucciarelli defined the concept of object world (Bucciarelli, 1988) as a set of references and knowledge that every expert has embodied during his past experiences and that gives him a unique and particular nature. Going further on Bucciarelli (2002) described object world languages attached to individuals as a source of many misunderstandings even if, externally, everybody is apparently speaking the same common language (e.g. English).

An object world is a world of a variety of things particular and specialized modes of representation. Object worlds have their own unique instruments, reference texts, prototypical bits of hardware, tools, suppliers' catalogues, codes and unwritten rules…

> …each object world language of an engineer is rooted in a particular scientific paradigm which serves as a basis for conjecture, analysis, testing – and designing – within that world.

Given that for granted, how can we speak of shared representation if any individual has a specific language? How can cooperation be possible then?

If we consider individuals as isolated islands, therefore any communication must cross the boundaries of these islands. In the external world the obvious things that are shared across these islands are the design artifacts. Some of these artifacts remain inside the island (drafts, specific models of simulation, etc.) but others cross the boundaries and are shared during design meetings for example. The concept of boundary object gave a framework for classifying and identifying these artifacts (Star et Griesemer, 1989). This proved to be very helpful for design research. But analyzing more deeply the nature of these shared objects we found that they were related to the individuals object worlds and also part of this transactive memory, the material side then allowing the others to grasp the object and create or activate knowledge out of the analysis.

The shared objects clearly have two sides: a material side and a cognitive side, which led to coin the concept of Design Intermediary Object (Jeantet, 1998):

- An intermediary object is a representation and therefore the sense of this representation is attached to the context and to the individual that interprets this representation.
- An intermediary object facilitates the co-operation within the group: it has a mediation role and its form influences the performance of the communication.
- An intermediary object is involved in a translation process and may act as a spokes-person (Akrich et al., 2006), for example if a given actor is not present during the meeting.

Design intermediary objects can also be analysed within the framework of many other approaches. We have successfully linked DIO and the situated FBS (Dominguez and Boujut, 2008) and show how these intermediary objects can be the vehicles of the shared understanding between internal worlds and the external world as defined by Gero et al. (2004). DIO are a part of the shared understanding if we consider that shared understanding is a process. Kliensmann and Valkenburg (2008) defined the concept of shared understanding as:

> "a similarity in the individual perceptions of actors about either how the design content is conceptualized (content) or how the transactive memory system works (process)"

As design constantly evolves, the context of the design also evolves. Therefore the similarities in the perceptions also are subject to evolution. This is why we consider that, in the same way some consider the "process of knowing" we consider that shared understanding is a process, and in a way DOI can be seen as the external vehicle of this process, the material side of a cognitive process.

3 Annotations as a means to support argumentation and collaborative design debate

As an illustration of the process of creating shared understanding, we observed, as many other authors that during design meetings, the argumentation developed by the stakeholders were the source of many rich improvements in the understanding of the designers and also a keystone of the decision making process. Then how can design intermediary object be more open to explicitly support the argumentative side of design?

We propose therefore to focus on the argumentative process and analyze its role in design debates. We also propose to analyze annotations as good candidates for the creation of specific objects for supporting argumentation during design debates.

3.1 Qualifying argumentation and design debate

Argumentation is a key element of any logical discourse that aims at demonstrating or convincing someone else. Argumentation includes debate and negotiation which are concerned with reaching mutually acceptable conclusions. In Logic an argument is a set of one or more meaningful declarative sentences called “propositions” that can take the value “true” or “false” or even “unknown”. However, the study of human discourse cannot be limited to pure logical status when we consider the discursive aspect of argumentation. In a discourse an argument can be used for various purposes (i.e. statement, proposition, indication, etc.), and the question of the truthfulness of the argument is seldom considered. Mostly argumentation is used for convincing someone, presenting or defending a position, explaining or justifying a decision. This is also true in the particular case of design.

Argumentation in design has not been studied very much despite it plays an important role in decision making. In design reviews, designers and other stockholders present and discuss the proposed solutions. Design review meetings are privileged place where design debates occur, but it should be an error to strictly limit design debates to design meetings, as informal debates also occur all the time. The debates rely on the expertise of the participants and on the analysis performed before the design meetings and allow the participants to express their point of view. This point of view is therefore defended by various assertion or statements we call arguments. Previous works have proposed some interesting classifications of these arguments. For example Detienne and al. (2004) proposed a classification based on 8 categories among which 5 are dedicated to the argumentation, proposition, and clarification of the design. While Lund and al. (2009) propose an approach for studying computer-mediated debates with 7 categories among which 3 are dedicated to the object of the debate (opinion, argumentation, deepen), in our case: the solution to be evaluated.

3.2 Annotations that support the discussions during design meetings

Lang et al. (2002) made an interesting summary of the requirements for an environment that supports collaborative design. Among the main factors that influence collaborative design the authors identified cognitive factors such as cognitive synchronisation and highlight negotiation as an important factor for achieving good collaboration. Among all the tools referenced in this study, the authors surprisingly never mentioned annotation tools as good candidates for supporting collaboration. This is a good illustration of the gap between engineering tools (CAD, CAE, etc.) and collaborative tools or groupware.

Our aim is to integrate into design oriented platforms some groupware functionalities such as annotation functionalities.

Annotation has been recognized as an important activity primarily in text elaboration. From the ancient religious text comments to the modern digital text collaborative editing, annotation has been the main way people used for expressing themselves about a given text and attached to it. More recently annotation has been recognized as an important way for supporting argumentative episodes in design meetings. In that case, annotations are mainly graphical or mixed textual and graphical and serve as a support for expressing an idea, supporting an argument, highlighting a specific point. These annotations loose there meaning out of the context of their creation. There is no persistence of the interpretability, even for specialists. These annotations may keep some sense if they are integrated in an environment that records the meeting itself and stores the video and audio transcript of the meetings (Chiu et al. 2001).

Guibert et al. (2009) have exposed the main characteristics of the annotations in the case of engineering design. For these authors an annotation always refers to a target document that may have various forms. The content refers to the information that aims to be transmitted. The anchor of the annotation corresponds to the geometric point designating the zone the annotation refers to. An annotation may be private or public. The life span of an annotation may vary but remains linked to the lifespan of the document. The author of the annotation may or may not be the author of the document.

It is interesting to notice the clear distinction made by the authors between the document and the annotation that refers to the document. This distinction is not so clear when confronted to actual practices and the analysis of sketches created during design meetings (fig. 1).

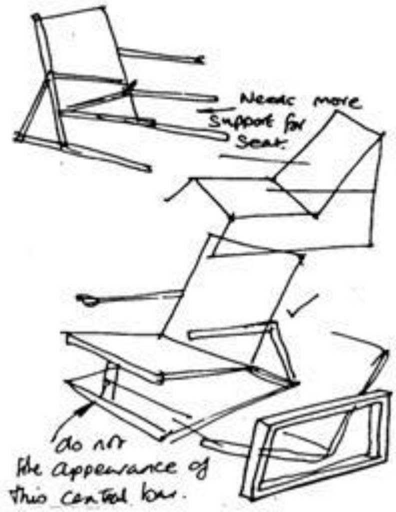

Figure 1: It is difficult to distinguish annotation from the document reference of this annotated sketch.

In that case annotations are good media for discussion and synchronous debate, but rather poor media for memory and information transmission for future reuse.

3.3 Annotations that supports asynchronous exchanges

In engineering design most of the representations that transit among the designers are CAD models and these CAD models are mostly using dedicated formats. The full CAD models are very heavy and not easily shared outside the sphere of the design experts. Ding and Mc Mahon (2009) propose to introduce the concept of lightweight representation, which is a simplified digital representation independent from any commercial software, therefore easily shared transferred and interpreted by external web based software for example. This approach is providing a good way for introducing multi-layer mark-ups within a lightweight geometric representation. These mark-ups are used for triggering other calculation in an automatic way providing automatic information computation for the experts. Figure 2 shows the result of an FEM calculation related to a markup previously positioned on the lightweight shared model. Unfortunately this work remains limited to the markup technology and does not extend towards the cognitive dimension of the annotation.

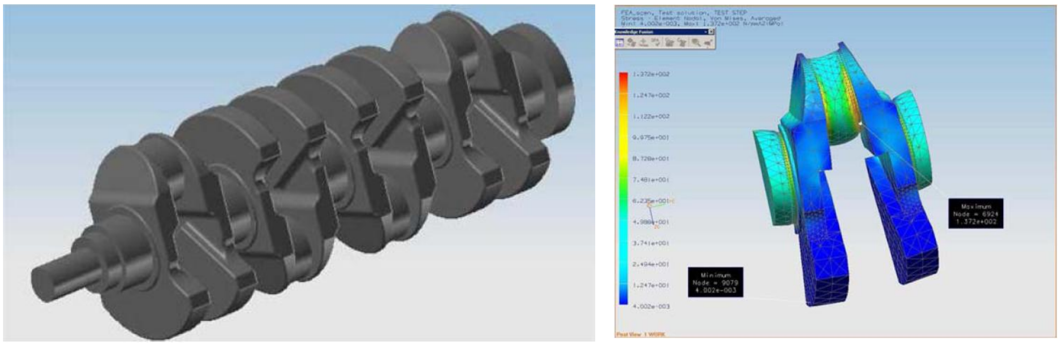

Figure 2: FEA linked to a lightweight representation from (Ding et al., 2009)

Another interesting work concerning annotations linked to CAD environment proposes to integrate semantic metadata in a simple knowledge model describing the main terminology of the domain. This facilitates the creation of the annotation and simplifies the exploitation of the annotated documents (fig. 3).

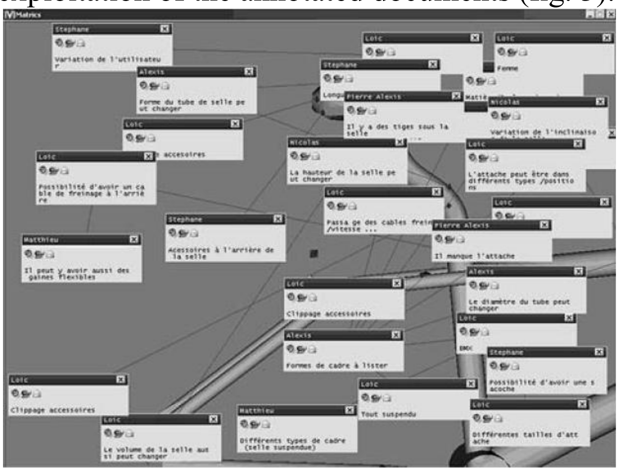

Figure 3: a great number of annotations require appropriate search and sort tools (Lene et al. 2009)

These work show a brief state of the art of some interesting attempts to introduce some richer semantic into digital design environments. They provide a good help for project memories and storing of some design rational elements. These attempts however neglect the discursive aspect of design being it synchronous or asynchronous. We will see now a work that aims at integrating discursive and design rational element into lightweight 3D platforms.

4 Annotation based shared representations for supporting asynchronous communication

This section presents a collaborative plate-form that has been designed for enhancing asynchronous communication in design teams. We will briefly present the concepts of the tool and discus them with regard to the concepts exposed before.

Most of the annotation tools developed in the field of engineering design assists asynchronous communication. This is the case of the two examples presented in the previous section. The literature often distinguishes between asynchronous and synchronous work and proposes to deal with either one or the other. If we adopt communication point of view on design this distinction becomes a barrier as professional communication in design occur in both situations. Particularly in distributed teams where people may even work on very different time zones. During our fieldwork we have observed a recursive sequence in the teams' design work. This loop involves synchronous and asynchronous work (fig. 4) and a wide variety of shared objects.

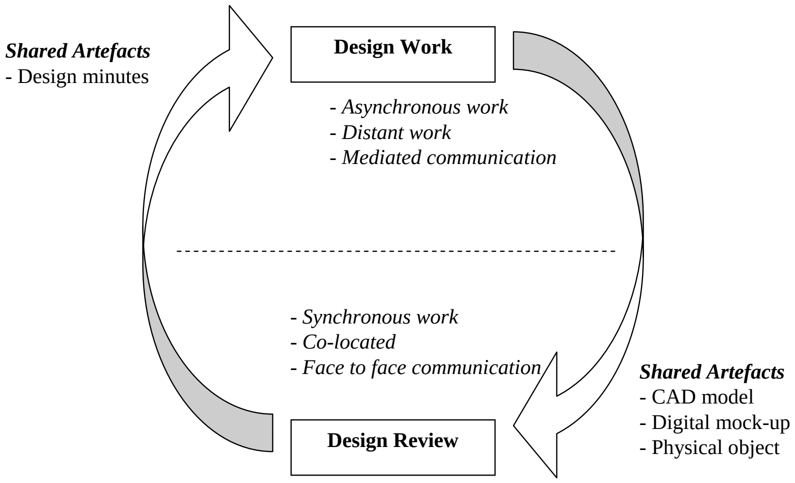

Figure 4: mediated communication in design: a basic pattern (Hisarciklilar and Boujut, 2009)

The design reviews (or design meetings) are the most classical cases where a communication approach is important but what we noticed during this study is the deep interrelation between the two phases and the need for smooth information and communication flows. What forms of design intermediary objects are relevant for supporting the design teams across all the process and to allow a communication continuum between synchronous and asynchronous phases?

The aim of the system is to bridge the gap between design work and design review by providing a plate-form for sharing information and initiating a debate in asynchronous mode while providing a synthesis that can be used during design meeting.

4.1 The semantic annotation model

Our model is based on semantic annotation principles considering the annotation as an additional set of information (see section 2.2) that carries a certain meaning and with a certain purpose in a given context. We have been deeply influenced by the speech act theory (Austin 1975, second edition), (Searle, 1969) and is consistent with our approach of design communication exposed before. Speech act theory indicates three dimensions of a given message: the locutory, illocutory and perlocutory dimensions. We concentrate here on the locutory and illocutory dimensions and consider that the structure of our application should support these two dimensions. Indeed most of the approaches only concentrate on the locutory dimension forgetting that the illocutory side which is the case of almost all the PDM systems today. This may lead to misunderstandings for the obvious reason that a simple utterance like: “this is green”, may have a very different purpose depending on the context: it can be either a clarification or an evaluation for example.

Our model includes two axes (fig. 5): a message axis and a context axis. One design context axis dedicated to indicate some element of context (e.g. the who and the object), the second axis reflect the SAT concepts storing the intent behind the annotation (the intent). For example, the designer (author) may say “this pipe is too long” referring to the solution (purpose) and intending to evaluate (intent).
The annotation is then defined as:
Annotation = {body text, author, purpose, intent}

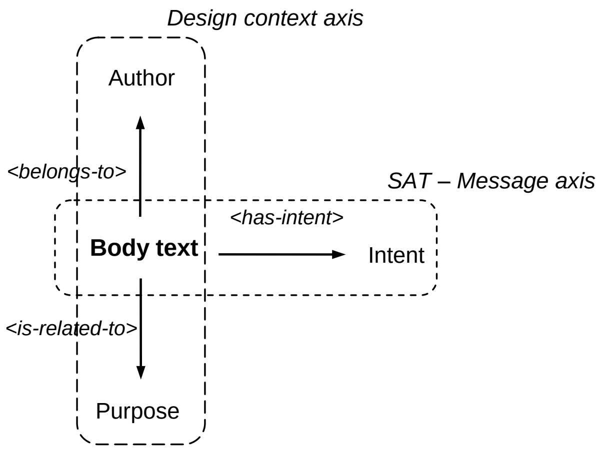

Figure 5: The Annot'action's annotation model (Hisarciklilar and Boujut, 2009)

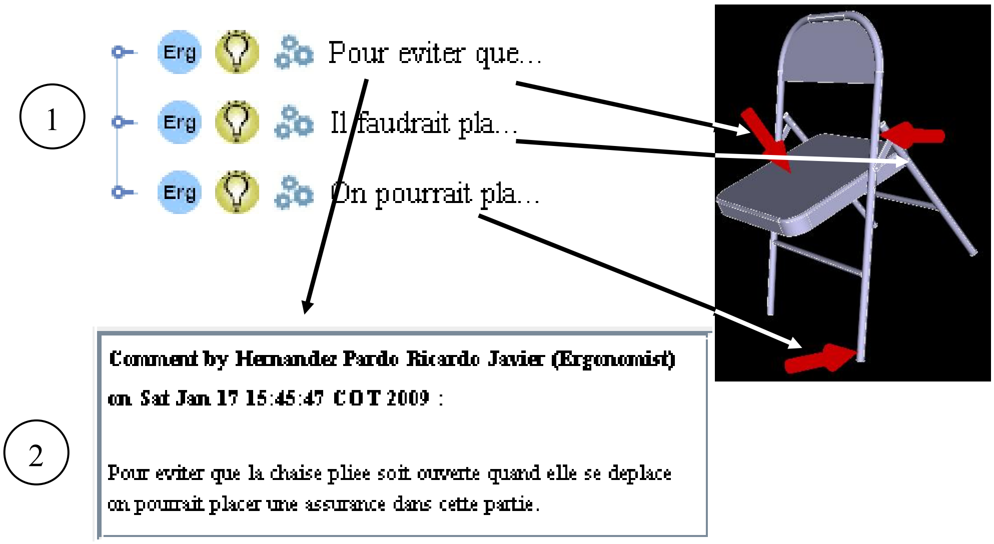

Figure 6: Three levels of representations

On figure 6 we find an illustration of the annotation model. On the top left (1) we have a synthetic view of the context of the annotation with 3 symbols. The first one indicates the author, the second one the intent and the third one the purpose of the annotation, all this representing the illocutory dimension of the message. On the bottom (2) we have the utterance itself, the text of the annotation and on the right (3) we find the graphic representation with the geometric pointer referring to the impacted zone. An annotation is associated with one pointer and can be composed of as many as sub layers as necessary. All this depends on the discussions engaged between the participants.

5 Discussion

Figure 7 shows a short discussion between two participants. The ergonomist ask for an additional feature for the product in order to improve the security. The ergonomist adds some clarification to the proposal and the designer answers with a technical solution proposal. Later, this point has been discussed during the design meeting on the basis of this exchange and a decision has been made. Through this short excerpt we see how two points of view have been expressed and related to the same subject.

This functionality of the software intends to support the expression of the diverse points of view that can be expressed in a design team through an argumentation thread. We have then a trace of the preliminary exchanges and the participants can come back later to the point and expand their arguments during face to face meetings. This aspect aims to support the development of a transactive memory as the participants can share some argumentations and progressively allows some cross learning on each others' capacities, expert knowledge, etc. and that on the basis of a real exchange and not on the basis of a reputation (this person is a manufacturing expert so he is supposed to be knowledgeable on every aspect of manufacturing, which is obviously not the case).

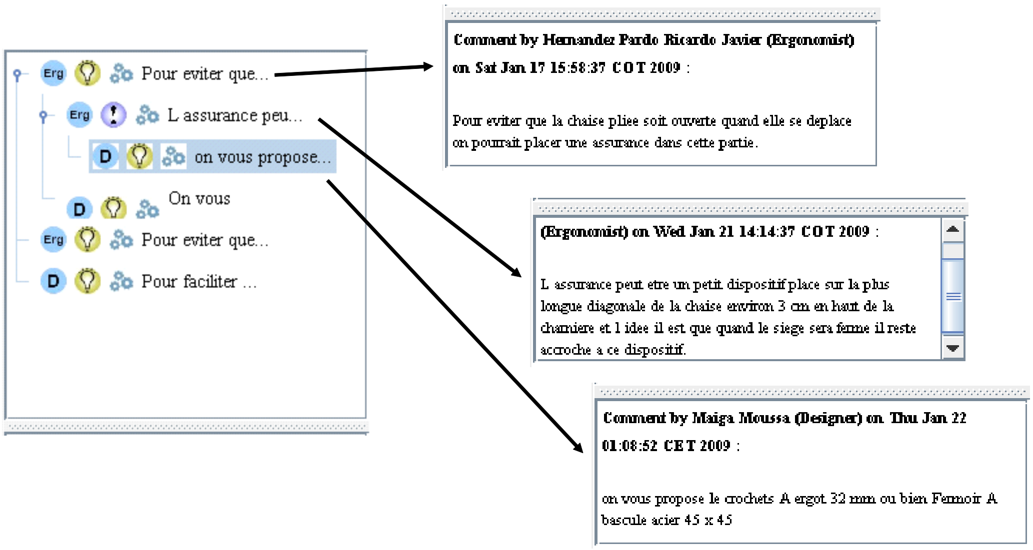

Figure 7: Example of an argumentation thread

How this environment does support shared understanding and can we talk of shared representation?

In this paper we have developed the thesis that design communication can be assisted and eventually improved by supporting argumentative exchanges among design teams. Most of the design software neglects this dimension of collaboration and the discursive dimension is seldom considered as a relevant aspect for developing design software. The support to communication is then achieved by providing software features that allow the creation of proper shared representations that link graphic (3D in our case) and discursive dimensions. As Schön (1991) stated, design is a conversation with the design situation, involving all sorts of media, and essentially graphic representations. Therefore we need to provide graphic representations to the designers. However, as we mentioned in our development on the intermediaries and boundary objects, the cognitive dimension of the representation should be carefully supported if we want to talk about shared representations. In that case sharing graphics appears insufficient as many other aspects of design are shared through common language. Supporting the designers' discourse cannot be avoided.

Some attempts have been made to record and store video and audio minutes of design minutes (Chiu and al., 2001) in order to grasp the discursive dimension of design. Our approach is slightly different and considers that the participant must be active in the process of eliciting there arguments in order to foster the enrichment of the transactive memory. So the argumentative thread (remember fig. 7) is to be filled by the participants themselves. The main effect of that is that the participants remember what they have done during the asynchronous argumentative phase and come back naturally to the discussed points during the meetings. This is a major point in the process of creating a shared understanding – f we adopt a process perspective- as we have discussed in section 2.2.

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Shared Representations for Innovation: Experience Feedback on Two Innovation-oriented Projects

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Abstract. To facilitate the cooperation among the participants of two different innovation projects, we proposed them to rely on specific shared representations: (project #1) the "Service System" and (project #2) the "Unified Framework". In this paper, we present how these shared representations were experienced in the projects, and bring up a work in progress aiming at better characterizing the effectiveness of shared representations for innovation.

1 Introduction

Our work deals with the design and evaluation of adapted mediation supports within innovation contexts. Innovation contexts could concern innovation on conceived or used tools, innovation on proposed or used method/approach, innovation on designed products, or innovation on supported or proposed processes. We try to conceive cooperative systems to answer the innovation actors' (innovators') difficulties. We make the hypothesis that, in all the innovation contexts we address, we must be able to answer the cooperation, communication and creativity difficulties by the provision of a shared representation through three steps:

1) Identification of the context (actors, objectives, tasks), difficulties, and definition of hypothesis.
2) Proposition and conceptualization of an intermediary object (Vinck et al., 1996) which could not only be a mediation support but also an operational tool for the design and the implementation of innovative services/solutions.
3) Design and evaluation of an adapted formalism/model (e.g. the improvement of the perception of processes within an organization through their modeling has already been demonstrated (Marciniak, 1991)), approach and supporting tool (i.e. cooperative system).

It is important to note that we are more interested in the evaluation of the impact of the proposed shared object and its formalisation on the collaboration than in the evaluation of the cooperative system functioning itself. This interest is linked to the originality of our approach. Indeed, we work on the notion of "process" through two main distinct (but often confusing) dimensions: the semantics of processes (i.e. processual entities) and the modeling of business processes (i.e. organizations' procedures). This paradigm and this mechanism are what we finally try to develop and evaluate. It is thus important to introduce and describe the dimensions related to mediation that not only should be considered when designing a new cooperative system involving the representation of a shared object but also when evaluating this object as an intermediary object. The relevance of the proposed medium, the adequacy and usability of its formalisation could be measured, for example, with the number and disciplines of the participants in the collective task, the degree of guidance offered to the users to perform the task, the number of ideas and the degree of their articulation, the degree of individual and collective comprehension, representation and memorization.

We applied the previous steps (identification of the context, proposition of a mediation support, design and evaluation) to two case studies which are good examples of cooperative activities in the innovation universe. These projects are two distinct examples but they have in common the high level method we used to address the problems, and the non-traditional intellectual orientation we propose based on the opposition of objects and processes. The first case study concerns the opportunities research upstream step of a telecom operator's innovation cycle. The second case study concerns the co-design of Web 2.0 solutions for technology watchers by an interdisciplinary design team.

2 Experiencing the "Service System" Shared Representation (Project #1)

The project#1 is a current real life project of research which is experienced within the organization of a French telecommunication operator. The objective of such a services provider is typically to make innovation (i.e. to imagine, conceive, develop and supply some innovative products/services to their customers). This operator tries to improve its process of opportunities research upstream of its design cycle. Our work aims at supporting this early phase and guiding the innovators' work and decision-making thanks to the provision of a new research object. The role of this new concept is to allow the involved innovators to better exchange their knowledge, better individually and collectively represent the service situation of the customer (or customers segment) they want to study, and finally find ideas of new services.

2.1 Step 1 - Identification of the Services Design context and difficulties

Telecom operators usually implement a services design process that involves very different interacting actors. We studied this design process and had a reflection on the innovation conditions for a telecom operator. We have detected an important lock during the upstream phase of "opportunities research". This sub-process aims at identifying ideas of new services/solutions in order to meet the customers' expectations and to ensure the operator market position. It is based on the design reasoning of its innovators (Bugeaud et Soulier, 2009), and it gathers a lot of data and documents. But these innovators meet some difficulties because of the remote and interprofessional nature of their work. They have to co-design services but they have neither an adapted approach nor a supporting tool. Their marketing, ergonomic, uses, technical and other views have to converge in order to describe the current situation and propose new adapted solutions. These ideas are then evaluated by an anticipation committee that checks their relevance and transfers them towards the design, development, deployment and then market launch phases.

But the basic problem at this upstream stage of opportunities research does not really lie in the remote and inter-professional nature of their network (these lead to important business difficulties that are common to many collaborative networks) but in the concept of "service". The different categories of innovators (IT and Telecoms engineers, Usages/practices experts, and Marketing experts) have different, unshared representations of what is a service according to his profile, profession and experience, and these representations also differ from the representations of the customers. "Service" is a polysemous word within the innovators' world. For example, the IT and Telecoms engineers often consider it as a web service in the context of a service oriented architecture (SOA); the marketing experts consider it as the business of some customers segments (in the tertiary sector) and they are interested in the economic view and the possible revenue of the provided services ; the usages analysts consider the usages scenarios as operational processes or customers' journeys ; the sociologists consider the service as an exchange between a provider (in our case, the telecom operator's corporate customer) and a customer (the final customer of our corporate customer) and as the help that the proposed service can bring to them ; etc. An interesting point is linked to the user's view of the service (even if the user is not involved in the step of opportunities research). It is focused on the provided response to his need / requirement and more and more on the provided and lived experience.

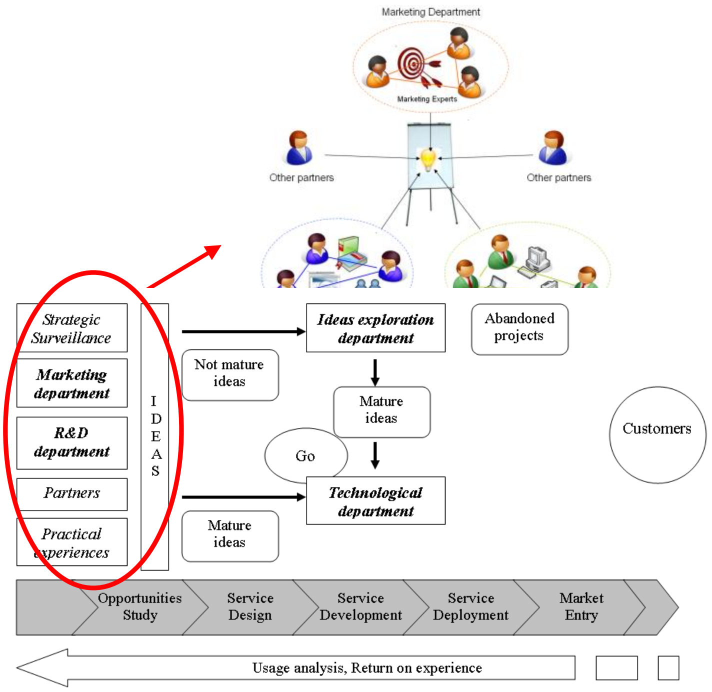

Figure 1. Convergence of the views and emergence of new ideas upstream of the design cycle

However, this experiential view, the service interactions (Cerf et Falzon, 2005) and, in a general way, the dynamic nature of the service are not enough identified and considered by the innovators. Providing a systemic and high-level view of the service to the innovators (i.e. the concept of "Service System") is thus a way to gather them around a shared representation of the targeted services situations. It aims at increasing their capacity of innovation and the success of the conceived services. The Service System is an intermediary object that offers to the innovators the possibility to co-describe a service situation without taking them away from their own representation (see Figure 1).

2.2 Step 2 - Proposition and conceptualization of an intermediary and operational object: the Service System

The understanding of the concept of "service" by the innovators determines their intervention in the research opportunities phase which feeds the process of services/solutions design and thus affects innovation. Instead of proposing an articulation of their points of view (which are very different), we propose a new object of research at a business and abstract level in order to bring them a common higher level view from which a consensus can appear.

In the literature, the majority of the approaches are socioeconomic, marketing, organizational or technological. But few works allow an integration of these points of view. Tannery (2001) proposes four main poles around the service: the relation of service, the flows and the process of realization of the service, the result / offered service, and the structuring of the offers system. Based on the SSME (Services Science Management and Engineering, initiated by IBM and several universities to gather, thanks to a multidisciplinary approach, all the initiatives and synergies around a "service science" (see the IBM Systems. Journal, vol.47, no.1, 2008)) discussions (Spohrer et al., 2007), we proposed to conceive the service as a "Service System" (Bugeaud et al., 2009). This dynamic configuration expresses a particular phenomenon (i.e. an experience) and is linked to the combination of heterogeneous entities. The concept of Service System helps us to provide a suitable shared representation through its co-modeling and its simulation (see 2.3). These steps provide a common vision to the innovators (i.e., at the same level of abstraction) based on the service situation they study and for which they are trying to detect new opportunities. The final goal of this "shared representation" is to better conceptualize things and more specifically to remove the lock around the service and the service experience in order to better include the innovators in the services design process and thus to promote innovation.

However, the formalization of this concept requires a particular approach. The semantics of objects usually disconnects the conceptual representations from the field of experiences. It is based on the idea that the reality is linked to conceptual things. This paradigm of the substance, which often considers the processes/actions only as properties or second-class entities, is a classic vision in Knowledge Engineering, Ontology Engineering, and also in CSCW. Conversely, the pragmatism and ethnomethodology fields fail the question of representation. In this work, we adopt an intermediary position through which we propose a theory of meaning that is not based on objects/substances but on processes. Reality is thus a continuous flow based on structures of emergence and not on an apriori known metalanguage. But there is in the West a cultural and historical habituation to the object-oriented thinking. It is interesting to note that in the Eastern tradition, there is no concept but processes/flows. The question is therefore whether such a processual representation may be substituted to an object/substantial representation and if so, would it be more efficient (see 2.3)?

Some recent ontologies of processes criticize the current ontological attempts on concepts and try to substitute different items (e.g. ontologies about non-traditional properties or tropes). We proposed a new paradigm about "process-oriented knowledge" and a formalism to represent Services Systems: a mereological ontology of processual entities (Soulier, 2009; Seibt, 2009; Bugeaud et al., 2010a). This proposal responds to the hypothesis that we may be able to not only describe flows/processes (rather than objects and their attributes) and hence to provide an experiential representation (rather than a conceptual representation) of the addressed situation, but also that we may provide a common vision to the innovators involved in the design process of new services. The Service System (i.e. object to be designed) and the Service Experience (i.e. projection of a service experience as seen by the designer) are two necessities in the innovators' and designers' perspectives to better understand how the product could be proposed and how this product could be used. It allows the convergence of the innovators' views and brings the artefact and the usages closer.

2.3 Step 3 - Design and evaluation of the OntoStoria[2] formalism, approach and tool

A method and a web-based design studio have been created to build such Services Systems ontologies and simulate them in order to facilitate the innovators' communication, collaboration and creativity.

We have studied the existing models of the concept of service (the molecular model of Shostack, the service offer of Eiglier (Eiglier, 2004), the service characteristics vectors (Gallouj et Weinstein, 1997) etc.) and the possible models of the delivery system of the service, or servuction, (blueprint, Petrinet, UML diagrams, etc.). However, although they adopt different perspectives, they all neglect the dynamic/performative nature of the service for the benefit of a conceptual representation of its contents/substance. Moreover, an ontological representation can be considered based on the existing hierarchy between core services and peripheral services. But traditional ontologies (i.e. domain ontologies) describe concrete, countable and located entities and do also consider the substance as primary-class and the processes/actions as properties or second-class entities. Our work defines the Service System as a collection of processual entities (Soulier, 2009; Bugeaud et al., 2010a) which express a dynamic phenomenon (generally described in the services providers' documentation through an interactional and verbal form). We therefore propose an ontological alternative considering dynamic categories rather than abstract classes and static concepts. This proposition is based on the processes ontologies discussions, and the mereological (based on the formal study of the "part-whole" relation rather than the traditionally used "is-a" semantic relation) (Varzi, 2003) and General Process Theory (GPT)(Seibt, 2009) principles. We created a method, called OntoStoria², to represent Services Systems. It is based on a semantic semi-formal description of dynamic categories implementing information and knowledge related to the studied Service System through: the extraction of key information from the upstream available documents, the use of the Galois Lattice rules to build a network of dynamic entities (this is an essential step to move from the conceptual space to a dynamic/pragmatic space thanks to the link between objects and actions), the application of classical and mereological criteria on the actions for the characterization of the entities and their interactions, and then the generation of an ontology. The details of this method is the object of further publications (Bugeaud et al., 2010a).

To go further, we propose to simulate the studied Service System thanks to an *animation*. This kind of animation is often more effective in terms of memorization and understanding than "flat" models. Some existing tools already generate such animations based on Business Process Modeling (e.g. OnMap from Nomia). Although it is not still the case, we imagine a similar simulation approach for the studied Services Systems through the implementation of a link between the Service System model and its animation. However, the Service System ontology does not allow to easily create an animation. Several steps are thus necessary: the identification of the Service System universe using the ontology, the identification and description of all the successive scenarios which could happen in this service situation, then the characterization of a typical customer's profile and goals, and finally the simulation of each scenario. Moreover, it will be possible to replay the simulation with multiple user profiles. The innovators can thus simulate almost all the service interactions that could happen in the real service situation.

To amplify the benefits of the Service System modeling and simulation, we are implementing a *Services Systems Design Studio*. It is a web-based tool associated with a database server. It can be used in an asynchronous way (through the remote and inter-professional network of innovators) or in a direct access way (an innovator or a group of innovators). It uses the traditional mechanisms of social networks for the asynchronous access (eg. profiles, tags, etc.).

Finally, we have evaluated the impact of the Service System as an operational and intermediary object on the collective representation, and the impact of the processual principles and the Service System animation on the collective and individual representations (the overall assessment of OntoStoria² as a collaborative system will be the subject of further publications.) The criteria used to evaluate this proposition are: the relevance of the Service System as a shared representation, the adequacy of the mereological and processual principles for the representation of dynamic phenomena, and the usability of a simulation for this performative construct. These macro-criteria have given rise to three sub-evaluations that have been published elsewhere (Bugeaud et al., 2010b). As the e-health domain is a key domain for services providers and a rich field in terms of Services Systems, we have led a first experiment with a group of telecom innovators (sociologists, marketers and engineers) about the remote monitoring of diabetics patients. This Service System has been the subject of numerous studies but it has not been represented in a consensual way. During a first step, the group of innovators made an opportunities research session by phone (to recreate the remote and inter-professional nature of the activity). They had to co-describe the service and find new ideas of solutions. During a second step, we presented them the Service System concept and our ontological model. We invited innovators to annotate these propositions and to discuss them. At the end of each session, we asked them a set of questions such as: do you think you have reached unanimous definition and description of this service? Have you shared and/or learned something? Did ideas appear? We also tried to know which differences they had noted between the brainstormings. The result shows some interesting consequences of the use of the Service System and its models such as the reduction of the disagreement between the innovators and the improvement of the individual and collective representations of the remote monitoring of diabetics patients. Indeed, the innovators used the same level of abstraction and were aware about the economic, social, technical dimensions, etc., of the studied service. The comparison of the exchanged information, the perceptions of the users regarding the process and the quality of the representation, but also the number of ideas (e.g. a classical vocal server may be more relevant for old diabetics who are not familiar with PDAs and the Internet) encouraged the continuation of our experiment.

3 Experiencing the “Unified Framework” Shared Representation (Project #2)

The project#2 is a current research project which is realized by an interdisciplinary design team, the so-called ISICIL consortium (Gandon et al., 2009) and funded by the French National Research Agency (ANR). It proposes to study and to experiment with the usage of new tools, relying on Web 2.0 advanced interfaces for interactions and on Semantic Web technologies for interoperability and information processing, to assist tasks of corporate intelligence and technical watch. Business Intelligence relies on a collection of applications, technologies and methodologies that support access to and analysis of information in order to manage the competitiveness of firms.

3.1 Step 1 - Identification of the ISICIL context and difficulties

In a collaborative research project such as the ISICIL project, there are often two main difficulties:

- Understanding and representing the strategy, organisation, business processes and so on of the project end-users despite the fact that the transition from the business view to the design of applications is still a major difficulty in the field of Information Systems,
- Making a remote and interdisciplinary consortium of researchers and engineers collaborate.

ISICIL acknowledges the problems in reconciling Open Web practices with corporate processes. Beyond its technical objectives, one of the scientific objectives of ISICIL is to ensure that advanced web interfaces are not only nice but also anchored in the corporate reality, usable and effective in the tasks they are designed for. Moreover, given the fact that this reality is moving, ISICIL has to anticipate and to take into account the strategic, business, functional and applicative evolutions that end-users are facing. Therefore, beyond the design of adapted interfaces and the proposition of appropriate algorithms and models for trust and privacy management, it is necessary to reconcile Web 2.0 applications and corporate organizational and business reality.

These difficulties are increased by the recent trends on business and IT alignment, processes and services emergence, urbanization and, today, enterprise architecture works. One of the current difficulties in the field of Information System design is the transition from the business view to the applications design. This difficulty is increased by the IS evolving nature and the emergence of some computer concepts such as service-oriented architectures or web services. At the same time, the industry has discovered that the structuring of activities into processes has many qualities. These trends make urgent the need for mechanisms of transition from one layer to another. Moreover more and more companies want to improve not only their Information System ad-hoc projects but also the global governance of their IS. The Enterprise Architecture (EA) is a way to achieve this high-level goal. This approach requires the definition of requirements, applicative mapping, targeted processes and use cases. Moreover, the Enterprise Architecture presents three main layers that are far from being well connected: business layer, logical layer (composed of a functional layer and an applicative layer) and technological layer.

This leads to an important confusion and a need of mutual understanding at all the levels of abstraction. It is necessary to provide, since the early phases of such a research project, shared representations from which the consortium members could collaborate.

3.2 Step 2 - Proposition and conceptualization of an intermediary and operational object: the Shared Framework

One of our contributions to the ISICIL project concerns the association of two kinds of analysis: the usages analysis and the processes modeling. The objectives of the usages analysis are to understand the users' characteristics and the different usages/scenarios regarding the tasks they accomplish (or they will have to accomplish) and to capture their requirements. However, this approach presents some limitations due to the interest in individuals/actors. It can be described as a psycho-cognitive approach. First, the vision of the proposed tool is related to the representation that an actor is able to formalize (as use cases) based on the potential use of this tool. But complex and innovative tools often exceed the ability of the actor to represent and describe it exhaustively. Secondly, this approach offers a technological and human view of the activity but it does not take into account the economical aspect. Yet, this economical aspect can often overcome some constraints (e.g., when a company can outsource a part of the activity that could not be achieved in-house for various reasons). Thus, we provide a framework for the formalisation of the processes. Their analysis allows us to complete the usages approach thanks to the provision of insights into the economical facet of the activity (without neglecting the technical aspects).

However, the notion of "process" conveys a notion of flow or dynamicity that we cannot always get with the traditional modeling techniques. In a general way, we find two kinds of attitude: people who join the modeling of persistent objects (stable semantics) and those who join the modeling of IS thanks to processes (syntax, pragmatics). We found this tension among the members of the ISICIL consortium where we meet business, usage and IT points of view. Some partners are interested in the structures of concepts which are useful to find information and some others are more interested in the activity of the studied actors/users. Although the level of granularity is different from the projet#1 (here we are interested in the business processes, i.e. procedures of the company, and not in the semantics of processes, i.e. processual entities), it is another demonstration of the problem which opposes objects and processes. Then the question is, do we have to represent concepts or activities? Or do we have to bring back activities to a classification when we are interested in the description of the IS and the EA of an organization? It is an interesting lock that we suggest rising by the contribution of a shared representation based on all the EA layers.

We have proposed and implemented a Unified Framework (a kind of models repository based on the ARIS platform from IDS Scheer) considering the strategic, business, organisational, functional, applicative and technical contexts of the ISICIL end-users processes (Gandon et al., 2009). This framework connects the business, usages and IT perspectives. Its enrichment allows the provision of an integrated and complete vision of the ISICIL end-users (a French telecom operator, and a French agency for the environment and energy management) organizations, activities, practices and tools to all the members of the ISICIL consortium. Based on this description, the ISICIL members can exchange ideas and discover lacks and opportunities to propose adapted Web 2.0 tools. The methods and transition process we propose (see 3.3) build some bridges between the architectural layers.

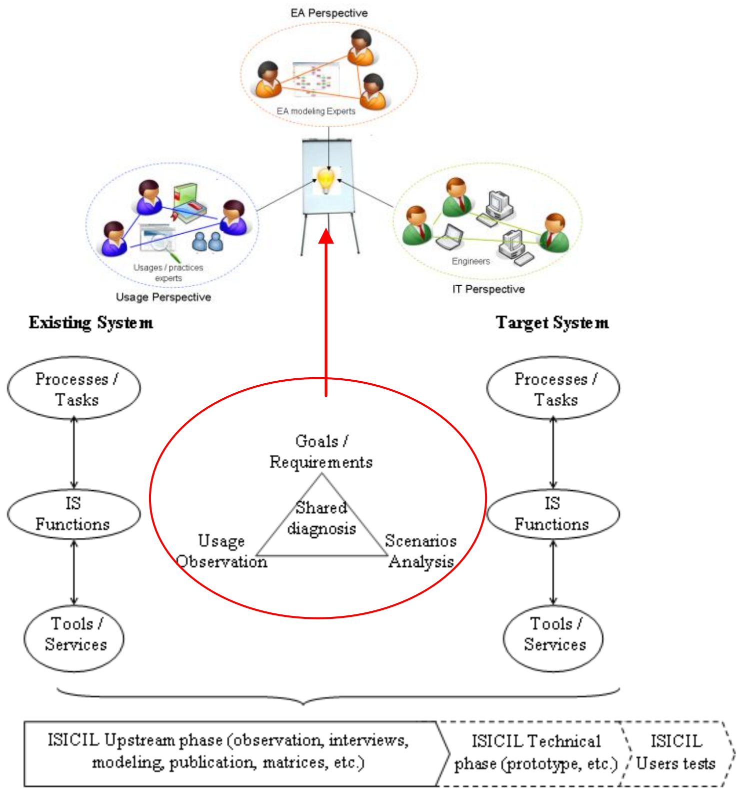

Figure 2. ISICIL Modeling Framework Architecture.

Such a cartography allows people who are not computer specialists to better understand the link between the value creation processes, the tasks of the organization's actors as well as the information processing associated to these activities (IS function) and the potential existing supporting tools. Two methods have been created to manage the framework (see 3.3).

3.3 Step 3 - Design and evaluation of the ISICIL Shared Framework models, methods and tool

We have suggested combining a modeling tool and a web-portal publication tool. We therefore used RIS Business Architect from IDS Scheer to model and enrich the ISICIL repository and the ARIS Business Publisher to publish a ISICIL web-portal to give access to all models and their information. We also proposed a complete approach based on two methods managing the framework: "from the business modeling techniques to a SOA implementation" and "from the existing

EA capture and analysis to the target EA". This framework is a platform of co-design which has a mediation role at two levels of abstraction. The former is a "human level" because it concerns the cooperation of the ISICIL members. Once the repository has been so filled, we have generated an online publication and have sent its URL to all the consortium members. We have invited them to use it and exchange information, remarks, ideas, etc. This framework is therefore a unified view which is available for each member no matter who and where s/he is. The later is a "technical level" because it concerns the effective modeling of all the elements we have detected and described within the ISICIL end-users organisations and the technical linking between the business, functional, applicative and technical architecture levels.

The enrichment of our modeling framework is based on the result of several interviews that we have made with some representative actors of the Information and Technical Watch Processes of the ISICIL end-users. Thanks to these discussions, we have discovered and modeled key elements such as their objectives, products/services, organization/actors, domains of processes, key data/business objects, tasks and their context, functionalities and applications/tools. Moreover, in order to take into account the ISICIL end-users' requirements and evolutions, we have proposed the following rules: during the enrichment of the business processes descriptions, if there is no existing tool to support an existing or a new task, we use UML modeling to describe the target/future scenario(s). Finally, a shared diagnosis between the project actors has been required to validate the modeling work and to co-analyze the existing EA and the possible developments/tracks of evolution.

We have published the models on the web portal and made them available to all the ISICIL members throughout their modeling and improvement. However, the reading and translation of these models in terms of opportunities for the ISICIL project remained difficult. We therefore have created several convergence matrices based on these models and their objects relationships. These matrices have allowed the ISICIL engineers to not only detect opportunities and develop new solutions based on the other members' upstream contributions but also to consider the overall chain from business processes and activities to web services and their implementation in an IT platform.

This medium has allowed each ISICIL partner to be situated and also to situate the others within the project and with regard to their respective contribution. It also has allowed going further than the notion of "needs" which is bound to the conception of a system and not to the task and its contextualization. Every proposition of Web 2.0 tools stemming from the ISICIL consortium or BI suppliers have been positioned in these contexts and the realized matrices.

Although the use of this framework allowed to answer the question of the medium relevance, to guide the ISICIL members, and to provide a context and the link between business and IT views, it would be relevant to realize other measures to correctly demonstrate its role (e.g. number of on-line connections to the repository, number of realized models, number of propositions stemming from the analysis of the models and/or matrices, etc.). A validation plan has to be implemented.

4 On-going Work: Better Characterizing the Effectiveness of Shared Representations for Innovation

We concluded the presentation of the shared representations experienced in the two innovation projects considered here, by the need (1) to further validate the representation effectiveness for the first project (by establishing a second validation plan) and (2) to develop a validation plan for the second project. For the second project, our goal is to better characterize what is the effectiveness of a shared representation, and specifically to enrich the set of criteria for evaluating the representation effectiveness that have been used hitherto, and to structure these criteria in a coherent framework.

To achieve this goal we decided to rely on the existing literature surveying the characteristics of effective shared representations, boundary objects, intermediary objects, or related notions (see, e.g., Borch & Kristiansen, 2007; Bresciani et al., 2008; Trompette & Vinck, 2009). So far we mainly considered existing work on effective boundary objects. An analysis of this work has allowed us to discover other criteria than those we used (see Table 1), but also to highlight "evaluation approach scopes" that can be used to structure the criteria identified. By "evaluation approach scope", we mean the extent of the context of boundary object taken into account in assessing the object effectiveness, i.e. contextual elements such as the actors "carriers" of the objects, the process involving the object, etc.; this explains the use, in the "broad-scope" approaches, of such terms as "boundary spanning activity", "boundary spanner", "boundary spanning role", "boundary work", "boundary process", "boundary project", etc. For us, this "contextual broadening" means that the representation assessment should not focus only on the boundary object as such but on the "system" that integrates this object, or "boundary system". In other words, we favor the broad-scope approaches and the criteria coming from these approaches.

Table 1.- Criteria for evaluating the effectiveness of shared representations

Our Criteria	Criteria Identified (e.g. Fong’s, 2007, criteria)
Relevance	Granularity
Adequacy for representing a concept (e.g. the concept of service)	Freshness
	Malleability
Usability (e.g. of the simulation)	Inclusivity
Quality of the exchanged information	Synchronization
Innovative ideas elicited	Importance
	Understandability
	Traceability
	Accessibility

The validation plan we envision will rest on three such broad-scope approaches, the last two approaches being based on the first one: Carlile’s (2002) approach, Fong’s (2007) approach, and Holford et al.’s (2008) approach. Carlile (2002) argues that boundary objects can either be beneficial or deleterious depending on the social context at hand. Carlile identifies what can be called three levels of boundary objects’ effectiveness for knowledge sharing: (1) Syntactic level: Boundary objects as providing a common language (or shared syntax) for actors to represent their knowledge (e.g., repositories). (2) Semantic level: Boundary objects as providing a means for actors to express different interpretations, thereby allowing the possibility for novelty to emerge (e.g., standardized forms and methods). (3) Pragmatic level: Boundary objects as facilitators of processes which allow the actors to change the contents of the object in order for it to continue to be useful to all involved participants (e.g., models and maps). We see that the representations developed in our two projects apparently fall into the third category.

Relying on Carlile’s work together with complementary work on boundary objects, Fong (2007) characterizes boundary objects considered as “communication interfaces” between organization members along the ten attributes given in Table 1: (1) medium, (2) granularity, (3) freshness, (4) malleability, (5) inclusivity, (6) synchronization, (7) importance, (8) understandability, (9) traceability, and (10) accessibility. Characterizing effective boundary objects is determining which attributes of these objects or “communication interfaces” are most important in some environments compared to others. Ordinal or nominal scales are provided for determining the value of each attribute. For example: Synchronization describes the extent to which duplicates of the same artefact are linked, such that a local change in one artefact will be propagated globally to all similar artefacts. An ordinal scale is provided for synchronization, with three levels (low, medium and high) referring to the amount of effort and time required to ensure synchronization work. A case study performed by Fong showed that the most important attributes for a boundary object are inclusivity, traceability, and synchronization. Our projects show that we should not overlook the other attributes (e.g., malleability for the project#2).

Noting that Carlile’s level of analysis “tends to imply [boundary objects] as being independent variables to the subject-actor, while simultaneously implying the subject-actor to be dependent on [the boundary objects]”, and drawing upon Latour’s (1993) work on the nature and relationship of the object and subject, Holford et al. (2008) propose “to shift more emphasis on the active and dynamic role the actor has over the [boundary object]”, i.e., to consider that “the object is as much affected and transformed by the subject, as is the subject affected and transformed by the object”. As a consequence, Holford et al. “reword the factors identified by Carlile for effective [boundary objects] as follows: (1) the actors must provide a common language for them to effectively represent their respective knowledge across the help of a co-constructed or conegotiated [boundary object]; (2) the actors must provide a means to express their different interpretations across the help of a co-negotiated [boundary object]; and (3) the actors must continually co-negotiate and cotransform the [boundary object] so as to maintain an on-going pertinence to all involved participants.” We assumed above that our two projects were at level three of Carlile's scale. Holford et al.’s scale being a rewording of Carlile's scale, we could deduce that the projects are also located on level 3 of the reworded scale. However, this remains to be verified: all actors were not equally involved in the process of co-negotiating and cotransforming the boundary object so as to maintain the on-going pertinence.

The Carlile’s, Fong’s and Holford et al.’s approaches are a starting point to develop a plan for validating the actual effectiveness of our shared representations. We have now (a) to complement the criteria for characterizing boundary object effectiveness with criteria for characterizing intermediary objects and other related notions, (b) to elaborate a coherent and operational evaluation framework integrating the criteria identified, (c) to use the framework for validating the effectiveness of the representations used in our two projects.

The validation (of the project#1 in particular) should allow us to determine the relevance of the choice we have made to provide innovators with a shared higher-level representation rather than with instructions to directly articulate their heterogeneous lower-level representations. The validation should also allow us to explicit (a) the articulation work made by innovators between the shared representation and their own unshared representations, and (b) the changes or deformations made as result of the articulation work on the shared representation and the unshared representations respectively.

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Adversarial Collaboration through Shared Representations

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Abstract. This paper is about adversarial collaboration through shared representation, and its empirical basis is data from citizens and their interaction with local government. The eGov+ research project deals with the design of service applications that support the collaboration between municipal caseworkers and citizens applying for some sort of benefit or permission using the Internet to a great extent.. By analyzing the case and drawing on literature about adversarial collaboration, we present a tentative design framework. This framework presents the key dimensions to consider when a designer is aware that the users are likely to collaborate adversarially, mediated by one or several shared representations.

1 Introduction

An influential stakeholder in the Danish IT industry advocates that Danish IT services should be handled with one common interface for citizens and case workers (KL 2006), i.e. all representations of cases should be shared. The first author of this paper has argued elsewhere that this is naive in some cases

(Borchorst et al 2009). However, when citizens get advice or discuss a specific case, it seems useful that the caseworker and the citizen can see the same shared representation of the case in question. It may, for instance, be a timeline that summarizes all events in a complex case with multiple hand-ins, payments from the municipality and with several actors.

The eGov+ research project deals with the design of service applications that support the collaboration between municipal caseworkers and citizens applying for some sort of benefit or permission using the Internet to a great extent.. As a first step to understand this problem area, we tried to see a specific "service" as an activity comprising operations, necessary tasks and the overall motivating goal. It turns out that as well the skill involved as the motivation, and semantics of the activity is different for the case handler and the citizen. This difference has been explained in an activity theory (e.g. Leontiev 1978) as adhering from the difference between means and ends: for the case worker the handling is the means to get the case out of the way, making ‘getting out of the way’ the whole point, while for the citizen the handling and the handler is an obstacle/helper on the way to the goal, which is the solution to the case. Somewhat like in trading, where the seller wants to get on to the next customer, while the customer only want this one product.

In our trying to describe casework as an encounter between two activities, we found it impossible to describe casework in one coherent narrative. This is, however, what becomes point of departure, when for example a citizen wants information about rules and regulations for maternity leave, or a permission to build a carport. The caseworker knows the requirements for making a decision, but do not know the background on which the citizen makes her request. Both parties would when be talking in general terms be able to agree that "service" is when the closure feels good for both parties, while the moment of truth for each of them is whether they get the leave/permit or whether the case is closed respectively. The case handler is rewarded for keeping to the rules and for being efficient. The citizen may interpret the request metaphorically as going to a shop to buy. Both are guided by self-interest, and this colours their experience. Consequently, their view on "service" differs, although seldom spoken out loud. Seen from the point of view of the case handler the motive is "help to meet requirements". From the point of view of the citizen is efficient delivery of benefit or permit, integrated into his everyday life. So, representations may in some instances be shared, but the total object an actor manipulates stretches beyond the digital representation and into physical reality and into the life world of the actors – none of which are shared. However, we still call it collaboration in a CSCW design context.

In this paper we suggest ‘adversarial collaboration’ as a more adequate term, which we will outline in this section. We define collaboration here as a set of actions (Leontiev 1978) which are systematically interconnected, and which shape each other in terms of content, form and outcome.

The attempt to understand the case worker-citizen relationship as a common activity with shared object, and the difficulty of doing so, has made us suggest to reframe the user relationship as one of 'adversarial collaboration' (Cohen et al, 2000). They define adversarial collaboration as "Situations in which the co-authors of a document have widely divergent goals yet must collaborate in order to co-author a document" (ibid, p. 31). Here we interpret "document" very broadly, as almost any piece of persistent inscription. Not all collaboration is adversarial; only when actors have diverging goals, or diverging motives which will eventually influence the goals and norms along the collaboration process (deMoor & Weigand 2004). A use situation can be seen as a system of activities, where each activity assumes some process with a continuous outcome (e.g. a flow of readymade products or customized products) (Engeström 1990). Therefore, a case-worker-citizen collaboration over a given application belongs to different activities. In the caseworker's case, he is involved in a collective activity with other case workers, where a filed case is just a part of his stream of cases. For the citizen, the application is only a small task in the activity of raising a child.

Cohen et al deal with situations, where the adversarial nature of collaboration is completely explicit. We show how sometimes collaboration is tacitly adversarial, and that this can suddenly emerge in checkpoints and make collaboration break down. By this we hope to expand the present state of knowledge concerning adversarial collaboration.

Consequently, in this paper we present a list of adversarial collaboration dimensions derived from literature and illustrated the by eGov+ cases. The aim is to formulate the dimensions in such a way that the attention leads to a system with higher usefulness. We discuss possible alternatives and dimensions of the design space we have been operated within. Although it would also be possible to understand the user-designer as adversaries to some extent, our analysis focuses on adversarial collaboration between users and user groups. We do not expect to be able to find a formula for how all adversarial collaboration in eGovernance should be designed – that is a task that is much larger than the scope of this paper, and perhaps CSCW is too situated and applied and situated in a way that it would be an attempt of overreach.

2 Method

We have employed an iteration between literature and empirical material. Initially we used an activity-theoretical lens to understand the services in the eGovernance systems. We realized that adversarial collaboration was important in order to understand our problem (and came up with dimension X and Y). We made a literature study on all CSCW literature on adversarial collaboration, and identified the rest of the dimensions. Finally, we revisited our case to illustrate the framework.

3 The Proposed Framework

Our purpose as designers of interfaces to this kind of applications is to make the social theory help us identify some checkpoints or dimensions at a design phase or iteration. The checkpoints may be possible to generalize across a number of e-government applications with shared representations such as divorcing, legal disagreements, ombudsman conflicts, right of access to documents, parental leave, getting a new passport, etc.

Consequently, the framework, shown in Table I below, expresses dimensions for the design space of adversarial collaboration in shared representations. What is the design space? We do not conceive it as the visual aspects of the representation only. Here we adhere to a relationist stance; it is more interesting to study the relations than independent entities (see e.g. Ritzer & Gindoff 1992 for an elaboration). We delimit this work to what is only directly related to the shared representation. Things that are indirectly related are beyond the unit of study (for instance it would be interesting as a designer to know the history of the adversary in his use case, but that is delimited in this study). The dimensions are only related to adversiality, not *merely* collaboration or shared representations in general.

Table I. A framework that describes key dimensions of adversarial collaboration mediated by shared representations.

Dimension	**Source**
Shared Motive-diverging Motive	(deMoor & Weigand 2004)
Shared goals - Diverging goals	(deMoor & Weigand 2004, Cohen et al 2000)
One activity - cross activity	Activity Theory analysis
Explicit adversaries - tacit adversaries	Gap in literature
Harmonization or acknowledgement of adversarialness	Activity Theory analysis
Alone versus Together	Bohøj et al 2010
Contract or sandbox	Bohøj et al 2010
Record keeping or planning functionality	Bohøj et al 2010
What others have done as authoritative road or for inspiration	Bohøj et al 2010
Open or closed information space	Bohøj et al 2010

The dimensions which the designer could use to conceptualize his design space with are listed to the left in the table. To the right are the sources from where we derived the dimensions. We will now briefly describe the dimensions, and in the following section they will be exemplified.

The first dimension is the **motive** – do the adversaries have an identical motive or are they different? The motive should not only be thought of as the concrete output, but also in the context of needs and subjectivity.

The next dimension is the **goals**. Independent of what motives actors have, their goals may diverge or converge. It cannot be presumed that collaboration with shared representations involve *one* object of work only.

The third dimension, **number of activities,** is more theoretically complicated. First, collaboration can take place as one activity, or over a number of activities. Matusov (1996) argues that within *one* work activity, it is misleading to see disagreement (adversarialness) as the disjoint elements of actors' motives. Rather, disagreement is the outcome of the activity. This is not necessarily true for cross-activity adversarial collaboration. The adversarial collaboration inside an activity is therefore qualitatively different from cross-activity adversarial collaboration. For instance, it is self-contradictory to harmonize the interests without changing the rest of the activity.

A common dilemma in conflict resolution is the dimension of **tacit-explicit adversion**. Should the designer invite that users are open with their disagreements with other stakeholder, in the hope that this will facilitate interaction more efficiently than if the stakeholders are navigating without declarations from their adversaries. Explicating functions can exist on at least two levels. The first is mere declarations. The second, and more advanced, is mechanisms that try to make the users be sincere in their declarations. This is clearly a dilemma; an example of where it is intuitive that it is unwise to make adversaries explicit is when the collaboration takes place under strong time pressure. Perhaps stakeholders loose time because they start to resolve an issue they strongly disagree on, but this is highly unlikely. Another example is when designers think that it is better to have an agreement that may break, than to have a solid foundation.

Another problem is harmonization or acknowledgement of adversarialness. Designers may have the ambition to remove adversarial collaboration, e.g. by insisting that adversaries reach consensus. They can also be more "hands-off", i.e. agnostic about adversarial collaboration, perhaps they think it is inevitable in their design context. It may even be relevant to speak about pro-adversarial collaboration; where designers encourage the users to disagree and move in directions that enlarge the gap between users, because that will improve the outcomes of the process or summon some desired user experience.

Collaboration between citizens and municipality is often individualized, when the real question is if users should collaborate with municipality alone or together. For instance, applications that may require several citizens to apply for a service, e.g. parental leave in Denmark, is compartmentalized so that each citizen sends a form to the municipality, instead of a joint application. Communication can therefore be represented in terms of one citizen to one municipality. It is not always self-evident that it is beneficial, and may be a result of legal issues and traditions rather than for supporting a service which is easy to understand or for providing information that can be used by citizens for decision-making. There seems to be a design spectrum that includes more fine-grained sharing mechanisms than “this is my case, and this is your case”.

Another important dimension is if the shared representation should represent binding but incompletely filled in contracts/agreements, be a sandbox for negotiation and proposals, or a combination. A similar dimension concerns the question of whether the functions available for manipulation of the shared representations should cover record keeping (the past states) or the future (plan ahead). In some cases, it is necessary with different historical functionalities such as history, versioning, rollback, etc. In other cases, it is more interesting to be able to see future states (extrapolating existing tendencies, have several alternative futures, etc). And finally, it may cause the interface to be cluttered to have all record/plan functions.

In eGovernance, a common use pattern is to do what others have done. Sharing templates or suggestions is a part of collaboration. The question is if and how authoritatively they should be presented, or if they only should be shown for inspirational purposes.

The last dimension concerns whether the space should be an open or closed information space. On the one extreme, all types of actors can enter data (compare a wiki with no access restrictions). On the other extreme, the information channels are sliced so that only two types of actors communicate with each other through the same representation (compare ordinary one-to-one telephony).

There are dimensions in this meta-design space that are impossible to occupy in the context of adversarial collaboration. If motive and goals are both shared, for instance, it is no longer adversarial collaboration. That is, however, not a conceptual problem.

A final remark; Quite many of them arose from one of the first author’s previous work. The first author’s paper “timeline collaboration” reports designing for collaboration with timelines. The timeline is thus a shared representation, is based in the institutional context of eGovernance, and it has adversarial elements (users act to some extent with secrecy, advocacy and discovery). A framework for that design will therefore always tentatively to apply for a more general domain; but not only timelines, but also other shared representations in graphical user interfaces.

4 Illustration of the framework

In this chapter, we illustrate that the framework is relevant for each dimension. We also demonstrate that the dimensions do not have a “one best way” solution placed at a specific point of the dimension for any design, but where to place it (e.g. as an authoritative generalization or only for inspiration?) depends on the specific context of a given design task. This is true even within the relatively narrowly defined domain, (eGovernance, and shared representations).

It is important to know goals and motives for stakeholders in order to understand the design. As mentioned in the introduction, the caseworkers and citizens have **diverging motives**. During design work of a system for parental leave cases, it was not intuitive for caseworkers that citizens needed to enter e.g. when they wanted to have their children in day-care. Such information on the shared representation that was not relevant for the evaluation of the case itself when the caseworker evaluated the shared representation and compared it with her interests. But it was for the parents; a failure here would in the worst-case mean that both parents needed to work, but no day-care institution would be available for the kid. So, we may elaborate what we said in the beginning. Their goals are seemingly identical if one just looks at the final shared representation (a correct, approved case). However, their motives, which colour the criteria of the goals, differed.

We concur with deMoor and Weigand (2004) that sometimes the motives can be shared, but the goals may diverge as well in our context of shared representation. In our MobileDemocracy case, citizens comment on municipal planning using mobile phones and maps, which they annotate. The citizens may share the motives that a given village should have a positive economical development, but whereas one citizen may be prepared to put in voluntary work in order to reach this motive, others may have as their goal to pressure the municipality into realizing the same motive. Such situations are the easiest to resolve by communication over the representation; one side can realize that a strategy is inefficient, and e.g. that it is faster and more likely to be successful if some voluntary work is done (of course many situations will be more complicated; e.g. the belief that if one do voluntary work, the municipality will try to cut down resources in a local area even more).

It makes a difference between a design space where all users are engaged in the same activity and where users are in cross-activity collaboration. In what way? Within the same activity, disagreement is an aspect, not a result from comparison of motives (Matusov 1996). If we by analysing the users can ascertain that people have a shared activity, for instance among case workers in building permit admission and have shared representations, then they can be motivated to cooperate and co-construct their work (Bardram 1998). To such an activity, it make sense to provide functionality such as discussion about templates and best practices over a given shared representation, to provide organizational incentives for end-user programming, etc. If there is no dominant shared activity, the norms will diverge between activities, and a developmental project will be more complex. It will require more careful management. So, norms and best practice facilitation are conditioned by this dimension.

In our ongoing project on MobileDemocracy, we are incorporating functions that encourage participants to give proposals that also express solutions to needs of the opponents. The idea is to remove some adversarial elements that lead to deadlocks in the political process. This also explicates the adversaries built into the stakeholders' configuration. This kind of function would not be as relevant for instance in an application for case processing. It is not practically possible for an individual caseworker to change her objectives and interests in the particular case, at least not in the case of parental leave we have studied. That would require a fundamental redesign of the organizational objectives.

The dimensions of 'alone or together', 'contract or andbox', 'record keeping or planning functionality', 'authoritative road or for inspiration', and 'open or closed space' have already been discussed in Bohøj et al (2010) and will be omitted here due to space constraints.

5 Discussion and Further Work

This is obviously a framework under development. What we have done above is only to illustrate that the framework highlights interesting design questions. The next step is to substantiate that the framework is relevant beyond mere illustration.

The framework presented in this paper is not per se restricted for shared representations. It is not a goal in itself to create frameworks that work only for collaboration in shared representations but not non-shared representations. What we have done in this preliminary work is to challenge it in one out of several possible empirical domains. One future research strategy is to start with a narrow empirical domain (collaboration in shared representations and in eGovernance) and then generalize it towards non-shared representations and other institutional settings. The narrowing down could have been done in other dimensions.

The condition that representations are shared, however, occupies a special place in adversarial collaboration. Although it is theoretically possible to meet only in F2F, the typical adversarial collaboration situations probably involve some shared representation, even if it is simple PDFs. They constitute the digital battlefield and are therefore important for designers of IT systems if they want to understand adversarial collaboration.

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Mediating helpers for remote service provision

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Abstract. In this paper we discuss and introduce a framework for what we propose as a 'class' of CSCW systems – mediating helpers – that can provide assisted remote service provision among different groups of users with differing needs and characteristics. We make reference to two systems we have defined that can be seen as mediating helpers and that have inspired the current definition of this framework. We also describe some links among the mediating helpers framework and other conceptual frameworks, such as boundary objects and intermediary agents and discuss current work that comprises refining the concept and applying it to different domains.

1 Introduction

In the CSCW field a computer system is defined as a set of services that users/actors can use to access/create some resources and perform a task. Whereas a lot of research activities have been focused on defining how the system could enable the coordination or the negotiation between the users when accessing the resources, they do not address well the underlying communication problem encountered by the users, due to the fact that each user has its own conceptualization of the resources available for a service. For instance, tasks previously requiring specialist skills are routinely becoming part of the work of non-specialists in those tasks. It's often when people have to work across organisational boundaries that such differences in expertise are made manifest. This is because those workers often do not have easy access to the resources within the other organisation which could help them address the mismatch of expertise.

Instead of a system assuming commonly predefined definitions of the resources, we suggest that the system can act as a *mediating helper* between the users. In the recent years, we have worked on the design of several systems across different domains of applications, where the provision of a remote service is challenged by the underlying communication problems between users. For each project, our focus was to better address the provision to the users of a common understanding of the problem and resources being manipulated through the design of an appropriate shared representation. Reflections and lessons learnt from these individual projects motivated us to define the mediating helpers' framework. We believe that seeing a system as a mediating helper could be a useful thought framework for designers of collaborative systems involving provision of services across organizational boundaries in order to 1) understand the difficulties introduced by the context of the application and identify the users' needs and 2) explore all the dimensions where the designers can act and propose functionality that would reduce the communications gaps.

In this paper we will first introduce two cases of study and design in the domains respectively of remote troubleshooting of devices and colour management in digital document printing. We will then use these two reference examples in order to present our characterization of a mediating helper and illustrate how it can be used to inform the design of a system.

2 Summary of two design experiences

2.1 Remote collaborative troubleshooting

Office devices, e.g. printers, are often shared resources utilized by a variety of different users with a variety of different skills and abilities. When a user encounters a problem with a machine and cannot resolve it himself, he calls a support organisation for assistance. Users and troubleshooters communicate over the phone working together to understand what the problem with the device is, what the appropriate solution is and how to apply it. As described in O'Neill et al. (2005) and Castellani et al. (2009) a number of difficulties arise doing this work. For instance, users and troubleshooters need to routinely describe parts of the device and give spatial directions or descriptions since users do not necessarily have the technical vocabulary to identify device parts by name and the troubleshooters cannot indicate them directly on the device. The lack of access to the device for the troubleshooters results in effort being devoted to produce instructions and directions without being able to see how they might be appropriately framed to the current circumstances, i.e. status of the device, actions of the users, etc.

In order to help users and troubleshooters to overcome these difficulties and better support their work we have designed and built a collaborative troubleshooting system (Castellani *et al.* 2009) based on the idea of providing users and troubleshooters with a shared representation of the device status and the troubleshooting problem. The shared representation mainly consists of a 3D model of the device and a number of means of interacting with it adapted to the user and troubleshooter roles in the troubleshooting task. The shared representation is presented to the user on the device and to the troubleshooter on his terminal. The representation is linked to the device itself, such that actions on the device are shown on the representation, e.g. if a user opens a door, that door will appear on the representation and the troubleshooter will see it. This is enabled through the sensors that reside on the devices. Reciprocal viewpoints are supported and remote troubleshooters and customers are able to coordinate and co-orient around the representation of the device. Figure 1 and Figure 2 show an example of the viewpoints respectively for the troubleshooter and the customer.

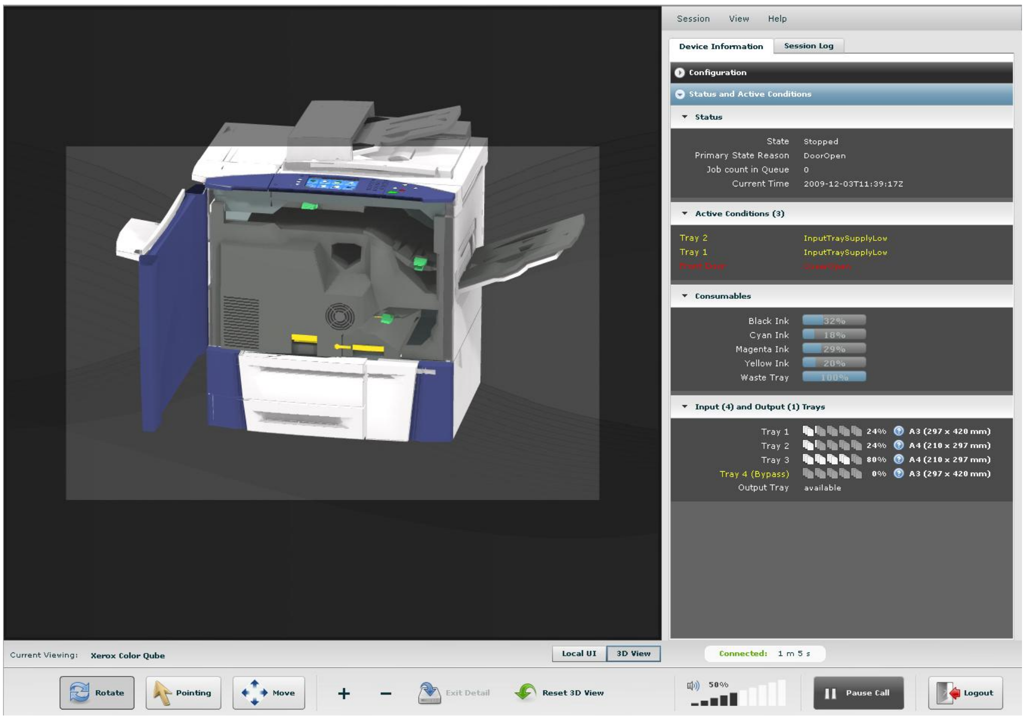

Figure 1: The remote troubleshooter interface.

The troubleshooters' interface includes also information on the operation parameters of the device and a history of past interactions with it. Troubleshooters can view the device representation from different spatial perspectives, to facilitate at-a-glance recognition of problems. They interact with the representation to demonstrate visually actions which should be performed, e.g. lifting a handle and sliding a toner cartridge out of the machine.

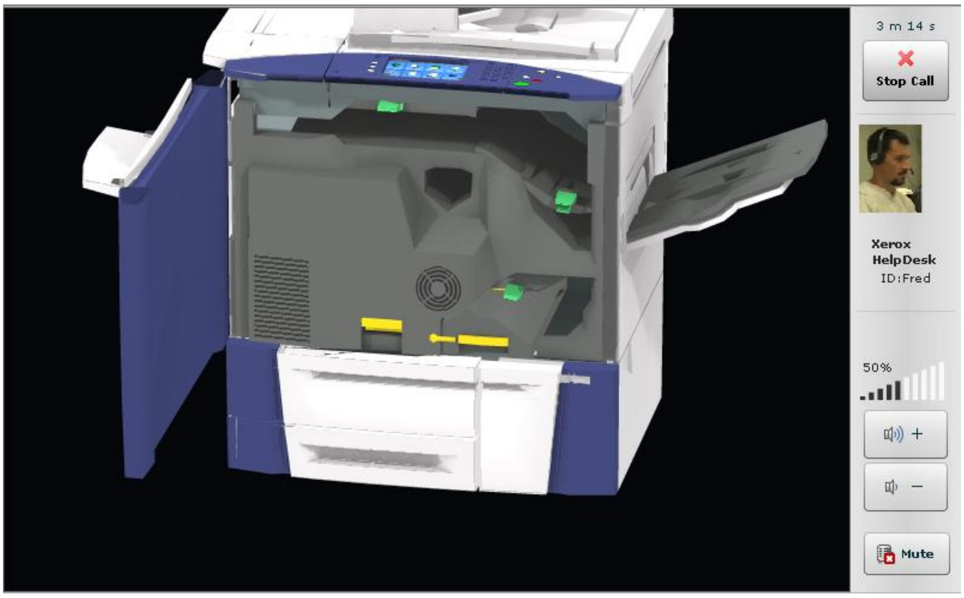

Figure 2: The customer interface.

Troubleshooters can see the actions performed by the customer on the device which trigger sensors thus they can infer, for example, if the customer is following instructions correctly.

On the customer side, the user can indicate device parts to the troubleshooter through the touch screen.

2.2 Colour management workflow

In digital colour production printing workflows designers create documents and submit them for printing to remote printshops. While ideally the document designer would submit print ready files, i.e. files containing the exact and complete specification of the desired target colours, the currently observed workflow usually consists of a significant number of iteration cycles between the document designer and the print shop operator before a satisfying print out is obtained. The reason is that the problem of colour reproduction across various displays and printers is a very complex socio-technical problem that state of the art approaches have failed to solve as explained in Martin et al. (2008) and O’Neill et al. (2008). These studies have in particular highlighted the mismatch between the way document designers think about colours and the way they are handled by colour management infrastructure as a barrier to the creation of documents prepared for being printed accurately. Another issue is related to the fact that the printer operator cannot get any cues of what is the original intent of the designer with respect to colour when the result is not satisfying.

It is along these ideas that we have designed the Print Mediator system (Willamowski *et al.* 2010), which provides support for communication and colour problem detection and correction during print job submission.

The document designer will use the system at the document submission stage to foresee and appreciate potential colour issues when printing the document. Through the review interface shown in Figure 3, the system will assist the designer in either applying immediate colour corrections or in specifying and communicating corresponding requirements to the printer. The printer operator or a pre-press agent will afterwards also use the system to visualize the submitted document together with the requirements added by the submitter and select the appropriate print options depending on the designer's requirements.

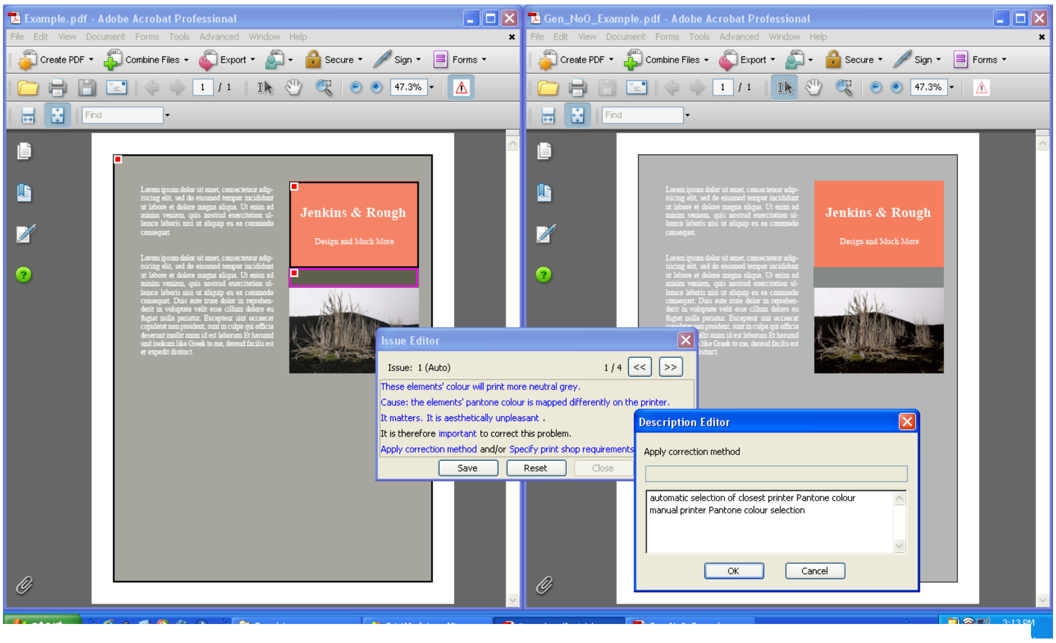

Figure 3: Print Mediator comparative soft proof view with original document on the left and simulated print result on the right.

3 Definition of a Mediating Helper

Although the two systems presented in the previous section differ in terms of services provided, resources being shared and technology being used, they can be seen as two instances of the same abstract class of Mediating Helper systems. A mediating helper is a conceptual view of a system as a mediating technology component whose role is to improve the communication between some users accessing a service by providing a common understanding of the task being performed and the resources being manipulated. A mediating helper can be seen in a very schematic way as described in Figure 4.

A mediating helper incorporates all the service information resources being manipulated by the users. Some of the resources are created during the collaborative activity and some are created by technical editors.

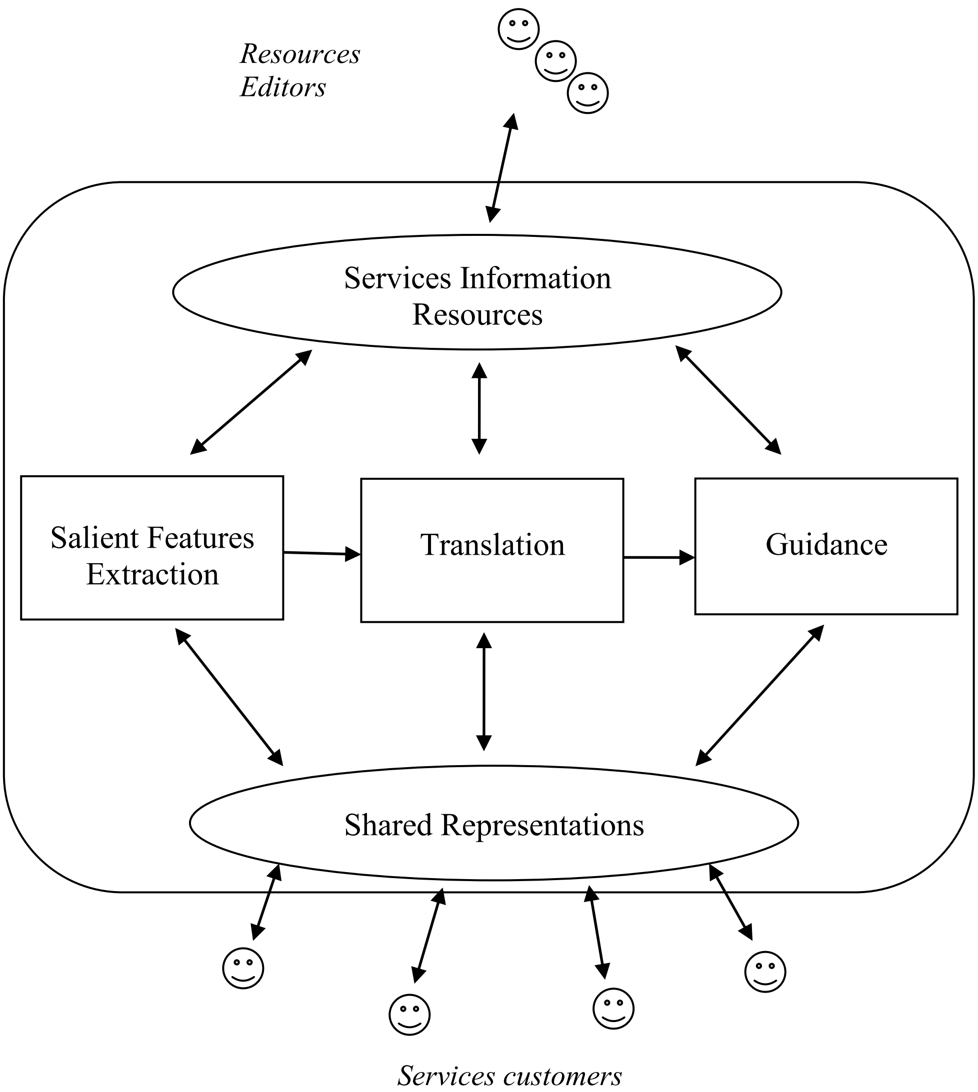

Figure 4: Mediating Helpers components.

The technical infrastructure being used and the way it is configured can be seen as well as part of the resources being manipulated by the users. The resources are made available to the final users of the service through a shared representation. This representation can be of different nature: physical/digital, audio/written/visual content, structured/unstructured. It may be accessed through different user interfaces corresponding to different types of users or roles and show an individualized perspective of it. In order to bridge the resources and the different user perspectives with this shared representation the system must provide some mediation capabilities.

We have identified three levels of mediation that can be provided whatever the nature of the representation. However, the type of technology being used will be very different depending on this nature.

A first level of mediation that can be provided is an extraction of the salient features within a resource. This means extracting from the overflow of information available within the system the pieces that will be of particular use to a group of users or to an individual user at a particular moment of the activity. For example, in a device troubleshooting activity this could be the current or recent error codes that were associated to the component of the device being troubleshooted by the user(s). The extracted features can be provided as such to the end-users so that they can assess more quickly the problem or the situation. However, a further level of mediation is often required before they can be added to the shared representation and used.

A higher level of mediation is to provide a translation between the resources and the users if the users do not have the right level or domain of expertise to directly manipulate the resources (e.g. a machine part illustrated graphically or a fault code translated into a user understandable message) or between two users' perspectives on the same resources (e.g. a designer and a printer).

Finally, the highest level of mediation that a mediating helper can provide is to be able to guide a user in his task or to coordinate several users according to the translation mechanism it uses to interpret the exchanged resources. For example in a device troubleshooting activity, the system may know which actions can be performed given the state of a device component being investigated by the users. It can therefore make the list of possible actions available to the users in order to help them to decide on their next steps. This level implies that in addition to having access to some translated features of the resources, the mediating helper has some knowledge of the domain of the activity in order to assist the users.

4 Characterizing a system as a Mediating Helper

We suggest that the design of a mediating helper can be articulated around the identification of the following points:

- The needs
  - What is the nature of the resources being shared?
  - What are the perspectives of each type of user and how do they differ?
- The proposed solution
  - What is the nature of the shared representation that can be used?

- What can the system do in order to appropriately mediate between these perspectives across the three levels of mediation: extraction of features, translation and guidance?
- What is the technology that can be used to enable the mediation?

These points are interrelated and cannot be answered sequentially but rather through some design iterations. We illustrate below how they relate to the two design cases that we have introduced in section 2.

In the remote troubleshooting case, the **resources** being shared are the status of a broken device and the objective of the system is to help users and troubleshooters to collaboratively move it back to a normal working state. The user of the device can see the device physical status and is aware of the symptoms of the problem but lacks technical knowledge. The remote troubleshooter has the technical knowledge of how the device works and what are the potential causes of a problem but lacks some access to the device status.

In the system that we have designed, the device status is **represented through a shared 3D view** of the device. A semantic model defines the properties of the device that are relevant for troubleshooting and the way they are mapped from the device sensors to the 3D view. Our system **extracts** the status information from the device that is relevant for troubleshooting and **translates** it into the 3D device representation shared between the local user and the remote troubleshooter. The 3D representation is also used to translate name of parts and operations into visual elements that can be pointed and operated to compensate the lack of technical terminology of the end-user during his dialogue with the remote troubleshooter. Finally, the system provides **guidance** in showing to the remote troubleshooter the actions that can be performed on each component of the device. The remote troubleshooter can select among these actions the ones that s/he wants the end-user to try. Another level of guidance is provided by the interaction protocols defined for synchronizing the two views of the representation according to the activity, which allow, for example, coordinating the provision of controlled step-by-step instructions to the end-users.

In the case of the colour management workflow, **the resources** being shared are the document submitted, in particular the colour specifications, and the printer characteristics i.e. the colours the printer can reproduce, the way colours are rendered, and the actual print queue settings modifying the colour rendering process. Furthermore, available colour correction components might be considered as resources. The printer of the document is aware of the printing capabilities but not of the original intent of the document. Reciprocally, the designer has a precise idea of the intended message conveyed by the colour of the documents but do not know what the capabilities of the printers are and what is the best way to obtain an accurate reproduction of the document intent.

The **shared representation** is constituted on one hand by the comparative soft proof view of the document that motivates the designer to indicate and specify apparent colour problems. On the other hand it visualizes the detected colour issues and their current status. The issues and their current status are included in the document and can therefore be exchanged and solved collaboratively between the designer and the print shop operator. From this visualization both users can engage the problem solving process for each issue. Human perceivable colour differences and any colour settings that can explain the cause of the differences are **extracted** automatically by the system. A colour **translation** technology allows the system to describe both the underlying numeric colour values contained in the document and the observed numerical colour differences between the original document and the printed version in natural language. This makes colour and colour differences easier to appreciate for non colour expert human users. **Guidance** is provided during the problem specification and solving process where natural language templates adapt to each user expertise and concerns. This facilitates the required interaction to specify the colour problem, its relevance and the important aspects to consider, and finally enables solving the problem providing an interface to relevant technical colour processing components.

5 Discussion

The shared representations in our mediating helpers framework are related to the "boundary objects" concept (Star and Griesemer 1989). For example:

- "Boundary objects are artifacts that allow information to be exchanged across organizational, team, and other boundaries" (Phelps and Reddy 2009).
- "They contain sufficient detail to be understandable by both parties utilizing the object, although neither party may understand the full context of use by the other" (Star 1989).
- "Their main purpose is to carry information and context that can be used to translate, transfer, and transform knowledge between communities of practice" (Ackerman 2000).

Actually, our shared representations in connection with the service resources for mediating helpers as shown in Figure 4 are close to "intermediary objects" (Vinck and Jeantet 1995). Intermediary objects act as boundary objects but they are also intermediate states of the product when considering the objects as mediators translating and representing the future product (Boujut and Blanco 2003).

Since their definition from Star a lot of work has been dedicated to study the role played by boundary objects in several contexts and domains, e.g. in group collaboration in construction project teams (Phelps and Reddy 2009), collaborative reuse in aircraft technical support (Lutters and Ackerman 2007), cooperation fostering in engineering design (Boujut and Blanco 2003) to cite a few.

Both the concepts of boundary objects and intermediary objects may be mapped quite nicely onto our framework for mediating helpers. This, it can be argued, may be due to appropriateness of fit but it may also be to do with a certain looseness – and even mobility – of definition. We might make a distinction in terms of the fact that we have a fuller description of the framework for mediating systems – (1) they are CSCW systems, (2) our systems are based on the findings of ethnographic studies that allow us to discover, we would argue, relevant user requirements for the shared representation and assistance, (3) so far they have been applied in situations of organization-customer cooperation in definite tasks, and less for knowledge sharing, and (4) we have a more clearly defined framework in terms of task and resources with three possible levels of assistance: extracted features, translation and guidance.

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Mediation Role of Boundary Objects in Articulating Common Information Spaces

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Abstract. In this paper we conceptualize the mediation role of common information artifacts in articulating collaborative work. The artifacts are perceived as boundary objects and are characterized as devices for mediating local and global articulation, interpretive articulation, and organizing coordination. This conception is based on Grounded Theory driven qualitative study of collaboration among heterogeneous work communities in the air traffic control work process. Each work community setting in the airport is taken to be a Common Information Space (CIS), with the airport constituting multiple overlapping interdependent CISs. The common information systems comprising the CIS of different work communities act as boundary objects. These act not only as devices for placing information in common across different work communities but also as devices that help synthesize multiple perspectives and establish common enough interpretation of shared information to undertake tasks collaboratively.

1 Introduction

In the field of Computer Supported Cooperative Work (CSCW), research has been undertaken to provide support for articulation of cooperative work through the construction of information spaces, which are viewed as communication or interaction spaces (Schmidt and Bannon 1992). A number of terms have been used to describe such spaces, namely, shared workspaces, shared information spaces, shared and common communication spaces, and more recently common information spaces (Bannon, 2000). The notion of Common Information Space (CIS) was put forth as an extension of the concept of shared information space by (Schmidt and Bannon 1992). According to this notion, CIS does not represent just a repository of information to which people have common access but also how different people incorporate it in daily usage and integrated it into their work practices by establishing 'common enough' understanding of shared information. Although some scepticism has been raised by researchers concerning the loose definition of this concept, most researchers seem to perceive a value in this notion. For example, (Reddy, Dourish and Pratt 2001) consider it valuable because the concept "*relates shared information to the activities that are conducted over and through the information*" and "*it offers a perspective on how shared information is incorporated into daily work practices*". The notion is still in its early stages of development and more work needs to be undertaken to strengthen its conceptualization. In the CIS literature, cooperative work has been mainly analyzed by focusing on how information represented in artefacts which are common to different work communities have been employed through the work practices surrounding their use. We perceive these common artefacts as boundary objects (Star and Griesemer 1989) and analyze how they perform various mediation roles to support articulation work in a collaborative work setting.

In the next section we briefly present the data collection and analysis method driving this research. Then the field study setting is described in the form of CIS of an airport. The mediation roles played by artefacts common to different work communities are presented next. Finally, the paper concludes by presenting the contribution of this study to the conceptualization of mediation roles of shared representations in cooperative work.

2 Research Background

The discussion presented here is part of an investigation aimed at contributing to the development of the notion of Common Information Space (CIS). The study focuses on collaboration among different work communities in Air Traffic Control (ATC) work environment, particularly in and around the airport. The work communities studied are the Control Tower, Airlines Crew (pilots), Approach Control, and Operations Centre. Field studies have been conducted at a medium sized airport in the United Kingdom over a period of three years. Data was collected through the ethnographic techniques of observation, semi-structured interviews and concurrent protocol conducted with personnel working in the Control Tower and Operations Centre of the airport. This was supplemented with secondary data sources such as photographs, audio recordings of conversations, technical documents, and literature on the field site. The discussion presented in this paper is based on the analysis founded on Grounded Theory methodology (Glaser and Strauss 1967).

3 CIS of Airport

The airport is characterized by multiple work communities whose physical establishment is considered to be work centers and are placed in a vastly distributed setting. Each work community setting is perceived to be a CIS with the airport consisting of interdependent overlapping CISs (Figure 1). The CISs are heterogeneous with respect to the physical space, social space, and information space.

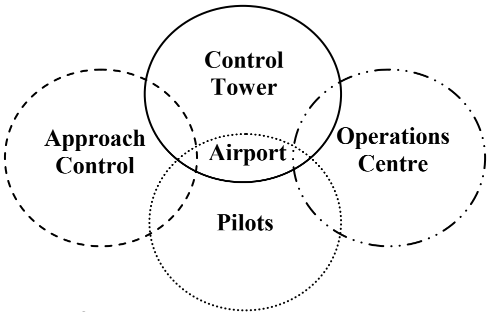


Figure 1. Overlapping CISs of Work Communities In and Around Airport

Among the many work communities residing and functioning within the airport, three central work communities were chosen, they are: the Control Tower, Operations Centre, and Aircraft Pilots. Another work community considered for this study is the Approach Control, which resides outside the airport but is integral to the functioning of the other chosen communities residing within the airport. In this paper, the focus is on information artifacts common to these work communities with the aim of theorizing how they mediate articulation work required to function collaboratively.

4 Role of Common Information Artifacts in CIS of Airport

A framework of the mediation role played by common information artifacts in the CIS of an airport is presented in this paper. Two such artifacts, Flight Schedule Information System and Departure Status Information System, are used to depict the mediation role characterization. These artifacts are considered to be boundary objects and were found to perform various mediation roles based on the practices by which information presented by them was put to use by those utilizing it. The artifacts are characterized as

- Device for Mediating Local and Global Articulation
- Device for Interpretive Articulation, and
- Device for Organizing Coordination

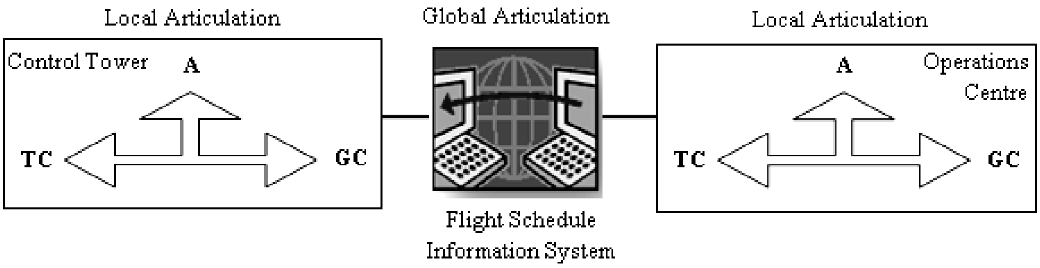
In the ensuing sections each of the above roles is discussed through the concepts emerging from Grounded Theory analysis and illustrated through field data.

4.1 Device for Mediating Local and Global Articulation

The analysis revealed that local articulation is required to coordinate work of individuals within a work community. In addition, global articulation work is needed to manage dependencies among the different work communities and coordinate their activities during task performance. They are not discrete activities and in order to collaborate across heterogeneous work communities in the airport, there is a need to interweave local and global articulation. The following transcript from the field data illustrates this.

> The Assistant has to print the flight strip half an hour before the aircraft has to depart or arrive, put them in strip holders and place it on the corresponding controller's strip racks. For inbound and outbound aircraft, the parking gate number for the aircraft has to be written on the strips. The parking gate number is provided by the Apron Control and is fed into the *Flight Schedule Window* system by them. If the gate number is not available in the system, the assistant has to telephone the Apron Control to find it. She has to check the SLOT time from the *Flight Schedule Window* system and write it on the strip.

In the above transcript, to articulate activities locally within the control tower, the assistant has to articulate activities globally with personnel in another work community, the operations centre, which manages the apron area in the airport. This Flight Schedule Information (FSI) system is a common artefact in that the assistant in the control tower and the ground controller in the operations centre each have their own system through which the two work communities can place and hold information in common (Figure 2). The syntax and presentation of information is standardized in the system, thereby rendering common information representation across multiple personnel.



A – Assistant, TC – Tower Controller, GC – Ground Controller

Figure 2. Flight Schedule Information System Mediating Local and Global Articulation

Three kinds of dependencies are addressed in this scenario. One is the procedural dependency, where the flight progress strips (FPS)[1] (Figure 3) required by the controllers in the control tower are to be provided by the assistant. Also, the gate number (*Stand* [2] in Figure 3) is to be provided by the ground controller in operations centre to the assistant in the control tower through the FSI system.

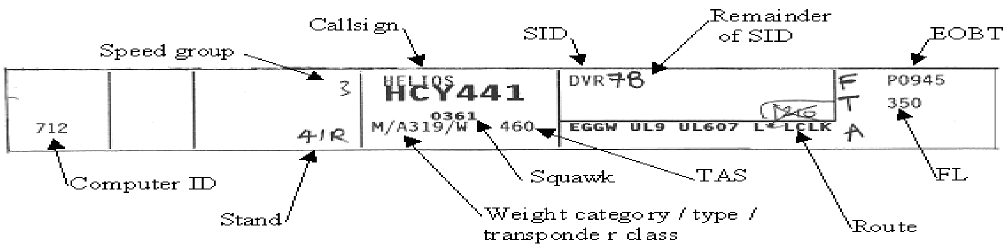


Figure 3. Flight Progress Strip

The task of managing inbound and outbound aircraft by the controllers in the control tower also entails information dependency between personnel. Within the control tower, this dependency between the assistant and controllers is managed by the assistant printing the FPS with information from the Flight Schedule Information System and physically taking it to the controllers to place it on their strip holding bay. The information dependency between the two work communities of control tower and operations centre is managed by the ground controller in the operations centre entering the gate number in the FSI system.

Another dependency to be managed is the temporal dependency. In this scenario it is invoked by the timing of flight strip provision to the controllers in the control tower by the assistant, which is half an hour before an aircraft departure or arrival. Hence, the gate number has to be provided by the ground controller in the operations centre by the time the FPS is printed by the assistant in the control tower. In the event the gate number has not been provided within the required time, the assistant in the control tower telephones the ground controller in the operations centre to obtain the required information.

In this scenario, articulation work taking place within the control tower and between control tower and operations centre is not discreet. The dependencies in the work process necessitate 'meshing' (Schmidt 1994) of local and global articulation work during which the FSI system forms an overlap in the information space of the two work communities. Articulation work taking place within the CIS of the operations centre produces the gate number made available in the FSI system. This in turn is required for articulating activities within the control tower. Thus, the FSI system acts as a device to mediate the local and global articulation work required to manage various dependencies arising during task performance.

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1 paper strip containing information the controllers need to know about a particular aircraft

2 location in the apron area of the airport where aircraft are parked

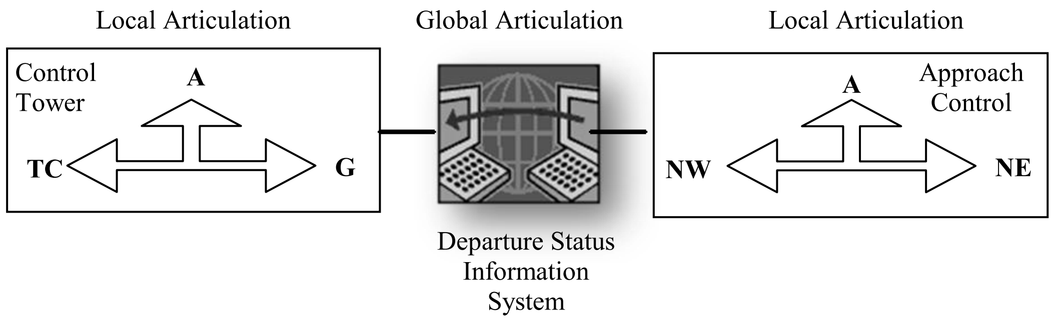
4.2 Device for Interpretive Articulation

One of the main aspects of the notion of CIS is the interpretive component where there is a need to establish common enough understanding of information for communities to work collaboratively (Schmidt and Bannon 1992). An important aspect of this is "Synchronizing Perceptions", a concept derived during the Grounded Theory analysis coding process. Any translation of information placed in common among different work communities is achieved by unfolding the standardization of information representation and adapting it to changing conditions. Since interpretation of common information occurs during task performance, it is relative to the conditions in which task performance takes place. ATC being a dynamic environment, perception of personnel functioning in varying conditions affects the way common information is interpreted and utilized. Therefore, it is vital that sufficiently common understanding of information is established to collaborate efficiently.

The common information artefacts, besides overtly facilitating information sharing also covertly serve other purposes such as revealing contextual conditions, indicating task performance status, and creating situation awareness. This has been revealed during the coding process. An example illustration is the role played by the common information artefact – Departure Status Information (DSI) System – depicted in the following transcript extracted from the interview conducted with the ground controller in the control tower.

> The 'Departure Status Information' screen is used to give messages to the Radar centre as to what state the traffic is in the airport. When I (ground controller) give an aircraft pushback or annotate it with an active sign, the Assistant at the radar centre will put the strip in front of the Coordinator there. When it taxis out to the holding point, our Assistant will then put a hold and again take-off on her Departure Status Information screen. So basically what it is is situation awareness with the Radar centre down the road.

The DSI system is common to personnel within the control tower and between personnel in the control tower and approach control. Each personnel from these two work communities required to collaborate during aircraft departure have their individual DSI system. These systems are linked and facilitate placing information in common across the two work communities (Figure 4). The scenario depicted in the above transcription is that of aircraft departure from the airport. This task requires collaboration among multiple personnel from the different work communities of control tower, aircraft pilots, and approach control. The DSI system provides information about departing aircraft and is represented in the same way across all DSI systems. Personnel in the control tower change information in the system depending on the location of the aircraft during its movement from the stand to the runway. Hence, changes made to this common information artefact reflect change in status of elements in the work environment.



A – Assistant, TC – Tower Controller, GC – Ground Controller, NW - North/West Coordinator, NE - North/East Coordinator

Figure 4. Articulation between Work Communities through Departure Status Information System

The syntax and depiction of information is standardized across these multiple DSI systems to provide a common view (Figure 5). Each row on the screen contains information about a particular aircraft with information representation being similar to that of the paper Flight Progress Strip (FPS). The menu on top of the screen provides options for various functions.

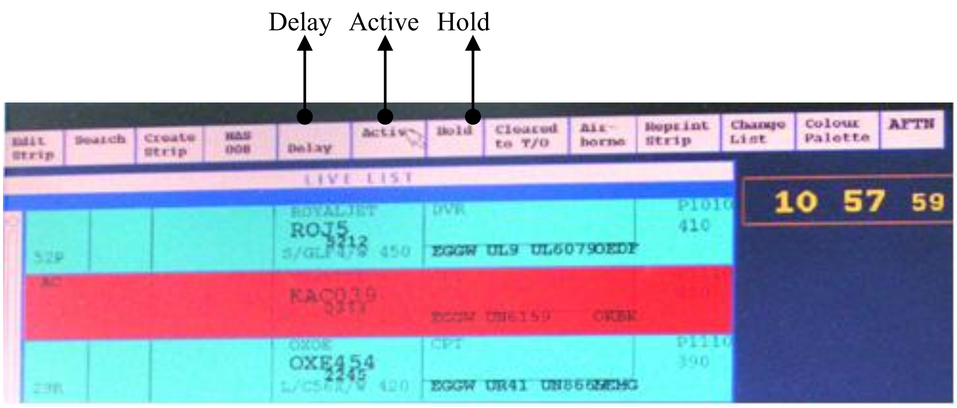


Figure 5. Departing Aircraft Status Information Representation on DSI system

In this scenario, when the ground controller in the control tower has given the departing aircraft pilot permission to push-back from the stand, he annotates the corresponding aircraft information in the DSI system to “active”, which changes the colour (from blue to red) on the system screen. This is reflected in the DSI system of the assistant in the control tower and the radar controller in the approach control. The assistant in the approach control will then print the paper FPS and hand it over to the corresponding controller there.

Then, when the aircraft moves from the stand onto the taxiway and reaches a holding point near the runway, the assistant in the control tower will change the status of the strip in the DSI system to “hold”. This changes the colour of the strip again and gets reflected in the ground controller and radar controller’s systems. In case the aircraft is unable to depart at the allocated slot time after pushback clearance, the status of the strip in the system is changed to “delay” in which case the assistant in the approach control will remove the strip from the coordinator’s strip holding bay. This is illustrated in the following interview transcript with the ground controller in the control tower.

> Delay, if he decided he couldn’t go now…if he has got a technical problem or if the passengers haven’t turned up, the strips sitting out there now at the Radar Centre (now I’ve done that), they don’t want loads of strips cluttering their bays if they are not going, so if it wasn’t anything going I will press the delay button… the assistant would probably go and pick the strip off the display, put it back in the pending bay, to remove the strips off the board because there are a hell of lot of strips down in the Radar because they have a lot of traffic to deal with.

Aircraft information in the DSI system is constantly updated to reflect the changing conditions in the airport. The approach control is spatially separated from the airport and personnel there cannot view aircraft movement in the airport. This system helps overcome the drawback by creating awareness of the state of the departing aircraft across work communities. Based on the information provided by the system, personnel in both work communities can synchronize their perception on the state of the departing aircraft. Updating aircraft departure status through colour coded depiction in the DSI system helps collaborating personnel to achieve common enough understanding of occurrences in the work environment.

4.3 Device for Organizing Coordination

Information presented in the two artefacts – Flight Schedule Information System and Departure Status Information System – are used not only to perform individual tasks but also for collaborating with other personnel. This is because information representation in the artefacts depict various aspects of work performance such as contextual information (status of aircraft departure), decisions made by controllers (give permission for aircraft pushback), and task performance status (aircraft pushback, taxiing, delay). The incorporation of different aspects of work process in the information representation of artefacts allows common information artefacts to function as devices for organizing coordination between collaborating personnel.

For example, the Departure Status Information System mediates temporal relationship between personnel belonging to different work communities. When the ground controller in the control tower highlights aircraft information in the system to “active” or “delay”, it triggers an action from the assistant in the approach control. Based on the changes made to this artefact, personnel in the approach control structure their coordination locally such as the assistant placing or removing FPS on the coordinator’s deck.

Making changes to common information artefact has various implications for interaction within and across work communities such as triggering, sequencing, and handing over tasks. It not only aids personnel in determining their individual actions but structures coordination and communication. This is illustrated in the use of Flight Schedule Information System. If the gate number is available in the system, the assistant performs the required coordination within the control tower. If the gate number is not available within the required time the actions performed by the assistant differs. She first obtains the required information from the ground controller in the operations centre by verbally requesting them over the telephone to update the gate number in the system, waits for the information if time permits and then places the FPS on the controller's strip holding bay. Due to the temporal dependency involved in the task performance, if there is not sufficient time to wait for the gate number to be updated, the assistant first prints the paper FPS without this information and hands it over to the controller. She then telephones the operations centre to request the information or waits until it is provided and then verbally gives the gate number to the controller who then writes it on the strip.

5 Discussion

The discussions presented in the previous sections depict how the common information artefacts act as devices that mediate articulation work of personnel from different work communities. The standardization of information representation provides a common language and common frame of reference for personnel from multiple work communities to collaborate with each other. Also, the common information artefacts help people to relate their partial and provincial knowledge. The two artefacts discussed in this paper cater to the varying interests of multiple personnel belonging to the communities of control tower, approach control and aircraft pilot. For example, in the case of aircraft departure, the aircraft pilot aims to depart from the airport within the time slot filed in the flight plan, the ground controller in the tower schedules the aircraft departure in relation to other aircraft waiting to depart and land in the airport, the radar controller in the approach control needs to organize gaps in the airspace surrounding the airport based on the aircraft's departure route and other aircraft movement in the sector. The Flight Schedule Information System and Departure Status Information System mediate the reconciliation of these differing interests.

The common information artefacts present both pre-planned information and dynamic information. Changes made to information representation in the artefacts reflect changes occurring in the work environment during task performance. Personnel holding the artefacts in common are then able to gain perspective of both individual and other's task performance. This is because the artefacts function as "awareness mediators". The use of Departure Status Information System is akin to the way closed circuit television is employed in the Copenhagen ATC centre where it performs similar functions (Berndtsson and Normark 1999). Personnel in the control tower are able to make changes to information representation in the artefact to disseminate up-to-date information about the conditions of task performance and inform others about the current work situation. The system provides possibility for synchronizing actions by facilitating spatially distributed personnel to oversee the status of other's task performance. This helps the collaborating personnel to anticipate prospective conditions and plan their individual and collaborative work.

The Departure Status Information System in a way acts as the "shared notepad", a label used by (Bentley et al. 1992) to describe the FPS as a public document within the control tower. In this case however, the system is 'public' across communities. It might not permit the same malleability as the paper FPS (Mackay 2000) to make annotations but facilitates establishment of common enough understanding between personnel from different work communities to coordinate their actions. Another feature of the two artefacts is that besides facilitating information dissemination across work communities they also unobtrusively draw attention when required. The artefacts provide possibility for "at a glance" information availability across spatially distributed work communities thereby enabling personnel to oversee each other's activities.

6 Conclusion

The common information artefacts presented in the discussions of this paper are perceived as boundary objects because they capture, transfer, and transform knowledge. They serve to coordinate perspectives and actions of personnel from different work communities by mediating their partial and provincial knowledge. Hence, they are looked upon as mediating devices in the overlapping spaces of different work communities. In the process of exploring information systems common to different work communities we depict how by acting as boundary objects these take on the role of devices for synthesizing different perspectives, planning, organizing, and coordinating work activities across interdependent work communities, thereby uncovering their mediation role in articulating different Common Information Spaces. This paper contributes to the ongoing discussion of mediation roles of shared representation in cooperative work by depicting common information artefacts as devices for mediating local and global articulation, for interpretive articulation and for organizing coordination across heterogeneous work communities.

7 Acknowledgements

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“Mediating objects” in new industrial cooperative practices: an empirical *in situ* study.

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Abstract. This paper studies new cooperative practices using an “anthropo-based” approach of “mediating objects”. It provides insights into cooperative modalities with draughtsmen and mediating objects’ potentials as efficient cooperative medium. It suggests considering design tools’ and representations’ complementarities instead of maladjustments in order to design cooperative support systems closer to real industrial practices.

1 Introduction

Providing designers with more intuitive and user-friendly cooperative design tools or more accurate design support systems are some of the challenges faced by CSCW (Computer Supported Cooperative Work) and SBIM (Sketch-based Interface for Modeling) researchers. Most of these researchers attach some importance to shared and mediating representations used during design tasks, as they constitute a tangible way to approach such complex activities.

These representations are usually studied according to the tools they proceed from, and this generally leads to a comparative analysis of these tools’ pros and cons. This tradition of confrontation occurs for instance in architectural or industrial design, between free-hand sketching and CAD software that remain the main design tools. Indeed, on the one hand, free-hand sketches are said to be the most powerful support to preliminary design phases, without effectively meeting the constraints of collaborative and remote design tasks (Goel, 1995; Cross, 2000; Visser, 2006). On the other hand, it is claimed for a long time that CAD tools fail to support ideation (Whitefield, 1986; Ullman & al, 1989) but ease long-distance communication and documents exchanges. On top of these tools inadequacies, designers have to deal with the numerous issues remote cooperative design occasions: multiplication of large projects introducing relocated skills, increase of exchanged information volume and need for specific competences are some of them.

Whatever the point of view, each design tool presents respective particularities that can (in)efficiently equip the design process. Contrary to all expectations, designers facing these complex tasks, using their "maladjusted" tools, yet go on with successfully completing their goals. They adapt their work practices, their tools and representations to constraining environments and achieve, in a constant evolution process, the work they are paid for. This paper will try to understand how designers effectively reach their goals through the exploitation of their mediating design tools. How do they select them, and according to which characteristics ? Is this choice subjected to changes all along the cooperative process ? What factors do "shape" the use of design tools? To what extent are "new" and "traditional" design tools impacting work and cooperative practices?

2 Theoretical framework

To answer these questions, we suggest to combine the study of "front-to-front" cooperative design practices with an anthropo-based approach of real industrial projects and the study of "mediating objects". The hope is that the better understanding of these "basic" collaborative characteristics (that is, working *in presence* of others using *every-day* tools) will lead to the definition of more coherent and effective remote collaborative support systems, closer to real practices and their current evolutions.

To begin, the paper will present the three stages theoretical framework that structures our research. We will next present our *in situ* methodology and the data's analysis. The main observations will be then discussed.

2.1 Stage one: the "anthropo-based" standpoint

Comprehensive Ergonomics provides sound methods to conduct empirical in situ studies. Through its multi-disciplinary standpoint, this field enables us to better understand the actors of design activity. Without being restricted to the single “end-user” of an application, this scientific approach enables us to study all enclosed profiles, to define the real and prescribed tasks, the strategies, the required competences, ... that could impact the cooperative modalities and the use of design tools.

These observations, interviews and analysis methods help us to take into consideration two major elements. First the impact of new technologies: since the integration of CAD tools in every-day design practices, we should evaluate how designers are able to adapt their cooperative work and competences in regard to what constituted their previous habits, and on the other hand how they adapt their tools to the cooperative context. Secondly there is a need to consider the context’s impacts (Dorst, 2008; Suwa & al, 1998), and we would even emphasize the multiplicity of elements to be considered by putting the term in the plural: working contexts, cooperating contexts, physical environments or project types.

2.2 Stage two: the focus on “mediating objects”

Among all the possible approaches of human cooperation, there is the theoretical framework of instrumental theory that suggests that any type of activity (and, by extension, cooperative ones) is mediated through the usage of artifacts (Folcher & Rabardel, 2004). This theory, developed by Rabardel and Vérillon (1995), introduces the notion of instrument as the combination of an artifact (material, symbolic, cognitive, or semiotic) and one or more associated schemes. The artifact can be commonly defined as the physical part of a tool. The scheme, on the other hand, is the result of “a construction specific to the subject, or through the appropriation of pre-existing social schemes” (Béguin & Rabardel, 2000). The example usually given is the hammering scheme, ordinarily associated with a hammer, but which could in case of necessity be adapted to a shifting spanner. Both sides of the instrumental entity (the artifact and its utilization scheme(s)) act together as the mediator between the subject and the object of his activity (fig 1).

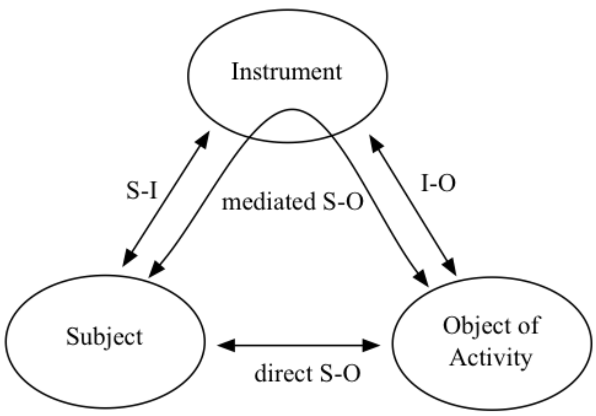

Fig. 1. The IAS Model, “Instrumented Activity Situation”, and its three poles: the subject, the activity, and the mediating instrument (i.e. an artifact and an utilization scheme).

As our interest is to better apprehend the use, the sequence of use and the modifications of "objects" inputs all along the cooperative design process, we will define here:
(i) the "object of the activity" as the "act of designing together";
(ii) the "subject" as an actor involved in the cooperation;
(iii) the "artifact's" part of an instrument as a "mediating object". We extend this way the term "artifact" in order to include in its definition not only its physical part (the pen; the computer, the prototyping machine, ...) but also the external representation linked to it (respectively the free-hand sketch; the 3D model or print, the physical model, ...). By considering the artifact this way, we try to avoid the general misunderstanding that can occur between "tool" and "external representation".

2.3 Stage three: the study of complementarities

As we underlined, a dichotomous way to consider the main design tools persists in literature. This comparative approach also expands to the consideration of designers' work habits (designers that sketch *vs*. designers that model; designers used to CAD tools *vs*. designers with no modeling expertise).

Our third theory framework, proposed here as an hypothesis, would be to abandon the study of these two opposite profiles of designers working in dichotomous worlds and using dichotomous schemes, but alternatively to consider a flexible mid-way profile taking advantage of the objects' diversity and complementarities (in regard to the appearing constraints and the cooperative contexts, see fig.2). We indeed believe in the human capacity to adapt to a constraining environment, or to deviate the tools from their original use when necessary, depending on the cooperative environment.

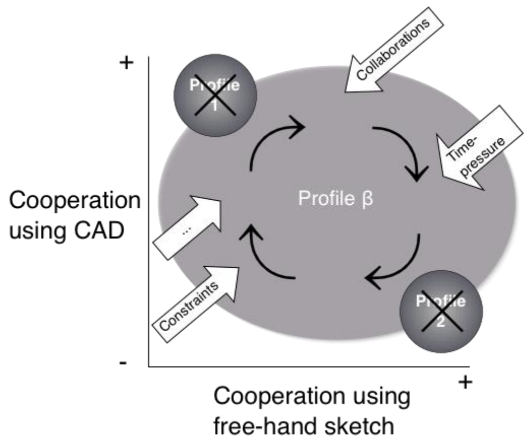

Fig. 2. The undo of the "dichotomous approach" in benefit of the study of complementarities.

This three-phased proposition structures our study of cooperative design's evolution and design tools as mediating objects, as presented next.

3 Case Study

A two months case study afford us to observe *in situ* a design team (6 designers, 4 draughtsmen) who is in charge of industrial projects in the field of contemporary heating devices development.

3.1 Methodology

The observer was allowed to stay 8 hours a day inside the open-space office to interview the subjects and capture (recording or filming) every step of their current designs as well as the cooperative facts (between the team, between members of the team and extern members such as the CEO or the prototypists).

On top of the 8 interviews (based on a semi-directive and retrospective analysis protocol) we selected 5 different products as a basis of observation.

This type of *in situ* intervention presents several advantages. First it avoids the limitations of a non-realistic lab situation by providing the essential contexts elements. Second, it enables a qualitative approach of the fine-grained details of the cooperative processes that would be ignored in a more quantitative study but still constitute a keystone for the whole project's rationale. Finally, it allows a global overview of several projects presenting diverse states of progression (formal, technical and productive). These projects provide a relatively complete view of the design processes, design methods, cooperative modalities and design tools' use without following a 2 or 3 years complete project.

3.2 Data Analysis

The whole data gained has been coded. The goal of this coding is a step-by-step "track" of the cooperative process given the appearing constraints and external representations' evolution (graphic, numeric and volumetric). The code applies to distinct unit of designing actions. One action is defined as soon as the mediating object changes, or as a new type of cooperation occurs.

This coding scheme is exploited to construct the projects timelines of the 5 selected projects (see an example in fig.3). The X-axis represents the project evolution in time, and represents different time scales since the data proceed from interviews or observations. The Y-axis sums up the various variables of the coding scheme (the use of one specific kind of tool - free-hand sketch; CAD tool or prototype, in parallel with the modality of cooperation - with whom, for doing what).

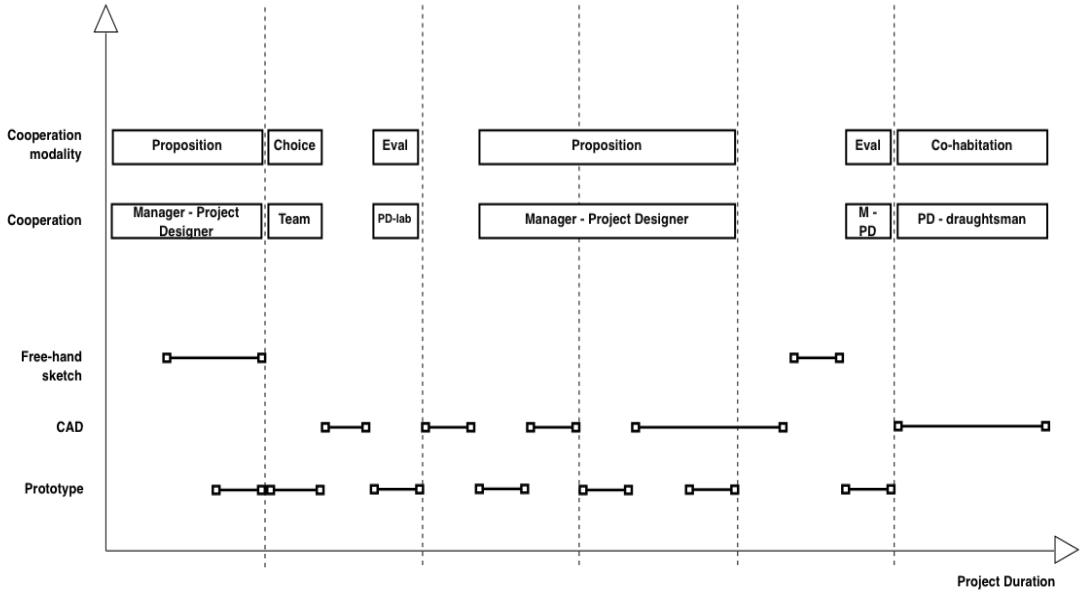

Fig. 3. An example of timeline with some variables (non exhaustive listing).

Among these 5 projects' processes, 13 more particular design "moments" were chosen for the quantitative analysis that will be presented in section 4.3. These 13 selected design moments (all video-taped or recorded) enable us to consider, second by second, a more detailed vision of the mediating objects' use (content, underlying model, ...).

4 Results

The next section presents our main observations concerning design tools and cooperative modalities between co-workers. We first discuss how CAD tools are nowadays completely integrated in industrial designers practices, sometimes since preliminary design (which tends to support our "*non-dichotomy*" hypothesis) and how this integration impacts the cooperation. Indeed, a new kind of cooperative work appears between designers and draughtsmen, whose tasks are part and parcel of a revalued design activity. Design mediating objects are mutually adapted to this new way of co-working, and the last part of the discussion will focus on their identified characteristics.

4.1 New practices, new cooperator: the draughtsman

CAD tools have, without a doubt, greatly impacted design practices. They are recognized as powerful tools to support production and execution stages of design process, but less efficient as early design support tools. Yet, our 5 projects' timelines, observations and interviews all tend to prove that CAD tools' potentials are now also exploited since the preliminary stage of the process (following other scheme of use, though, and in this particular team). They are required as early as possible in the projects, for economic, communication, time or productivity reasons.

Indeed, we observe several back and forth in the use of design tools all along the processes. For instance, a designer begins a project using a CAD tool to construct a "rough" 3D model, instead of using the traditional sketch. This simple 3D model is quickly created using primitive forms, without taking care of real dimensions, to visually test an idea and general proportions. As rough sketches, this 3D dynamic model supports the rapid evaluation of more formal or functional ideas. Having discovered some technical "nodes" in this model, the designer can then be in need of quickly exploring various solutions and in order to do so, comes back to "technical" sketches. These backs and forths between design tools are symptomatic of an effective usage of the tools given their complementarities, which tends to support our "non-dichotomy" hypothesis.

Since designers gained sufficient expertise in the use of CAD tools, we then tried to understand the evolution of draughtsmen's tasks. Interviews and observations revealed that draughtsmen are no longer performers of blue-prints or production plans and subordinates to designers, but take part in the design process since the task distribution's evolution. A graph of draughtsmen's activity has been constructed (following the activity theory's methods) in order to reassess their real tasks (fig 4).

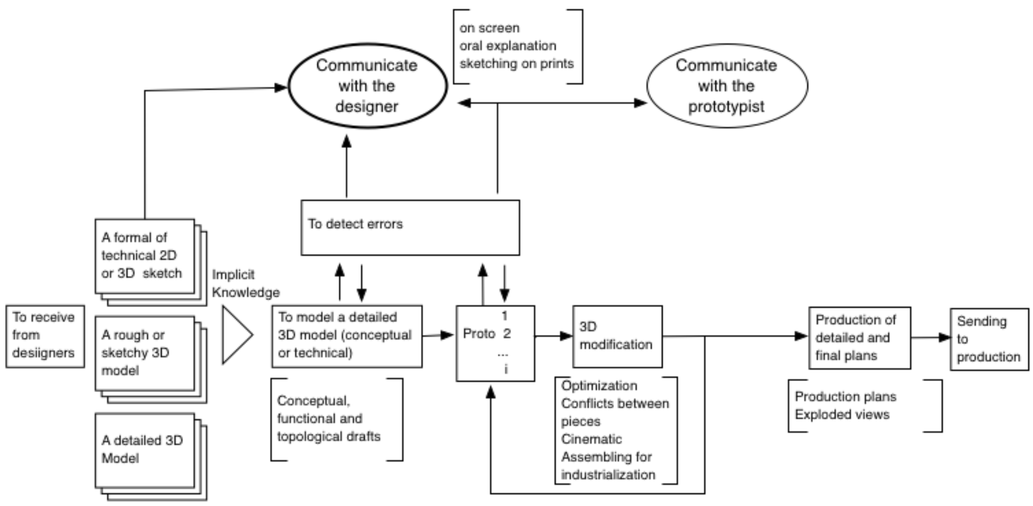

Fig. 4. Draughtsmen's activity graph showing the main tasks and cooperation modalities.

This simplified model underlines several observations. First, the draughtsman receives from the designer a "rough" representation that can either be a free-hand sketch, a rough 3D model or a sketch on a print. The main draughtsman's activity consists in detecting the errors and making the project evolve towards a final production plan (through the production of prototypes in this particular design field). Discovering these design errors (pieces' conflicts; production unfeasibilities…) the draughtsman sometimes even suggests solutions through a quick technical sketch, using this way a design tool he/she is not supposed to manage. We can say that draughtsmen develop in a few years a great expertise in this specific (and very technical) design field and are consequently totally able to co-operate with the designers in a win-win relationship.

This way of using both design tools as early in the preliminary design process without consideration for respective expertise lead us to two major conclusions. First, there is a need to distinguish "rough" sketches and "rough" CAD models or representations (that stay ambiguous and support ideation), from "technical" sketches and "detailed" CAD models (that focus on a more specific sub-problem and tend to a production goal). This questions the conventional boarders of "traditional design tools" in "preliminary design". Second, there is a new type of cooperation between designers and draughtsmen. A shared reference system is constructed between both actors as a function of the expertise and experience levels, and leads to a "co-design" situation at the highest and most effective point.

These first results tend to prove that the usual dichotomy (or hierarchy) that link designers and draughtsman indeed disappeared since the integration of CAD tools in work practices.

4.2 New ways of mediating the cooperative activity

This new cooperative work involves new ways of mediating the design activity through tools and representations. Since both designers' and draughtsmen's profiles aren't equal but just complementary, we try to understand how design actors respectively exploit the objects as a media of their cooperative activity.

The indistinct use of design tools whatever the profession is typical of a deep sharing of competences and sharing of the reference system. The verbatim suggests that co-workers are aware of this phenomenon and fit their cooperative modalities to ease each other procedures. For instance, one draughtsman explained that "the question of how to model has to be more often asked that the question of what to model". The draughtsmen have to develop a specific "way of thinking" to start the 2D or 3D virtual model, that leads them to question the essence of the sketchy representation they receive (phenomenon we call of *transition gymnastics*). Where and what are the "technical nodes" (or difficulties) of the product ? What kind of cinematic behavior will the product have ? How will it be possible for the prototypist to physically put a screw in such a tiny fold ? And last but not least, how will this piece co-exist with the pre-existing environment ? Clearly, draughtsmen learn how to interpret in essence the drawings or rough 3D models they receive, presenting heating devices technological details.

Designers, on the other hand, adapt their representations (in content and in aspect) to communicate with draughtsmen. They will for instance annotate the drawings, over-trace the main lines, use shadows or textures to suggest a material or draw arrows to define a cinematic behavior (these drawings' particularities being not exploited in a personal sketch).

Even if mental transitions (from 2D to 3D and vice-versa) are different between designers and draughtsmen, i.e. between the author of the sketchy representation and the interpreter, they always find the interface that will support their discussion. Generally speaking, as we will develop in next section, involved partners always tend to cooperate using the external representation the closer to their shared system of reference.

This cooperative interface sometimes is not totally appropriate to mental representations. In case of maladjustments, the subjects are able to adapt themselves to the constraining environment or sometimes transform their mediating objects to fit the cooperative situation (*catachresis* phenomenon). See in fig. 5 an example of this phenomenon: the prototype is diverted from its primary goal to be used as a drawing support, in order to ease cooperation between a senior designer and a junior draughtsman.

Fig. 5 An example of catachresis phenomenon.

4.3 Design tools' characteristics.

The previous sections suggest that the dichotomy principles are no longer adapted to the designers' realities, to their actual practices or design tools, and that a new proposition is needed. We will now investigate how the mediator objects complete each other and on which principles the actors select them in order to test our "complementarity" hypothesis.

As far as respective contributions and selection principles are concerned, each actor develops his/her own strategies but some constants can nevertheless be identified. The fig.6 presents the repartition (in percentage of occurrences) of use of the main design mediating "objects" (including here the oral; gesture or designation modalities) during the 13 design moments we chose earlier.

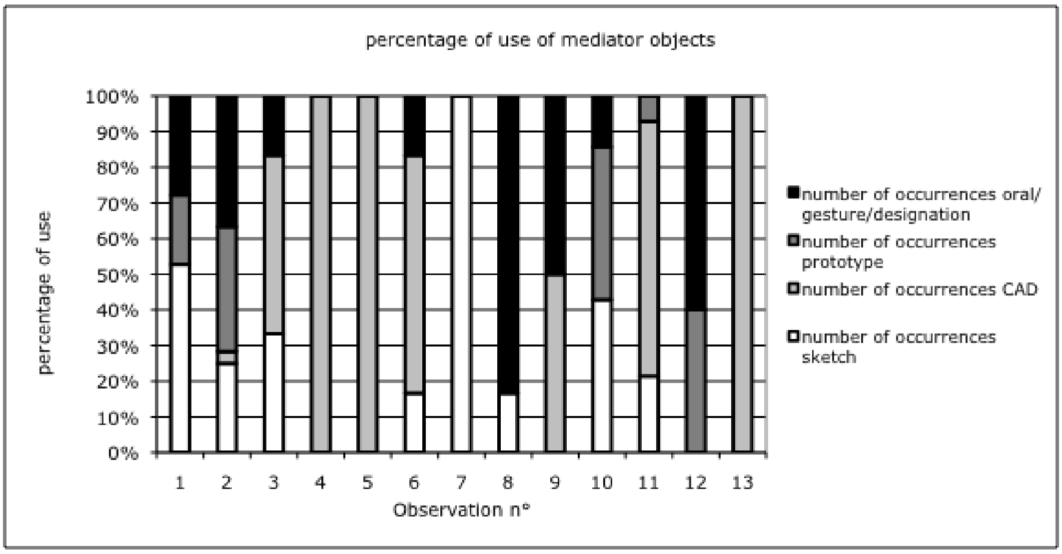

Fig. 6. Percentage of use of the main mediator tools.

The occurrences are globally balanced, with a maximum for sketches (sketches = 30,1%; CAD tools = 19,8%; prototype = 21,8%; oral/gesture/designation = 28,2% of total occurrences). We observed that two designers can easily understand each other simply by watching a computer screen and pointing at a virtual model. On the other hand, when a prototypist explains to the designer the difficulties encountered to build the first physical model, the support of cooperation is either the previous prototype or 2D prints, which also remain the main interface during larger meetings with sales managers. The sketch as a last example will remain the favorite support of cooperation between two designers co-working on an idea. We underline also the great importance of oral, gestural and pointing modalities to complete the information supported by the representation.

We observed that the interface of cooperation always stay the closer to the mediating objects all actors commonly exploit.

The objects' selection principle will also depend on the tools' features. We already summed up in introduction what generally appears in literature, and we present here our own observations.

The free-hand sketch specificities.

The free-hand sketch is mainly used during the definition and specification of a new solution, either conceptual, formal or technical. Sketch remains faster and more profitable than CAD tool for the quick exploration of diverse alternatives, although, as we saw before, this dichotomy nowadays tends to fade. One of the differences between the "rough-sketch" and the technical sketch is that this last one needs a geometrical environment to define some proportions (drawing on a 2D print for example with geometrical basis).

The principle of selection, inside the sketching modality, between a plan (or elevation) and a perspective depends of what kind of element has to be tested. The perspective drawing is efficient to quickly evaluate a functional aspect, a production method (such as a fold or assembling principle) or pieces' imbrication. It allows a faster "3D test" than a 3D model or a 3 views drawing. A 2D representation in a complementary way is sufficient to test dimensions, volume or intern functions.

The CAD tool specificities.

The CAD tool used (Pro-Engineer here) is particularly well adapted to the dynamic visualization of a piece assembling, alone or inside a pre-existing environment. This pre-existing environment visualization lightens the designer's memory load (it eases the reintroduction of a smaller piece in the whole heating system for instance). It allows the designer to check if no more conflicts subsist (static or cinematic), and to validate the geometric, volumetric and proportional sides of the project.

The main limitation is the time-consuming characteristic of a detailed 3D modeling. That's why the designers sometimes "divert" the tool from its first usage to make "quick and dirty" 3D models and to avoid time-expensive back and forths at later phases. There is also no "freezing" of attributes, which could lead to unexpected modifications after a parametrization of a linked piece.

The prototype specificities.

Prototypes are very helpful to evaluate and validate some formal concepts, to warn about production difficulties and as a support of team meeting. They nevertheless stay expensive.

Besides these selection principles, designers and draughtsmen underline the necessity of associating several objects in a "multi-modality spirit". This multi-modality is, according to Rabardel, the realization of a redundancy effect that allows the subject to make the better choice and achieve a balance between economic and efficient objectives (Rabardel 1995).

4.4 Representations' characteristics.

We will here study representations and their modalities. It appears that these representations aim at different functions. We code the occurrences in terms of usage: question or a communication (which will of course stay the main functions during a cooperation); generation of ideas; evaluations and modifications, or production issues.

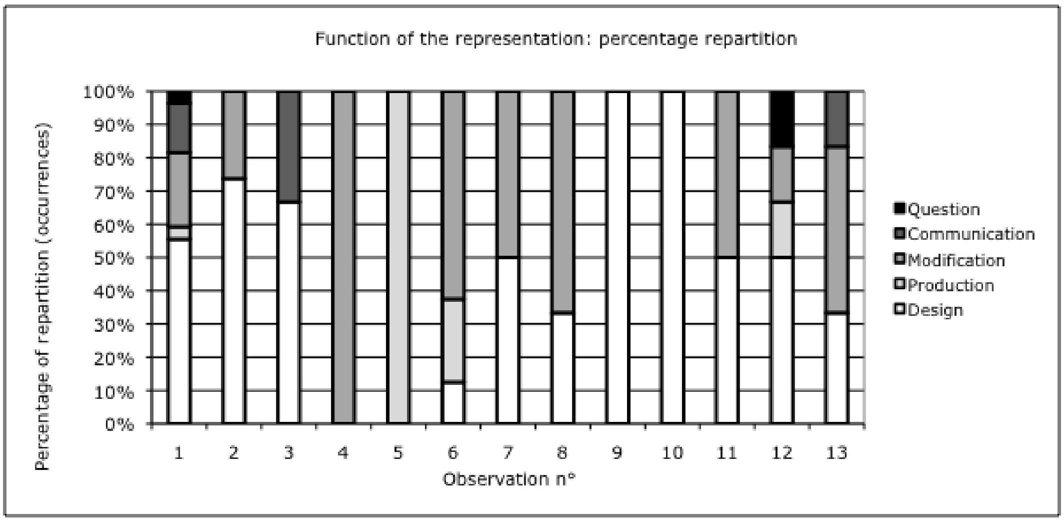

Fig. 7. Functions of representations: percentage of repartition.

Fig. 7 shows the percentage of repartition of these different functions. We see that generation (design) and modification present the highest occurrence in the 13 moments of design we selected, with respectively 52,4% and 31,7% of occurrences. This graph helps us to realize that one type of representation can support several functions and that the addition of several representations can diversify the design process.

Fig. 8 presents the underlying models of representations following Leplat proposition (Leplat, 2000). It codes the procedural aspect (the representation guides a procedure - generally a production method); the operative aspect (the representation supports the realization of an action - the act of designing of course but also the various other actions necessary to realize the project); the declarative aspect (the representation permits to declare a criterion, a characteristic, an opinion, an intention, ...) and the figurative aspect (formal representation).

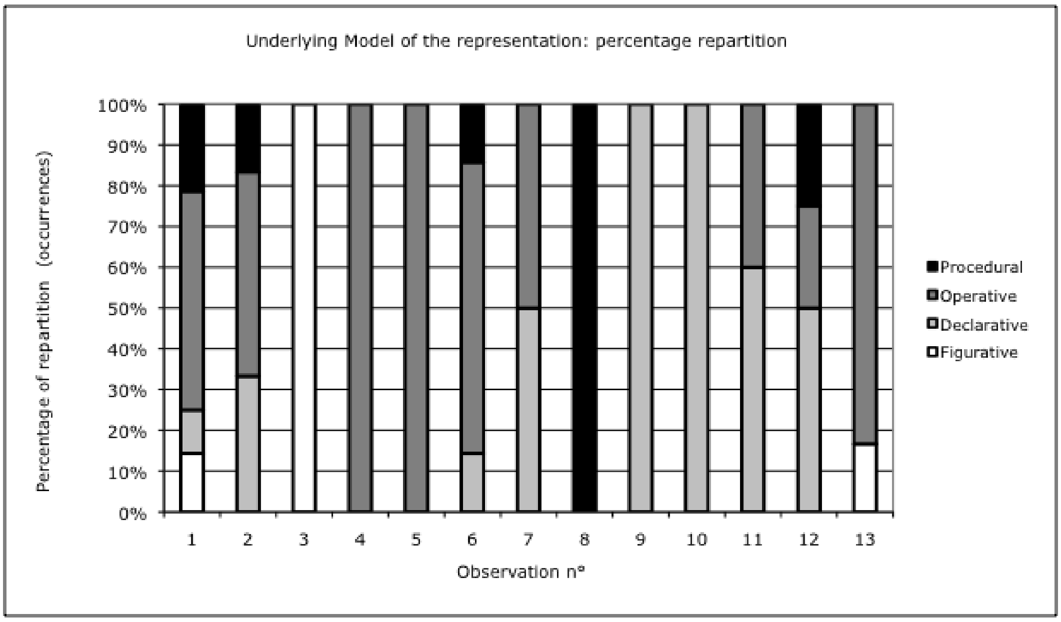

Fig. 8. Underlying models of representation: percentage of repartition.

The operative and declarative models, representative of the act of designing, are widely represented (respectively 50,6% and 22,8% of the total occurrences). This graph demonstrates the ability for representations to support several underlying models (in order to fit the contexts and appearing constraints) and always in a complementary way.

5 Conclusions

We assume that this work, considering its unavoidable sample's limitations, entertains futures possibilities for the development of cooperative support systems. These systems should take into account design tools' and design actors' complementarities and evolutions. Furthermore, instead of focusing exclusively on one cooperative channel (i.e. asynchronous data exchanges; virtual communication through avatars, tags and annotations,…), we suggest to consider all tools involved in every-day work habits and to study their complementary uses. Work actors constantly deviate and "misuse" them, adapt them to the constraints of their cooperative tasks, and enlarge the common boarders of what we usually call the "preliminary design phase" and its "traditional tools". The study of these deviations could provide interesting potentialities for further specifications.

Ergonomics and activity theory seem to constitute an interesting theoretical framework, that enable us to expand studies at all involved actors, in order to examine the several facets of the cooperative work. There aren't dichotomous profiles but flexible ones, actors adapting their work habits to the contexts.

In the field of industrial design, there is naturally an urgent need to analyze other teams and other processes to test the results. These projected *in situ* interventions will also enable us to deepen the study of “rough” and “detailed” representations’ contents.

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Shared representations: dyadic and triadic perspectives in work and training

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Abstract. The use of modeling, simulation and visualization techniques in scientific and technical domains has lead to the co-existence of large diversity of external representations that, when deployed in collaborative work settings, can be designated by the term "shared representations". This contribution will focus on dyadic cognitive and triadic semiotic perspectives on the issue of interpretation and construction of shared representations. Illustrations will be given from a collaborative design game situation and implications for the design of cooperative systems will be formulated.

1 Introduction

The use of modeling, simulation and visualization techniques in scientific and technical domains has lead to the development of a large diversity of external representations which, when deployed in collaborative work settings, can be designated by the term "shared representations". The main aim of this contribution is to call into question the prevalent intuition of the relative easiness with which representations may be shared. The counter intuition would be the suspicion that the proliferation of computer-based representations might just as well lead to a "confusion of tongues" such as during the construction of the Tower of Babel. We build a theoretical frame founded on both cognitive and semiotic perspectives illustrated by examples from a training situation in engineering design. Implications for the design of cooperative systems include the construction of a typology of shared representations presented in the final section.

2 Shared representations in collaborative design

The design process, as a technical as well as a scientific endeavour, heavily relies on shared representations of the problem, the product, and all its intermediary states. For example, in a context of globalization and multidisciplinarity, design processes involve many numerical representations through Product Lifecycle Management (PLM) systems. In this section, we present a training situation in engineering design that subsequently will be used to exemplify a preliminary definition of shared representations and their functionalities.

The Delta Design Game (Bucciarelli, 1991) is a serious game used in engineering education as a reliable and robust simulation of a collaborative design setting. The game engenders situations that show the importance of argumentation, conflict management, inter-relational aspects and intermediary objects (Boujut & Blanco, 2003). The game involves role-playing in which a team of co-workers enlist to design a house in a fictitious world according to a list of specifications concerning cost, internal surface, building time, etc. The design activity relies on the placement of red and blue equilateral triangles on a cardboard (Figure 1).

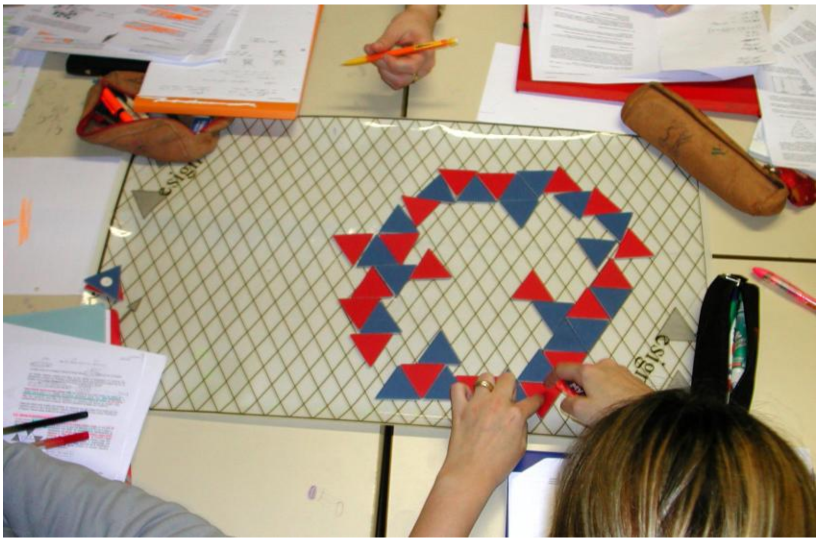

Figure 1. The Delta Design Game situation

During the game, each expert learns a job through a specific set of definitions and rules for a particular domain of expertise. For example, the tasks of thermal engineers and of structural engineers necessitate intensive calculus to evaluate design proposals. The rules of the different jobs are antagonistic enough to ensure that compromises are needed to find a solution that satisfies all team members. We exploit the game for exemplification because it is an artificial situation which, for training purposes, overemphasizes crucial aspects of collaborative design.

2.1 Defining shared representations

First of all, shared representations are necessarily *external*, i.e. outside the head, as opposed to postulated *internal* representations inside the head. A clear distinction between internal and external representations and their integration into a comprehensive framework (Norman & Zhang, 1994; Zhang, 1997) is essential to understanding shared representations. Shared representations designate structures in the external environment which allow one to interact with the objects, relations and phenomena relevant to the solving of a problem. Such external representations most often consist of configurations of inscriptions using a two-dimensional plane (paper, screen), but they might also be three-dimensional physical objects (mock-up, beads of an abacus, pieces of a game), or a combination of the two (virtual objects, 3d model, digital mock-up in an augmented reality context). Shared representations in the Delta Design Game include the triangles on the cardboard, but also the written rules of the game, and the individual external representations (texts, sketches, calculations) that the players might choose to share with their team members.

2.2 Functions of shared representations

Shared representations inherit much of the functionality of the broader class of external representations. We describe three functions based on Duval (1995).

- *Objectification*. External representations allow making some abstract idea perceivable by the senses, i.e. becoming aware of something through expression for oneself. If this is true for an individual, it also happens in collaborative design settings. In design processes, the construction and the representation of a solution go hand in hand. Shared representations also satisfy the need for recording information about the process and facilitate the emergence of design rationale.
- *Communication*. External representations ensure communication between agents. In design, shared representations allow exchanging information between team members that have expertise in different domains, regarding the economical, functional, esthetical, structural, and thermal aspects of a solution in the Delta Design Game.
- *Computation*. External representations allow computations that would be too cumbersome internally. For example, in order to calculate the mechanical equilibrium of a solid, a graphical representation can be visually exploited to identify geometrical parameters and missing

values. Alternatively, the same goal can be attained by using an algebraic representation to mobilize mathematical solving methods that are usually too complex for mental calculation.

All three functions are highly relevant in professional and educational design settings. For example, Gero and Kannengieser (2004), in their situated FBS framework, show that production of new concept is a cyclic process (named "reformulation"), going alternatively through the internal world (both interpreted and expected) and the external world both individually and collectively. The three functions of shared representations, objectification, communication, and computation, may vary in importance as a design process unfolds.

3 An epistemological stand

Many claims about computer tools call attention to their so called representational affordances: cooperative systems are thought to be semiotic tools for meaning making by co-workers. The word "semiotics" refers to the tendency of humans to make sense out of signs and symbols; the word "affordance" refers to the activities that the computer tool allows. The notion of the mediating role of shared representations essentially hinges on the same line of reasoning. In this section, we examine some existing literature in order to find support for the two opposing intuitions stated in the introduction: shared representations might be an aid or, on the contrary, a hindrance in cooperative work and training situations.

3.1 The cognitive dyadic perspective

Within cognitive science, representation is essentially viewed as a dyadic or two-term relation: something that stands for something else. Both internal mental representations and external ones are defined as one-to-one relations between representing and represented entities (Palmer, 1978). For example, the nodes and links in a semantic network, whether postulated in the mind or simulated on the computer, stand for objects and relations in the real world. In the Delta Design Game, the shared representations consists of colored triangles, termed *deltas*, that represent the bricks of a wall, and a flat plane that stands for a 2D planet (on a cardboard such as in Figure 1 or on a computer screen such as in Figure 2). The spatial configuration of triangles represents the physical structure of a house.

In dyadic view, external representations serve to unambiguously identify objects, relations and phenomena, and to communicate about them. As in other scientific domains, definitions of symbolisms are fixed by *convention* (see Quine, 1976). For example, Arabic numerals are used for manipulating numbers, while taking for granted the *choice* of symbolism as a particular mapping of inscriptions to numbers (i.e. Arabic versus Roman). The same is true for logical diagrams, such as those of Venn, Euler, and Peirce, and for graphical representations, such as line graphs, pie-charts, and histograms. Each of them is a notational system to discuss its content and postpone the foundations of the representational system itself. According to Lewis (1969), a convention is the regularity observed in a recurring situation, because it is true that, and it is common knowledge that, everyone conforms to it, everyone expects everyone else to conform to it, even if an individual would prefer one of the other possible codes, he prefers to conform to whichever one everyone else conforms to. An example of such a convention is the color of the deltas in the game which represent the ability to produce heat (red) or to conduct heat passively (blue). So according to Lewis' definition, everybody likewise interprets the color of the triangles according to the regular code of red for heat and blue for cold, because you expect others do it the same way, even you would have preferred it the other way around. A convention boils down to sharing the arbitrary (de Vries, 2010). A legend or key is not neededb because, as Stenning and Oberlander (1995) put it: A legend or key specifies that part of the mapping from representation to world which has to be made explicit to users of the representation because they do not carry it as part of their general knowledge.

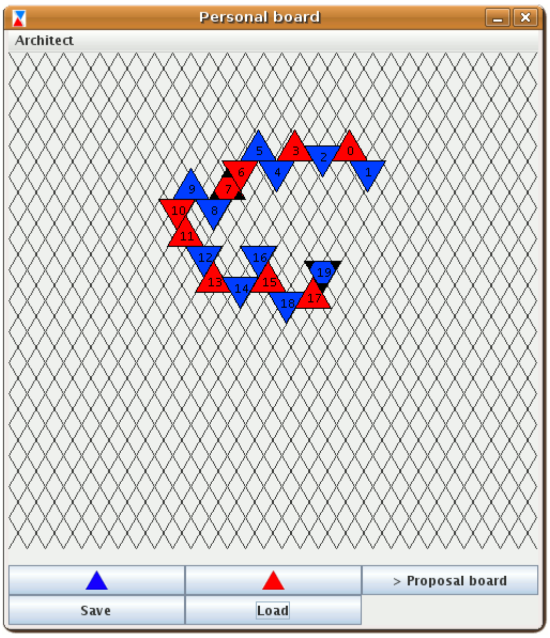

Figure 2. An example of representation as a two-term relation

Norman and Zhang (1994) and Zhang (1997) describe *isomorphic* external representations of an identical logical structure of objects and rules (of tic-tac-toe, of the Tower of Hanoi). For example, the design game can also be played at a distance using a collaborative system (Masclet, 2009). In this version, the triangles of the traditional game are numbered in order to facilitate their identification. Game players, without questioning the meaning of the numbers, use the triangles in the intended way. Some others functionalities, such as the annotation of chatting, were introduced to allow material utterance as defined in (Dearden, 2006). Isomorphic representations vary in degree to which they materialize the rules of a game. So for example, the computer game version does not allow superposing triangles, whereas the physical version requires the players to deliberately respect this rule.

In the beginning of the Delta Design Game, the external representations are genuinely shared. All players attribute the same significations to objects and attributes, even if thermal aspects (color) are irrelevant for some tasks. A unique shared representation (triangles in a plane) has advantages. It gives access to the same geometrical configuration for all players, and can used by all of them for proposing alternative configurations. It constitutes the common ground; players do not need to know the specific external representational systems of each other's jobs. In a certain way, it allows collective objectification. Like in science, shared representations are also crucial for their operational meaning. The rules for manipulating them are described exhaustively, much in the same vain as in a formal system consisting of rules and axioms. It is not allowed to invent rules for manipulation, even if some plausible interpretation seems to allow it (Hofstadter, 1979). For example, in the Delta Design Game, players should not invent purple triangles to represent moderate radiation capacity.

So in summarizing the first viewpoint, the particular way of representing in shared representations does not matter at all, the crux is that the allow to reason about the represented world. However, as Quine (1976) argued, external representations introduced by definition are formally arbitrary but must conform to a traditional usage or else one could express anything through the use of any random symbolism. Of course, the symbolisms in cooperative systems are not randomly chosen. In the Delta Design Game, blue for cold and red for hot is an arbitrary choice with regard to their role in the game, but it conforms to the cultural expectations of the participants.

3.2 The semiotic triadic perspective

Semiotics embraces a triadic view on representation as a three-term relation. Or, in other words, in citing Peirce: "Something which stands to somebody for something in some respect or capacity". A number of terms are used for the three entities (see Eco, 1988, for an overview). The first entity is the material form of the representation: a mark of ink, a configuration of pixels, a sound, the color or texture of a physical object. The second entity is the referent or the object in the world which is represented. The third entity is the idea or the thought that is evoked in someone's mind, the *interpretant* in Peircean terms. In a semiotic perspective, representation always implies a point of view. Even in natural language, a letter sequence, i.e. /hier/, only represents something from the point of view of a particular language, in this case "yesterday" for a French or "here" for a Dutch interpreter. Thus, understanding an external representation requires interpretation and heavily depends on prior knowledge of and experience with similar representational systems. As a consequence, any collaborative work situation that involves coworkers with different backgrounds is particularly interesting.

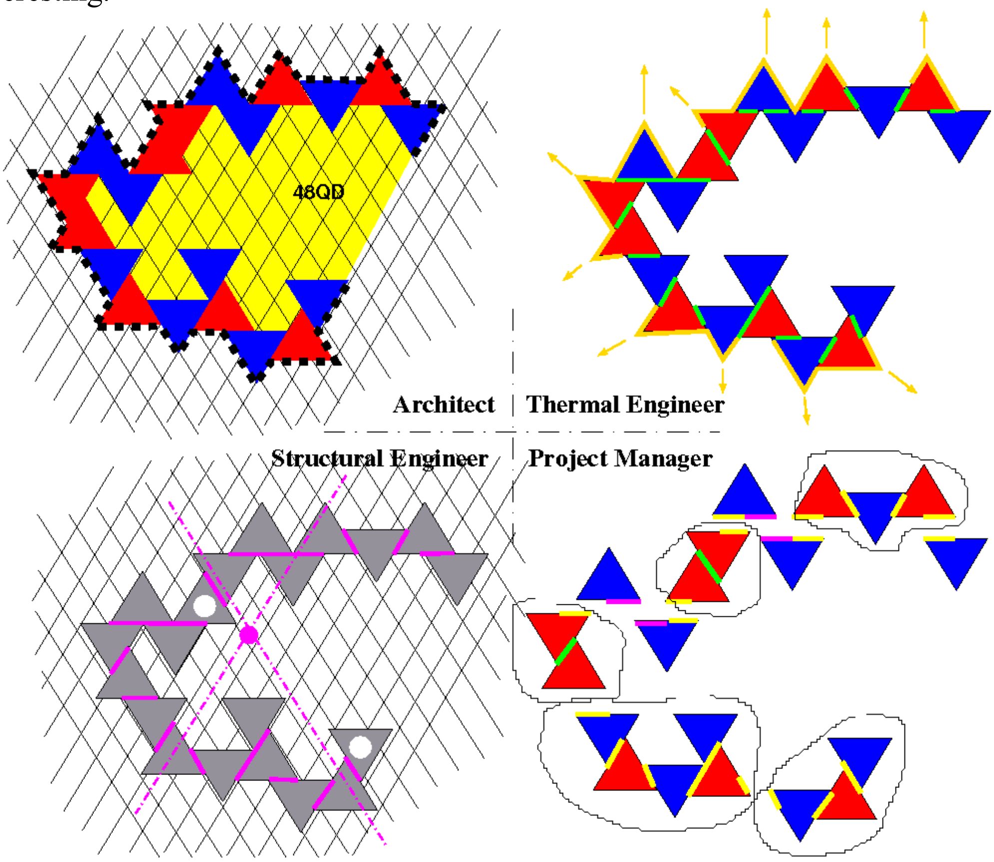

Figure 3. Task-dependent interpretations of a shared representation

In the Delta Design Game, as players gain expertise on their job, they start concentrating on different aspects. Figure 3 shows possible interpretations that are likely to occur for the different tasks.

- The architect examines the internal surface of the house, the exterior and interior shape, and percentage and spreading of blue deltas.
- The structural engineer focuses on positioning of the deltas and the length of the joints. He also pays attention to anchor points (the white dots) because they allow him to compute the resistance and strength of the structure.
- The project manager ignores positioning of the deltas and only analyses the type of joints between the different types of deltas. They give the essential parameters for calculating construction costs depending on the length and type of cement needed. Furthermore, the number of horizontal joints (viewed from the earth) also influences the overall cost through the need of special prefab blocks.

- The thermal engineer concentrates on red deltas (heat sources), length of joints (conductive mechanism), and length of outer angles (whatever their color) for regulation of the mean temperature.

The players produce critical information and create new external representations for themselves or for the team members, such as drawings or writings on the plastic game board (Figure 4). Players also often switch from a vehicular language (the deltas) to a more appropriate vernacular language (dots, joints...). In addition, Figure 4 shows pencils placed on the cardboard for indicating the direction of gravity or the « symmetry axes » of the house. The drawings and annotations express information produced by different team members. Thus, group members start from an imposed common language, then, depending on their task, associate new meanings to the objects of the game, and finally may enrich the existing shared representations by producing new representational elements. They introduce new elements of communication to enrich the basic set of representations. This might be seen as divergence from the shared representations, but players also often go back to the initial representations. A next step in the process could, in principle, involve designers deciding together upon improvements of the shared representations, e.g. their individual internal representations could be externalized which would allow each expert to speed up the operations. In sum, the triadic perspective embraces the possibility, in principle, that different members of a team associate different meanings to a common external configuration in the environment. In other words, sharing the observable or the tangible does not imply sharing the interpretation.

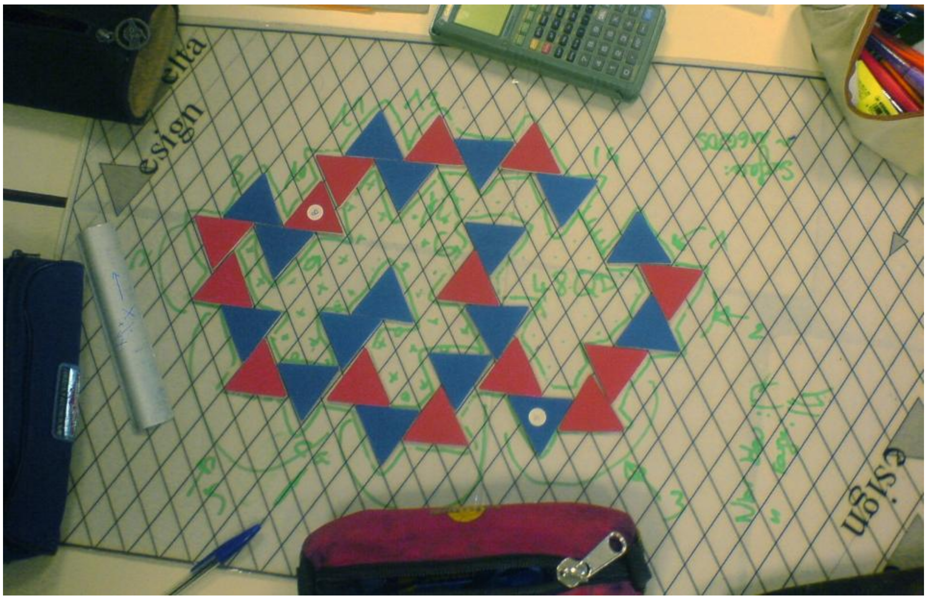

Figure 4. Mixed individual and shared representations

4 Implications for cooperative system design

The theoretical perspectives and the Delta Design Game reveal dynamic interactions between phases and activities in collaborative design and their associated shared representations. Different types of shared representations are appropriate at different times of individual and collective processes as a function of the tasks and activities at hand. Cooperative systems could capitalize on digital processing to dynamically adapt external representations to ongoing tasks, participants, and activities, not only in design, but also in other work settings. The dyadic-triadic distinction and the shared-individual distinction form a useful foundation for the identification of different types of shared representations. We define a typology of shared representations with a view to formulating implications for the design of cooperative systems.

Table 1. Typologie of shared representations

	Attribution of signification to inscriptions	
Application area	**Polysemic Multiple meanings**	**Monosemic Unique meaning**
Generic	Text, freehand drawing, photograph	Line graph, histogram, pie-chart, flowchart
Context-specific	Freehand diagram or schema	“On the fly” visualizations, (virtual) objects in a game
Domain-specific	Architectural sketch, floor plan, organizational chart	Molecular structure and electrical circuit diagrams

We focus on two dimensions: the way in which signification is attributed to inscriptions and the area of application (see Table 1). The first dimension roughly corresponds to the dyadic-triadic distinction and revives Bertin (1967) notions of monosemy (one-to-one meaning) and polysemy (one-to-many meanings). In polysemic representations, a particular configuration in the environment can have multiple meanings. In fact, the signification of an inscription has to be *inferred* from the configuration of inscriptions. Polysemic representations are often used in fuzzy contexts, where one needs to express the possibilities one has in mind, which are not certainties. The early phases of design, for example, are the privileged circumstances for such external representations that support creativity (Tversky et al., 2003). In monosemic representations, each configuration in the environment has only one accepted meaning. In other words, the attribution of the signification of an inscription *precedes* observation of the configuration of inscriptions. Such monosemic representations aim to reduce misunderstandings and are required (or even imposed) during negotiation and contracting.

The second dimension concerns the generality of the representational system. On the extremities, systems can be generic, that is known by the people of the same cultural background and taught at school. Or, on the contrary, representational systems can be specific to an application area and cautioned by domain experts (diSessa, 2004). These formats satisfy the need for recording information, processing information and communicating information between experts. The widespread use of new visualization techniques calls for a third category, context-specific representational systems, because some external representations only have local meaning attached to the particular context of emergence. The Delta Design Game falls in this category both because of the invented representations of objects that belong to the setting (e.g. triangles for bricks), but also because of the emergent representations during play, such as the pencil for indicating gravity, or the freehand drawings and calculation results. The frontiers between categories are not strict and playing the game involves traversing the categories of the typology in an on-going mediation of different types of representations for different purposes in different phases. Real work situations also involve differentiated use of different types of shared representations. Some phases of a process necessitate polysemy for creativity, others require monosemy for precision. Some problems involve cautioned domain representations, for some others, generic representations suffice, and some others still provoke the invention of new representations. In particular, in innovative design process, traditional representations may be too limited to express new concepts and knowledge.

The proposed typology should help system designers to characterize shared representations used in collaborative situations in a variety of work settings. Dependent on ongoing activities, subtle equilibriums between the various types of shared representations need to be found. Coworkers may be forced to navigate between polysemic and monosemic systems in order to get understood, many interdisciplinary collaborative processes involve such a dynamic interplay. However, shared representations are rarely identified as belonging to a particular category, i.e. they are not labeled. Moreover, non verbal representations do not communicate *about* their representational format (Wittgenstein, 1922), so users of shared representations may mistakenly attribute a particular representation to a particular type. This coins an old philosophical question whether the recognition of the type precedes understanding of the content of the representation or the other way around (see also Hofstadter, 1979). Study of the verbal interactions between team members, both in face-to-face and in distance, should provide data on the consequences of incorrect categorizations.

Further work should investigate mechanisms for allowing coworkers to propose their own external representations or to translate from one type to another. This may facilitate objectification, boost creativity and ease communication.

Finally, shared representations, according to the triadic view, may lead to multiple possibly inconsistent interpretations.

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Future Ideation: creating ideas despite distance

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Abstract. Team-based innovation, which builds on the true collaboration and thinking together strategy are at the heart for most manufacturing companies today. This strategy builds on a multifunctional team to increase the innovation potential. Diversity builds up the multifunctionality within the team and is a prerequisite for coming up with new innovations. Efficient idea generation demands facilitation, one example is brainstorming, which is easily performed. However, brainstorming is often misused, as it is not applied properly. A successful brainstorm seems chaotic, team members use Post-It notes and/or a whiteboard to write and sketch down ideas. In engineering design, computer tools support many of the development team's tasks, but an interactive computer support for idea generation is not commonly used. Also, existing tools do not support the "physical" activities found in classical brainstorming, they are commonly based on the logics of documentation than actual facilitation of a creative process. The study in this paper is based on observations of design teams and the purpose is to set up and present a specification for an idea generation tool that is both facilitated and mimics the best aspects of physical brainstorming.

1 Introduction

To be perceived as innovative or to provide innovations are at the heart for most manufacturing companies today. The stress on using virtual teams, sustainable development and an extension towards a service perspective put even higher demands on radical and new solutions.

Despite the intentions to focus innovation, we have in previous studies found that it does not always align with how employees perceive that the company encourage and handle suggestions of new ideas. Such experiences have been gained through how innovative ideas are managed within companies, e.g. no resources are allocated to follow up and realize the idea. The reasons for such an approach are understood and acceptable for all employees, for example launching a new product usually means that one established has to be taken out of stock. Yet, these experiences have an effect on the degree of innovation activities. If most of the ideas are just waste of time and put the project's deadline at risk, why spend time on exploring radical ideas, i.e. idea generation? Balancing risks and opportunities are part and parcel of innovation strategies, but it could be argued that risk management is more focused and many promising ideas are killed as mere embryos.

The study presented in this paper builds on the assumption that an efficient and user adapted tool for idea generation could sustain an innovation process. Our purpose is to, based on our experiences within team-based innovation, computer supported work and participatory design, synthesise our observations of team performance in innovation projects with the proposals from the literature to set up and present a specification for an idea generation tool.

Very briefly described, the methodology that support the results presented in this paper builds on 10 years of observing design teams and research within the engineering design area. The included teams have varied from student projects to industrial product realization projects. The degree of innovation has varied from incremental improvement to radical products. The design teams' collaboration have spanned from co-located to distributed work.

2 Innovation and idea generation

Team-based innovation, which builds on the true collaboration and thinking together strategy, propose a multifunctional team to increase the innovation potential (Törlind 2002; Larsson 2005). It is by contrasting the distinct understandings that novel ideas can be found (Bergström 2009). For example, diversity in backgrounds, competences, knowledge domains and sphere of expertise build up the multifunctionality within the team.

The divergent aspects are a prerequisite for coming up with new ideas, new combinations, new solutions and new products, though often also the cause for inefficiency. Therefore, it sometimes is argued that team work is waste of money, and that team work is often turned into team war (Paulus and Brown 2003). To prevent the innovation project to become a mess, team work has to be intentionally implemented and the idea generation phases have to be sufficiently supported.

Idea generation, i.e. to provide additional solutions and ideas, demands some facilitation to enhance the group effectiveness, i.e., a person within or outside the team takes the responsibility to lead the process. Such a facilitator needs specific competences to accomplish the role effectively and purposefully (McFadzean 2002). In view of this, idea generation is an assignment that essentially differs from ordinary product development work, therefore it can be perceived as both unplanned and inefficient. A method used for idea generation is e.g. a brainstorming session, where ideas should be presented under a limited timeframe, the quality of the ideas is not allowed to be judged and the team should go for finding as many ideas as possible (Kelley 2001). Brainstorming is an easily performed method, but oftentimes it is not applied properly. When the team goes with the creative flow and builds on each other's ideas, brainstorming is seemingly chaotic and quick. Commonly, the team members use Post-It notes and/or a whiteboard to write and sketch down ideas. Using sketching clearly improves group communication, idea development and expression (Tang 1991). The brainstorming session is usually performed on your feet; seemingly being on the "move" is part of the creative mode. The "landscape" of ideas that are displayed on the whiteboard after the brainstorming session is part of the result, if your creative session resulted in a bulleted list you have not performed a brainstorming session. This landscape of ideas acts as a record of the session and supports re-interpretive thinking and easy access to earlier ideas (van der Lugt 2005).

The basic logic for performing a creative session is to extend your view and explore alternatives that are not obvious from start. If facing a bulleted list with immediately realistic ideas it could be assumed that the team has jumped directly into solutions, probably such that they could have found anyhow. After displaying the ideas from the brainstorming session in what seems to be a hap hazard way, the team should categorize and cluster the ideas for taking them further. As a consequence the "landscape" is changed, therefore documenting and keeping track of "landscapes" of ideas is a challenge in brainstorming. Another important issue in brainstorming is the shared object manipulation by all the users, because building and annotating on the ideas or sketches of others are essential to increase not only the number, but also the quality, of the ideas.

3 Ideation tools

In general, in engineering design, computer tools are used to support many of the development team's tasks, but interactive support for idea generation is not commonly used. We have in previous studies (e.g. Törlind 2002) reviewed computer tools for idea generation and discovered that they do not support the "physical" activities found in classical brainstorming/sketching that are needed to encourage creativity and sharing of ideas in teams.

Also, contemporary ideation tools are commonly based on the logics of documentation and dissemination of the result than actual facilitation of a creative process. Finally, the tools specifically support text based idea generation, in reality innovation activities include more hunches and intuitions, which are not readily expressed only in text (Workshop Luleå 2010).

Reviewing the literature on idea generation support, we have found that proposals for more appropriate tools exists, but it is an intriguing question to ask why are they not realized, implemented and in use? For example:

- *Clearboard* (Ishii 1994) which combines remote sketching and videoconferencing between two sites, with gestures, eye contact and natural interface
- *Roomware* (Prante et al. 2004) which supports local sketching on private displays, sharing of objects to shared displays, annotation on shared objects, clustering and grouping.
- *The distributed designers outpost* (Everitt et al. 2003) which supports sharing of physical Post-Its in distributed meetings with a sense of presence of the remote users.

Boldly, we conclude that even though several promising concepts has been developed within the research community, the killer application for brainstorming and distributed sketching is still a challenge.

3.1 Five senses of interaction

One framework for categorizing and evaluating distributed tools for creative collaborative work is the five senses of interaction (Garrido, 2009):

- *Sense of presence,* describes the social presence – the feeling of being together that comes from the interactions between people (gestures, embodiment, spoken word, eye gazing etc).
- *Sense of space,* the interaction between the designer and the environment. This includes the awareness of physical location of other users and design objects.
- *Sense of sharing,* describes the interaction possibilities around shared design objects. A high sense of sharing includes that design objects can be modified by all designers at the same time.

- *Sense of time,* describes how events unfold - asynchronous or synchronous, and deals with the delay of communication.
- *Sense of naturalness,* describes how intuitive the system are.

Garrido (2009) found that commonly used tools are generally low on 'sense of presence' and 'sense of space'. Further, the tools, poorly support 'sense of sharing and sense of time', which are utterly present in co-located meetings. 'Sense of naturalness' in the case of providing for co-located behaviour is mainly lacking support by the tools.

4 Specification for a Future Ideation Tool

From our observations of distributed design teams we have found, for example that the lack of 'sense of presence' and 'sense of space' has hindered the workflow in the meeting, thus interrupted the ideation in the team. In one industrial project any sound from the video conferencing equipment made the session facilitator asking: "Are you still there? Can you hear us?". In one student project, long time was spent on finding out how to position the video conferencing camera to broadcast their interaction with a prototype. In our studies, so far, we have not observed a creative brainstorming session supported by technology that provides similar creative flow as in a co-located session. Based on our assumption that this is due to the barriers of technology, rather than people becoming less creative when using them, we propose a product specification for an ideation tool below in table 1, 2 and 3. A product specification should present what the product has to do, but not specify how to do it (Ulrich and Eppinger 2008).

Table 1. Software

Product specification: software
Easy update
Have connectivity to other tools
Provide a standalone work mode
Easy start and stop/log on and log off
Be compatible with other technology
Easy installation
Fast upstart
Highly interactive interface
Provide recording

Table 2. Hardware

Product specification: Hardware
Movable
High tech appearance
Lightweight
Affordable for firms

Table 3. Use

Product specification: Use	
Provide a private surface	Instil trust
Provide a shared surface	Prevent judgement of ideas
Allow swift use	Support multidisciplinarity
Allow easy operation	Support individual work
Enable visual work	Support shared work
Instil creativity	Easy access to results
Allow awareness of participants	Easy access to previous results
Allow awareness of work flow	Keep track of time
Support use of gestures	Bridge differences in preferences of work
Support use of postures	Provide facilitation
Allow awareness of mind-set	Affordable for firms
Support natural behaviour	Provide for flexible use
Support goal alignment	

Further work within this research project is to perform a workshop to develop the Future Ideation Tool, i.e. transform the specification into a product. The Future Ideation will be tested and evaluated in a three folded design observation study, where students, industry and academic representatives will be used. This paper is far from completed, we will report our rich empirical data more thoroughly, and also the literature review will be fully presented. This paper provides a first attempt to present the idea and gives us the opportunity to get feedback from the workshops participants.

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Supporting document augmentation to leverage representations in knowledge work

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Abstract The paper deals with the issue of representations as support of collaboration in knowledge work. On the basis of previous studies in different domains, the paper focuses on two aspects that led to the design of two complementary technologies: first, *underspecification* as a means to make the communication easier between professionals of different disciplines; second, the enrichment of documents by means of several kinds of annotations that convey individual and group experiential knowledge. Since annotations can be incrementally shared in collaboration and can contribute in building a shared cognitive context, they facilitate collaborative problem solving without requiring a posteriori (re)constructions of a consensual representation of either the ongoing discussion or partial solutions. The two resulting technologies are shortly described and a scenario where their envisioned integration could be profitable is illustrated by taking inspiration from one of the field studies discussed.

1 Introduction

Collaborative problem solving is a knowledge based activity. Often, this activity is conducted by sharing some representations that are linked to the problem at hand

and more generally to the domain(s) where the problem makes sense. Thus, speaking of representations as supportive means of collaborative problem solving implies to consider the relations between these representations and the knowledge involved in this process. A better understanding of these relations is a prerequisite for the design of a technology supporting collaborative problem solving.

In this position paper, we want to discuss the findings of our research in collaboration and knowledge management and the technological solutions that we derived from the observation in different settings of collaborative activities that encompass problem solving as an input for the conception of a more comprehensive support of collaborative problem solving.

2 Knowledge and representations

When knowledge workers and their collaborative activities are considered, sooner or later people end up by speaking of “knowledge sharing”. This expression can be obviously considered as a shorthand for a more complex phenomenon, but in the long run such an expression and similar ones can all contribute almost surreptitiously in considering knowledge as a sort of object (if not a commodity, a valuable asset) that can be produced, and then shared (and transmitted) among actors. In this view, representations are seen as means to *carry* what is often called “explicit knowledge”: since they can be shared and transmitted very easily, the same could indeed happen for the knowledge they codify and represent. Far from being a pure terminological matter, this way to speak of knowledge is dangerous for the consequences that these metaphors have on the conception of a supportive technology (McLoughlin, 1999). In fact, almost all knowledge-based technologies are (more or less consciously) based on the above assumption of “shareability”. On the other hand, according to a constructivist approach, our position is that knowledge intrinsically belongs to individuals and cannot be shared or transmitted; rather it is socially constructed through social practices and interactions (Winograd & Flores, 1986, page 78). Consequently, representations are not about explicit knowledge, but rather *linguistic means* that are able to evoke (tacit) knowledge in the mind of the participants of a collaborative effort. As such, these representations are necessarily an under-specification of what is needed to exhibit a knowledgeable and effective behavior. Under-specification concerns not only a partial view of the reality of interest (representations must be bounded) but it also concerns the intrinsic impossibility of drawing complete/accurate/ unambiguous descriptions of even small parts of that reality. In other words, we argue that representations cannot deal with two kinds of infinity, like an interval of rational numbers do in relation to real numbers.

In our view, this “limit”, far from being a real limit, explains why representations are so an effective way to support collaborative problem solving: in their intrinsic under-specification, and therefore in the room representations leave to human interpretation and to the human capability of "connecting the dots", lies the power of representations. On one hand, under-specification allows collaboration among actors that do not have a mutual acquaintance or do not share the same level of competence in the respective domains: in fact, such actors do not need to understand and reconcile all the (missing) details of an underspecified notation, simply because these are not reported in that notation: moreover, underspecified representations, while they are effectively usable by who knows their hidden details, do not overwhelm the cognitive capability of who ignores those details, but rather motivate them in acquiring the necessary meanings and conventions to participate in the discussion proficiently. On the other hand, under-specification makes collaboration time-saving and cost-effective for actors that are members of a community of practice: in fact, they can agree on efficient (since minimal) representations and fill in the gaps by means of conventions and informal practices that are derived from common experience. In so doing, they can keep their working representations at the right level of abstraction to develop the discussion in an effective and proficient manner. These claims and especially the latter one are based on our experience in two knowledge management projects where users constructed representations to play exactly these two roles within and across communities of practices in their collaboration for the design of complex products: hiding unnecessary complexities and fostering mutual alignment around conventional agreements (Bandini et al., 2003; Bandini & Simone 2006).

3 Under-specification at work

The first project was about supporting the problem solving needed in the design of truck tires (Bandini et al. 2003). A truck tire is a chemical device made up of chemical components and other elements: in particular, a truck tire is composed of rubber compounds (the chemical part), which is responsible for all the thermal-mechanical characteristics of the tire, and metallic reinforcement, which provides the tire with the necessary rigidity. The task of compound designers can be described as follows: they start a new project either to meet the requests of marketing, or to change one or more performance indicators of an existing product; then to this aim they produce a list of possible recipes and choose one of these after an evaluation of benefits (i.e. they evaluate if all the requirements have been satisfied) and drawbacks (i.e. what kind of costs and side-effects have been generated). During the field study, we realized that cooperative problem solving happens "in the wild", i.e., outside planned formal meetings and that it is based on mechanisms that are invisible and self-organized. The concrete aspects that emerged during the study were: a jargon owned by the designers to speak of rubber compounds properties and a set of paper-based media to record their (positive and negative) experiences in constructing new compounds basically as a modification of previous "recipes" (cf. continuous innovation). These two "tools" were seamlessly and continuously put to work during their discussions. They served as individual memory that was increasingly accumulated and "shared" by adding on previous individual contents: the jargon identified basic pieces of information; the paper sheets organized these pieces in order to make the way modifications of the recipes yielded to rubber (and hence tires) properties explicit. These individual supports showed marginal differences that were naturally reconciled in a comprehensive structure called "T-Matrix" that was based on the following information (see Table 1). Blends of rubber compounds are described by a set of Blend Features (BFs), such as tensile strength or hardness, while tires are described by means of Tire Performances (TPs), such as wet handling and mileage. BFs and TPs could be expressed in either qualitative terms (i.e. as textual descriptions or comments given by the experts) or quantitative terms (i.e. test results). In addition, a set of interventions on the recipe (RIs) can be performed to modify its composition. The very important knowledge about chemical compounding for truck tire stands in two relationships, called Compounding Relation and Design Relation. The first relation binds RIs and BFs, while the latter describes the correlation existing between BFs and TPs.

The structure of the T-Matrix was the basis of a very simple technology whose aim was to let all kinds of designers collect the conventional information that progressively stratified their design experiences. Interestingly, there was no need to define any sort of explicit structure for the access rights: a distributed social control guaranteed that each update was reliable since performed by (or on behalf of) a "reliable person".

TP 1	⊙↓	○↑	⊙↑	○↑
TP 2	▲↑	⊙↓	☒	▲↑
TP 3	⊙↓	○↑	⊙↓	○↓
	BF 1	BF 2	BF 3	BF 4
RI 1	☒	○↑	⊙↓	▲↓
RI 2	▲↓	☒	○↑	☒
RI 3	▲↑	○↑	⊙↓	○↓
RI 4	○↓	⊙↓	▲↓	⊙↑

	Symbols	Meaning
Correlation	⊙	Strong
	○	Good
	▲	Weak
	☒	No
Proportionality	↑	Direct
	↓	Inverse

Table 1 A uninterpreted example of T-Matrix and the meaning of the symbols describing correlations and proportionality of the relevant features

Some time later, the T-Matrix was also made available to the responsible roles of the production lines, although in read-only mode only, when they had to solve problems depending on contingent situations (e.g., an ingredient with not standard properties or the unavailability of a specialized machine) with the goal to preserve the same properties of the ongoing production. As a consequence, the jargon became a resource shared by additional people: this contributed to expand the role of this sort of "common language" and to the development of collaborative behaviors between design and production people, which historically constitute two communities not always permeable. Interestingly enough, a subsequent effort to build a much richer computational model of the technical content involved in design was not used to this purpose, but rather to support the self-education of newcomer engineers and to facilitate them in understanding the pragmatics of the communicative interactions supporting the design of rubber compounds.

Although in a fully different domain, i.e. software integration, the second project showed similar characteristics: underspecified and socially controlled representations of software architectures and non-functional requirements were the means to support distributed problem solving involving costumers too (Bandini & Simone 2006).

4 Enriching Flexible Representations

From our subsequent studies in the healthcare domain (Cabitza et. 2007, Cabitza et al. 2009, Cabitza & Simone 2009), it emerged that the role of technology has also to deal with the capability to enhance the *evoking power* of representations. Since knowledge belongs to individuals, this capability cannot do without the direct intervention of actors themselves. The technology can be used to allow actors define local and very specific "rules" that enrich and augment the available representation with visual cues that are able to support this evocation either explicitly or implicitly (e.g., by reminding them of an apt use of the representation itself, or of the represented entity) . To this aim, we designed and developed two kinds of technologies.

The former one is WEDYM: this is a text editor for web documents that is integrated with an annotation system that allows for the use-friendly and in-line insertion of two types of annotation: classic textual side notes (i.e., marginalia) that users can anchor to any element of the content of a document and that the system puts in the margin of the document in a visual manner that was strongly inspired by traditionally typographical conventions; and semantic annotations (depicted in terms of particular underlinings) that users can create by associating a part of the content with items that they can select from either user-defined tag lists (e.g., folksonomies) or standard reference taxonomies (like MeSH[1] in the medical domain)[2].

The latter application is ProDoc, a web-based application developed according to the WOAD framework (Cabitza & Gesso, 2010), that allows users to create, fill in and retrieve complex sets of forms, charts and documents. ProDoc organizes

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[1] MeSH is a standard controlled vocabulary to index documents and their content in the medical domain. http://www.ncbi.nlm.nih.gov/mesh

[2] WEDYM has been developed by Michele Bologna, who described its architecture and functionalities in his Master Thesis. The thesis is made available at the following URL: http://www.gl-iss.org/downloads/BolognaMScThesis.pdf

electronic documents according to a strictly paper-like document metaphor, i.e., as if each document and data mask were a single sheet from a multilayered virtual folder. In addition, ProDoc is able to enrich forms and documents by means of additional (mostly graphical) cues (e.g., underlinings, icons) according to the documents' content and interaction with the user: the conveyance of these cues (which we called Knowledge Evoking Information, or KEI in Cabitza & Simone 2009) is associated to the occurrence of particular conditions that characterize a specific situation by means of if-then constructs, called mechanisms. Within the WOAD framework, we also developed a simplified notation for the computable expression of mechanisms (Cabitza & Simone 2009b) and built a prototypical editor to allow users and communities define them participatorily according to their local conventions. Both WEDYM and ProDoc have been tested in different contexts: WEDYM was used as a support of team work and collaborative note taking at a university class on knowledge management; ProDoc was evaluated by a group of doctors and by a group of archaeologists to check its main functionalities (Cabitza et al. 2009b, Locatelli et al. 2010). In both cases, the outcomes were encouraging.

5 Towards an integrated scenario

Apart from the technical details, these two applications allow each single actor to augment either personal or common documents by means of what she usually deals with to interpret the representations that these documents contain (e.g., annotations, dictionaries, references). For the time being, these systems work on textual documents only, but their basic idea can be implemented for other kinds of representations (graphics, pictures, 3D renderings and the like). Moreover they are not yet integrated in a single application: this is part of our future work.

Irrespectively of these limitations, it is possible to imagine a scenario where their joint functionalities can be put to work to support collaborative problem solving, on the basis of the experiences reported in the previous sections. For instance, let us revisit the case of compound designers and describe a scenario where their activities, as we observed them years ago, could be supported by this fancied "integrated technology".

Compound designers work partially alone and partially in groups when the requirements of a customer have to be met. In the first case, they use their local representation of the basic concepts representing the recipes' composition and how this impacts the features of the tires that include that compound. During their individual work, designers can use all the annotations/affordances that the integrated technology makes available: for example, they can add annotations containing an indication of what customer a past solution was identified for, or rules establishing that some combinations of ingredients are critical for rubber production, and the like. When they meet in order to compare their individual proposals and reach a consensus on the best possible solution fulfilling all customer's requirements, their individual representations are uploaded to the T-Matrix (i.e., to an agreed shared representation) as potential solutions. This upload is made possible because the structure of the T-Matrix is derived from local representations through appropriate mappings. In so doing, designer have at their disposal a local space where their annotations and rule-based mechanisms hold and support their reasoning (like a personal information space described in Tang & Carpendale 2007); and they also have a shared space where alternative solutions are contained (Bannon & Bodker 1997, Hertzum, 1999). During the discussion, the latter ones can be collectively annotated (e.g., by the meeting facilitator, or in turn by the designers themselves) or annotated by transferring local annotations to the corresponding pieces of information in the shared space. Each annotation carries the information about its author and a time-stamp. The same can be done for local mechanisms that might be considered as useful to support the decision process, for instance by highlighting passages or relationhips to be further discussed because recognized as partially inconsistent with respect to elements imported from other authors. At the end of the meeting, the contents of the T-Matrix are transferred back as an update of the local representations, together with the annotations and the new shared mechanisms. At this point, each designer can discard the information she deems as not worth of being recorded in a persistent manner. In a subsequent meeting, the recorded information serves as a sort of self-managed minutes of the previous meeting and supports each designer in the next stage of the discussion.

This scenario mimics what we have discussed with the designers in terms of management of information during their meetings: a continuous and flexible transfer of contents from/to local and shared meaningful representations. This case is particularly favorable since the above mentioned mappings are the product of the mutual learning process that occurs in this particular community of practice. Of course, this is not always the case and the transfer of information from/to local and shared spaces would require a greater human intervention, until the mutual learning process occurring during the meetings partially reproduces the more favorable situation.

This approach contrasts the idea that problem solving is made easier by a top-down and rationalistic 'a-priori' construction of a common background and view of the state of affairs (i.e., a model), or by an 'a posteriori' reconstruction (if not a reconciliation) of the possibly divergent argumentations emerged during the discussion. Rather, we envision a technological support that enables the participants to embark upon discussions where they can co-construct their local and extemporaneous background 'on-the-go', i.e., by sharing content and meta-content (i.e., annotations and convention-based rules) in and out of their respective personal information spaces. To this extent, our approach differs from the one usually called “design rational” and it is more in the line of the “action-reflection” approach proposed by Fisher & Torbert (1995).

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Building boundaries on Boundary Objects: A Field study of a Ubicomp tool in a Design Studio

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Abstract In this paper, we provide the results of a field study of a Ubicomp system called CAM (Cooperative Artefact Memory) in a Product Design studio. CAM is a mobile-tagging based messaging system that allows designers to store relevant information onto their design artefacts in the form of messages, annotations and external web links. From our field study results, we observe that the use of CAM adds another shared 'space' onto these design artefacts – that are in their natural settings boundary objects themselves. In the paper, we provide several examples from the field illustrating how CAM helps in the design process.

1 Introduction

> Boundary objects are objects which are both plastic enough to adapt to local needs and constraints of several parties employing them, yet robust enough to maintain a common identity across sites. …The creation and management of boundary objects is key in developing and maintaining coherence across intersecting social worlds.
>
> Star and Griesemer (1989)

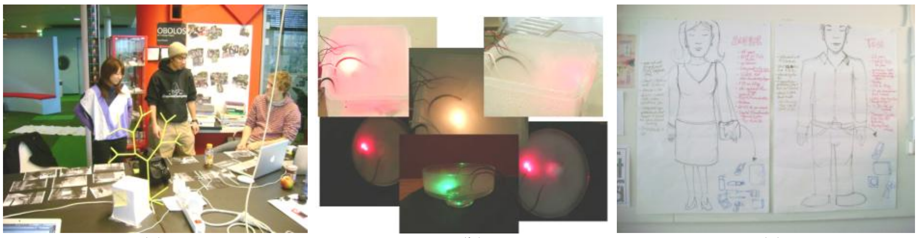
Over the years, CSCW research has established notions such as boundary objects (Star and Griesemer, 1989), common artefacts (Robinson, 1993), common information spaces (Schmidt and Bannon, 1992) and organizational memory (Ackerman and Halverson, 2004) to refer to shared informational objects that can be used by different groups for their own purposes. In the design studio context, design artefacts such as drawings, sketches, collages, storyboards and physical models can be seen as boundary objects, as these help in communicating and establishing a common ground between designers. When design ideas are communicated through these design artefacts, each artefact represents a space of possible interpretations. Within these spaces the designers can negotiate over further developments to the design (Eckert and Boujut, 2003).

With a goal of developing a Ubicomp technology (Weiser, 1991) to support communication within the design studio culture, we carried out ethnographic fieldwork in design studios (Vyas et al. 2008; Vyas 2009; Vyas et al. 2009a and Vyas et al. 2009b). Building on the results of our fieldwork, we have developed and deployed a Ubicomp technology called CAM (Cooperative Artefact Memory). CAM is a mobile-tagging based messaging system that allows designers to cooperatively store relevant information onto their physical design objects in the form of written messages, annotations and external web links. Using CAM, design artefacts could have an individual digital profile on the Internet where relevant information can be added, updated or changed by designers. In other words, CAM allows designers to build an added layer of communication onto these boundary objects, in full, it builds "boundaries" on boundary objects.

We have studied the use of CAM in a Product Design studio for three weeks, involving three different design teams. The purpose of the field study was to understand the role of augmented design artefacts in supporting creative work. Our results show that CAM was used not only for communication and coordination but it also facilitated designers to appropriate their design artefacts to be explorative, playful, and evocative – supporting creative aspects of design work. In the rest of the paper, we will briefly describe our ethnographic fieldwork in design studios and point out important design implications. We then describe CAM and provide the details of our field study. Next, we describe our findings and using examples from the field show how CAM facilitated design artefacts for supporting creative design practice.

1.1 Ethnographic Fieldwork

In our ethnographic fieldwork, we studied a mix of professional and academic design environments over a period of 8 months, with nearly 250 hours spent in the field. Our ethnographic approach was informed by ethnomethodological orientation (Randall et al. 2007). We intended to understand the everyday work practices of designers, methods and procedures they use to support their work and the resources they use to make sense of their design world. We used naturalistic observations, contextual interviews and video recorded collaborative design sessions of designers and design students. Overall, we explored three major themes of collaborative practices that designers frequently apply: *externalization*, *use of physical space*, and *use of body* (Vyas et al. 2009b). Our results show that material and visual nature of design practices support coordination through the use of physical design artefacts (Vyas et al. 2008). We explored the role of physical surfaces of design studios in supporting creative design practices (Vyas 2009). Moreover, our results also show that design artefacts play an experiential role (Vyas et al. 2009a) in supporting designers' exploration and communication activities. Figure 1 shows a few examples from the fieldwork.



(a) (b) (c)

Figure 1: Examples from the fieldwork. (a) Use of physical space, (b) Exploring and exploiting material richness, and (c) Personas as design artefacts for communicating design ideas.

1.2 Design Implication

From the fieldwork, we develop four main implications to design a Ubicomp technology to support designers' everyday work.

- *Artefact-mediated Interaction*. Designers develop a multitude of design artefacts in the form of paper sketches, drawings, physical models and so on over the course of their design projects. The materiality, stigmergy, public availability and knowledge landmarks left on design artefacts help in establishing and supporting communication between designers. We believe that a Ubicomp system should be able to incorporate these artefacts (at least partially) into its design space so that artefacts' experiential and natural qualities can still be exploited by designers.
- *Utilize Spatial Resources*. The way designers keep these artefacts and organized them in their workspace affects their work communication, organization, and coordination practices. It is this spatial flexibility of, for example, sticking sketches and drawings on a shared office wall that allows designers to discuss, criticize and explore new possibilities of their design work. In order to provide technological support for spatial flexibility, we need to think beyond desktop computers and involve the spatial aspects of design studios.

- *Creative Explorations*. We observed that designers spend a considerable amount of time in exploring new ideas and concepts by utilizing different techniques and design representations. Our fieldwork suggests that for creative explorations there is a need for a technological infrastructure that allows designers to collaboratively generate innovative ideas.
- *Social Flexibility*. We observed that the use of design artefacts and physical space allowed a level of flexibility in designers' everyday social interactions. This helped designers to discuss things anywhere and anytime. We believe that a Ubicomp system should not impose a social order onto the designer, on the contrary it should allow designers to bring about and establish new practices for design.

2 CAM: Cooperative Artefact Memory

2.1 Vision

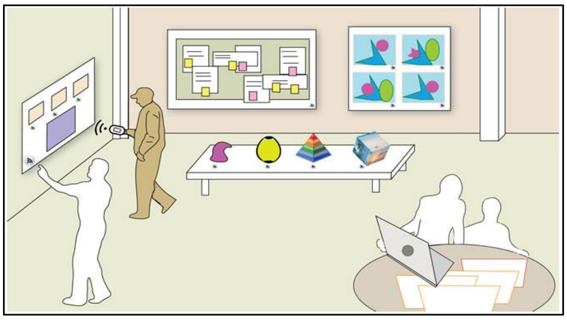


Figure 2: A vision for design studios.

Following the design implications, we developed a vision for a ubiquitous computing system in design studios, as can be seen in Figure 2. According to this vision, using mobile devices and barcodes or RFID tags design professionals can collaboratively store relevant information onto their physical design artefacts (e.g. sketches, posters, collages, post-its, physical mock-ups, prototypes) and can access this information though their mobile devices. Designers can exchange ideas and collaborate via these design artefacts, hence supporting collaborative work in ubiquitous ways. The relationship between these design artefacts (i.e. how a design sketch is connected to a physical model and a prototype) can be established via the technology. By this vision, design artefacts would eventually serve as a "memory" for all the events within a design project.

2.2 Technology

Figure 3: CAM running on an iPhone (a); Reading a design sketch using TagReader client (b).

CAM uses low-tech, off-the-shelf tools such as Microsoft's mobile-tagging application TagReader, 2D barcodes, a JAVA web server that uses Twitter API and camera based mobile phones. Using CAM, design artefacts can have an individual digital profile on the Internet where relevant information can be added, updated or changed by all designers. CAM has a very simple interface (Figure 3a): "Check Updates" allows viewing of all the messages about a design object and "Post Message" allows writing and sending a new message to it. The central idea in CAM is that it associates each 2D barcode to a Twitter account. Hence, when one reads a 2D barcode attached to a design sketch (Figure 3b), for example, one can read a set of messages about the artefact in the Twitter interface.

In a typical usage scenario, a designer can attach a 2D barcode to his/her physical design object and write messages to the barcode via the TagReader client. Whenever a designer writes something to a barcode, the message is sent as a Tweet to that barcode's Twitter account. Similarly, when one reads a barcode, he/she would see a log of Tweets in the form of messages, annotations and comments about that particular design object. In a collaborative design project, this would eventually lead to a collection of Tweets written by different group members that will provide information about different design activities in the project.

3 Field studies of CAM

In a Product Design studio, we studied the use of CAM over three weeks. We asked three student design teams to use CAM for their one week long design projects. Table 1 shows the details about our design participants and their design projects. Our design participants knew each other very well and were familiar with each other's individual design expertise and qualities. Also, they had all been in comparable group projects before, and were aware of the issues that might be important in a group project. In the current design projects we wanted to investigate possible ways of using CAM and explore how useful it can be for supporting creative work.

Design Team #	Educational Year	Design Subject	Number of Participants
1	1st Year	Remote Control	4
2	3rd Year	Alarm Clock	4
3	5th Year	Intelligent Lamp	4

Table 1: Details of participants

For the study, we gave each of the participants a camera-based smart phone. We also gave them 2D barcodes generated from Microsoft Tag, and we created several temporary Twitter IDs. They were first given a demonstration about how CAM works and how they could send and receive messages. They were asked to use CAM during their project as a tool to store information onto the design objects. Our intention was to use CAM as an explorative tool to learn what role design objects play in supporting creative work. Hence, we completely left it to the design teams to use CAM in their preferred ways. They were only encouraged to use CAM as much as possible. We also encouraged them to use the Internet from the mobile phones. We videotaped their design sessions throughout the course of the projects, and we interviewed all team members at the end of the sessions. We collected the logs of the 2D barcodes. We also analyzed the messages to individual design objects from their Twitter logs.

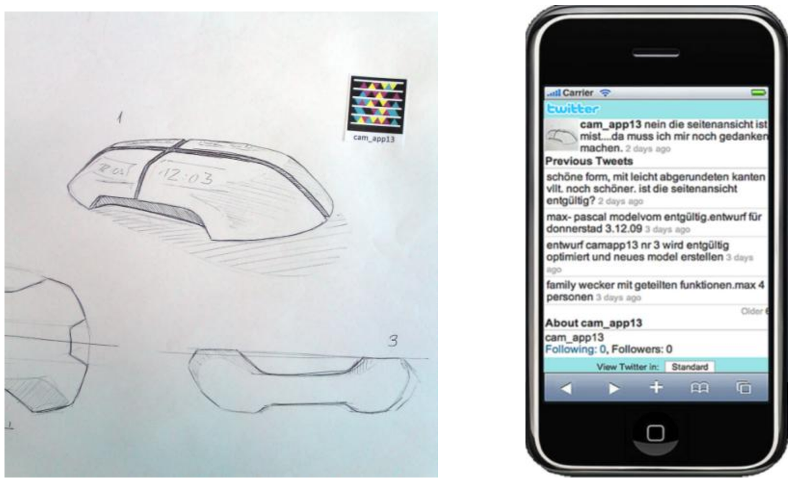
4 Results

4.1 How CAM was used…

Figure 4: An example design session. Tagged sketches are kept on a white board.

As can be seen in Figure 4, design teams integrated CAM in their everyday design practices. During their design sessions, designers attached 2D barcodes to their design sketches, physical models, collages and Post-it notes and using CAM they added annotations, messages and other relevant information to these artefacts. Since all the team members had access to the Internet through the mobile phones, they also added web contents to their messages.

An example of a design artefact can be seen in Figure 5a. The design sketch describes a conceptual alarm clock that is augmented by a 2D barcode. The creator has added details about the design of the alarm clock on the 2D barcode and subsequently his co-workers have commented back on his ideas. When one reads the 2D barcode on a mobile phone, one will be able to see a complete log of comments as shown in Figure 5b. This log shows the dialog that took place between co-designers.



(a) (b)

Figure 5: Design sketch of an alarm clock (a) and the log of messages sent to the design artefact.

It was observed that not all the design artefacts, developed during projects, were tagged with a 2D barcode. Designers tagged their artefacts only when they wanted to show or communicate their ideas to others. Using CAM they would discuss the artefact by writing and reading messages from the Tweet log.

During the interviews we received several encouraging comments from the design teams. Here are a few comments:

> “CAM makes the sketch interactive not only because of the details of the sketch but the communicational support it provides us, because all the team members can read what others have written about a particular design object.”

> “If you stand in front of these things [design artefacts] and scan everything, it helps to think about and understand what’s going on in the project.”

In addition to its communication functionality, CAM was described as a tool for reminders, triggers, notices, exhibits and resource sharing. The use of CAM was also seen as a tool for storing “minutes” of a particular design session, as relevant information can be read readily from the artefacts. A team member suggested:

> “These 2D barcodes provide immediate access to the information that you want without a need to switch on the computer.”

A few of the design students suggested that design artefacts with 2D tags can also be seen as archives for future projects.

> “If I have to design a new alarm clock again, I can go back and retrieve all the information that is stored and see how I can continue with that.”

> “It is important to collect a kind of archive of your ideas. So, you can always retrieve all sketches and all the ideas so that you can include what you and others have written into the work.”

Between the three design teams a total of 53 design objects were tagged with 2D barcodes, 197 messages were sent to these objects and these were read 488 times in total. The team-wise distribution is presented in Figure 6. Our approach also allowed us to analyze the use of 2D barcodes. Figure 7 shows a graph that shows the number of scans per design artefact (with 2D barcodes) from one of the design projects. In this project a total of 19 design objects were tagged with 2D barcodes and in total they were scanned 133 times. The tag that was scanned most (15 times) was a Planning object. This kind of information helps in understanding which design artefacts had more collaborative importance than others.

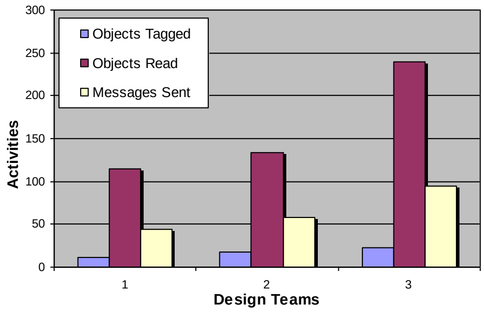


Figure 6: Team-wise usage of CAM over three weeks

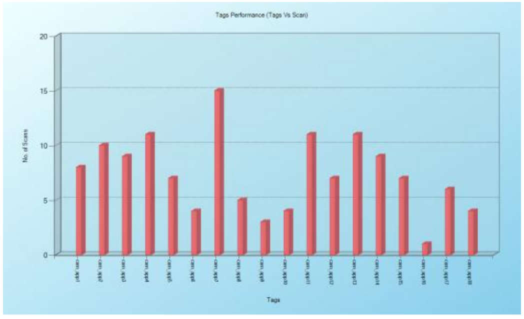


Figure 7: Usage of 2D barcodes during design project 2. (Generated by Microsoft Tag)

4.2 Tagged Artefacts

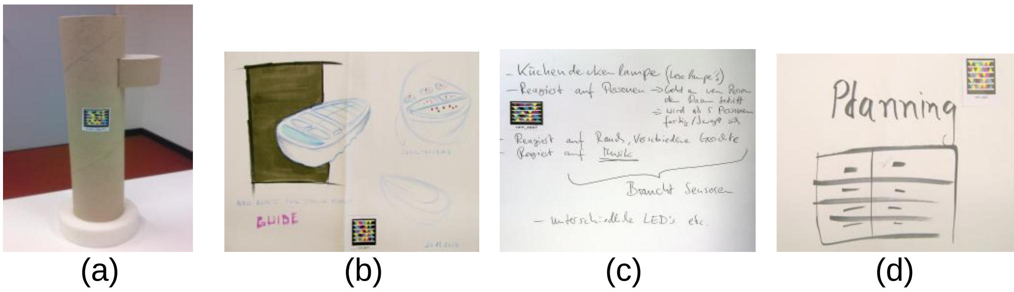


Figure 8: Different types of design artefacts tagged during design sessions. (a) a physical model of an intelligent lamp, (b) a sketch of a remote control, (c) a written note, and (c) a reference object for planning.

From the fieldwork, we observed several types of design artefacts being tagged to support different design activities. We explored four types of artefacts tagged: 1) Physical objects, 2) Sketches, 3) Notes, and 4) Reference objects.

The *physical objects* are three-dimensional objects or models made from wood, foam or cardboard that product designers create once their design ideas become concrete. Figure 8a shows a model of an intelligent lamp that was tagged with a 2D barcode. The paper-based *sketches* are the representations of design mainly used for exploring and communicating design ideas between co-designers. Figure 8b shows a design sketch of a remote control device tagged with a 2D barcode. The purpose of written *notes* varied from descriptions of a design artefact to a collection of brainstorming ideas. Figure 8c shows an example of a written note.

The *reference objects* are abstract, mainly pointing to a digital content. These artefacts themselves do not contain much information as such. Figure 8d shows an artefact that was created by designers to mainly create a storage point for all the planning and coordinating activities – which can only be accessed using mobile phones.

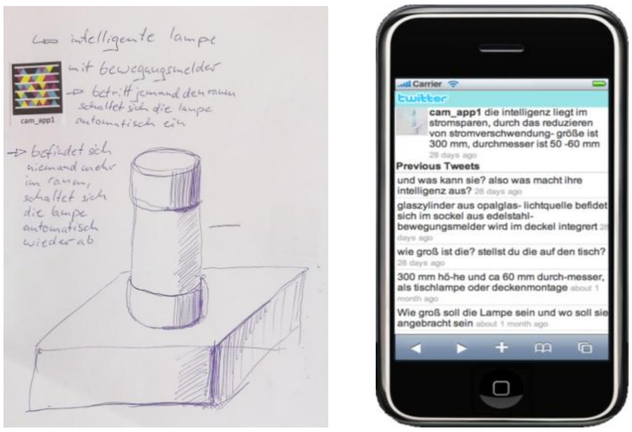
These four types of artefacts show a transition from physical, information rich artefacts to artefacts that do not contain information themselves but are references to digital contents. From the perspective of 'boundary object' theory, an important issue in this categorization of artefacts is to understand where the relevant information about design lay. These design artefacts are by their very nature boundary objects in themselves. And the use of CAM allows designers to store additional information onto the artefacts' digital profiles. If we take the example of the physical model of the lamp (Figure 8a), one can get information about its form, size and can experience other kinds of interaction with the lamp. Hence, the physical object itself can provide important information to co-designers. At the second layer, when one reads the tag, one can read information about the design artefact as described by designers and the dialog and information exchange that subsequently took place between them. If we move onto the reference object (Figure 8d), the artefact itself does not contain useful information for the design activity. However, on the second layer of boundary object, one can read information related to the planning of the project. In this case, we see the second layer of boundary object containing more useful information than the first layer of boundary object. This example is elaborated in Figure 12.

4.3 Manifestations of Artefacts

In this section, we provide different ways CAM helped in supporting design activities.

4.3.1 Design Narratives

The narration and description of design activities during the course of design projects was depicted through different Tweets that were sent using CAM. Although, the technological changes most likely lead to changes in narrative structures, these narratives do provide a clear indication of how design was carried out. An example of such a narration is described in Figure 9. Figure 9a shows a designer's annotated sketch of an intelligent lamp concept with a 2D barcode attached to it. Figure 4b shows the Tweet log of the sketch showing the description of the concept and different questions and issues raised during the course of the design process. In Figure 9b, one could read information about the size of the lamp and its functionality. Importantly, the log also shows questions and issues raised by co-workers such as: "where the lamp should be placed", "what material should be used" and "what should be its size".



(a) (b)

Figure 9: Sketch of an Intelligent Lamp concept with 2D barcode (a), and Tweets sent by the co-designers to provide a design description written in German (b).

One of the important aspects of these design narratives was their 'cooperative' nature. The design narratives in the form of Tweet-logs represented different views expressed by co-designers in a particular design project. To an extent this form of interaction provided an opportunity for collaborative concept creation. The design narrations depicted in the form of Tweets provided information about the design process that was used by the design teams. When asked about what they thought of these design narrations, designers had the following comments:

> "In my opinion, this is like making a design story. Maybe not the complete story. But it has a great deal of information about the conversation that we had while we were working".

We were interested to understand how our design participants viewed the narrative support provided by CAM and how useful they found them for their ongoing design activities. The narrative characteristic supported by CAM also triggered different uses. A collection of these design narratives can lead to providing an overview of the project. Here is a comment that we received during the group interview sessions:

> "If you stand in front of these things and scan everything, it helps to think about and understand what's going on in the project."

We also received some interesting comments about improving the current prototype of CAM. Here are some of the comments we received:

> "It would be nice, if we can administer these comments and filter out redundant and less relevant comments from the sketches."

> "It is sometimes difficult to squeeze some complex problems into such as short message. So, sometimes the results are strange formulations. It might be possible that you might not understand a particular message and there is a danger that something completely wrong might result from this."

It was clear that not all issues related to a design artefact can de described in the form of messages, and this was certainly not our intention. CAM is not meant to add large descriptions to the design artefacts.

4.3.2 Expressions & Aesthetics

The way designers used CAM and wrote messages onto their design artefacts had expressive and aesthetic qualities. Some of the Tweets that were written on the design artefacts had a certain amount of enthusiasm and affection. One of the designers had the following comment:

> “Sometimes you do see an enthusiasm of the designers in their messages. In some cases, I have seen detailed descriptions of a design sketch in the messages and sometimes its not detailed enough. So, then I had to ask them questions and asked them to elaborate some ideas.”

Although, most of the messages had a neutral quality, in some cases, we did observe that design artefacts had some level of evocative and provocative qualities or an ‘invitation’ for co-designers to comment back on the work. The following is a comment of one of the designers who intentionally wrote messages to get co-workers attention.

> “I would like to know if others like my sketches and design ideas. What do they think about my work? When they don’t have a chance to speak to me, they can write something on these sketches using CAM.”

The use of CAM allowed designers to express aesthetic qualities in their messages. Making a connection between the physical design artefacts and relevant messages as Tweets provided an interesting opportunity to the designers to express something that they would not express during their everyday cooperative design sessions. One such example can be seen in Figure 10. It shows the final sketch and concept developed by the group 3. In this case, a designer wrote a poetic message to express the aesthetic quality and functionality of the lamp. In Figure 10 we also include the original poetic messages in German and then their English translation.

German:
strahlemann, der strahlt uns an.
ob tag und ob nacht, wäre hätts gedacht

English:
the Shiny-man, who shines on us.
whether day or night, no matter what.

German:
die sonne am morgen,
die sterne am abend,
die langsam begleitend in den schlaf uns tragen

English:
the sun in the morning,
the stars at the night,
slowly accompany us into sleeping tight.

Figure 10: Final sketch of a conceptual Intelligent Lamp and A set of poetic messages adding aesthetic qualities to the Intelligent Lamp concept (with added English translations).

During the final group interview session with the design team, we asked about these poetic exchanges.

D#: "Somebody wrote a poem about the lamp. It's just funny. It describes the lamp in an artistic way. And the cool thing is that you are totally anonymous. This is something that makes this sketch beautiful."

D#: "The poem shows the poetry of the product. It is something about a good sleep and have a good night and wake up."

D#: "I didn't know who wrote it. And when I first discovered it, I thought look somebody wrote a poem. It was really amusing. It could be something to tell the customers who might buy this lamp. This could be something that separates this product from others."

D#: "I think it makes the concept of our lamp more romantic and magical, if you like."

More importantly, the setup and interactive opportunities provided by CAM were seen as intriguing by all the designer teams. To an extent, the idea of adding digital information to an ordinary physical object such as a sketch was very interesting for some of the design participants. Several designers commented that they saw Tweet messages as an extension of their physical design objects.

"To me it's a fascinating experience to read the details about the lamp that we designed in a mobile phone. It is like seeing the same thing in a different way"

"For me, it is an extension to the usual way we work. It is just like sending an SMS to somebody, but the messages are stored on the object."

4.3.3 Coordination

We discovered interesting coordination and communication patterns while observing the use of CAM. As we showed earlier, design teams used a large whiteboard to keep their design artefacts and all the team members could see one another's work. When 2D barcodes were added, other co-workers could read the information that was attached to different design artefacts.

Message log of Alarm Clock

1. Yes, ok. I have also touched on this once.
2. Perhaps you can tilt the clock view more towards outside. Four different clocks might confuse family members. Not intuitive.
3. Perhaps you could also consider the outer edges down further.
4. I would think more volume :)
5. Off when you push the lead of the alarm clock. The alarm can be switched off from each points of the housing.

Figure 11: One of the prototypes of an alarm clock

The design artefacts were in fact an important source of communication between co-designers. However, the 2D barcodes added an extra channel for communicating additional information. Designers could make comments about each other's work and negotiate specific ideas using CAM. Figure 11 shows one such example where a physical model of an alarm clock that has a 2D barcode.

The message log shows the information about this object and shows how designers negotiated (latest message at the top).

To give another example, Figure 12 shows a "Planning" object that design team 1 developed in order to make a specialized access point for organizing and planning their ongoing project. It also shows the Tweets that were sent to this object over the course of the project (latest message at the top). We have translated the Tweet log into English for better understanding. The purpose of this design artefact was to divide work responsibility, create a work schedule and for sharing important decisions between themselves. We observed during the course of their project that the design team iteratively added contents to this object. This kind of practice led to designers frequently checking the "Planning" object in order to 1) review their previous activities, 2) coordinate their ongoing activities and 3) create milestones for future activities.

Message Log of "Planning" object

1. Thursday: Grigorios - presentation Sketch
2. Thursday: Eric - technical drawing
3. Thursday: Tarek & Julia – finishing the design model
4. Make technical drawing
5. Wednesday: planning, task distribution. Grigorios
6. Wednesday: Braille design with Eric
7. Proposals on the buttons:
    1. Payment
    2. Volume
    3. Channels
    4. Program Selection
8. Joey's?
9. What else should we add for supporting touch-based facilities?
10. I would very much like to order pizza for tomorrow. Better designs with full stomach
11. Touch screen OUT. Agreed on the use of Braille writing system. Any proposals on the form?
12. How many keys does a blind remote control require?
13. I propose that we combine both the concepts, your form and our concept of designing for "blind people"

Figure 12: A "Planning" object and its message log.

One of the main advantages of CAM, as seen by the design teams, was its asynchronous and flexible communication support. One of the designers suggested:

> "When you talk to a lot of people during design meetings, you get too many opinions and issues that are not really important. But when you just write it on the sketches in black-and-white using CAM then you can quickly focus on the design".

We also observed that CAM could be suitable for large groups of people collaborating over a long period. In large corporations, where teams from different disciplines work together on a project, CAM can provide additional and relevant information of a multidisciplinary nature. One of the team members suggested:

> "In a scenario, where we have to hand over our work to product developers and engineers, these 2D barcodes can help these professionals who have not been closely informed about the kind of design process that we have applied to these design objects. So, I think CAM could also be helpful for inter-team collaborations."

The communications were both named and anonymous. Regarding anonymous communication, a team member suggested,

> "I thought confusion did occur after reading these comments on the objects. And I do think that there could be an identification mechanism for these messages."

4.3.4 Creative Explorations

We were also interested in exploring the role CAM plays in supporting design exploration and creativity in general. Some previous research has indicated that designers do not work in a pre-determined, mechanical fashion (Jacucci and Wagner, 2007). In fact they apply different approaches in different situations, involving different media (ranging from papers, foam, woods to digital tools) to understand and solve their design problems. Being able to explore and try out new design ideas is central to their design work. We observed that the social and collaborative nature of CAM allowed all the members of a design team to actively participate in the exploration process.

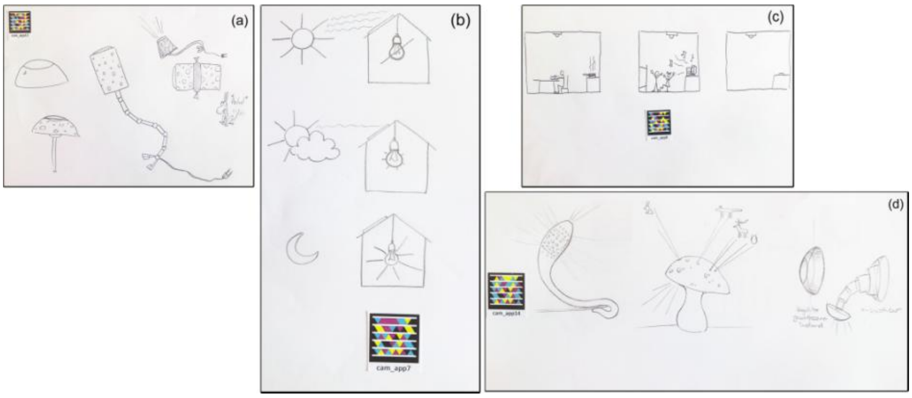


Figure 13: Design sketches to explore ideas for Intelligent Lamp.

In one instance, a team member developed several concept sketches for the Intelligent Lamp project (Figure 13). Sketching is clearly one of the quicker ways to express and communicate design ideas to co-workers. However, in this particular case, the team member's intention was to gather co-workers' comments about different exploration ideas that she developed. Figure 13a was meant to explore different shapes of lamp; 13b and 13c show the ways to apply intelligence into the lamp; and 13d explores different projection styles for the lamp. The intention here was to have a discussion via sending views and ideas onto the design artefacts and discuss these during the face-to-face meetings. Here is a comment from that design member:

> "CAM does help in creative thinking. Sometimes when I am drawing, I wouldn't know all the technical details. So after reading these comments about my sketches, I did find some tips about changing my original ideas."

By receiving comments from each other, members of design teams collaboratively learned and improvised their ongoing design projects.

> "The useful thing about CAM is the new ideas that we get from others. I found this very stimulating for my creativity. For example, Max had this function of pushing in the alarm clock and I had a separate switch. From Max's design and my design we merged the interesting ideas and came up with a combination in the final design idea."

4.3.5 Reflective Practices

Reflection – a mechanism for learning and improvising from experience is seen as an important aspect of professional design practice (Schön, 1983). In this section, we will focus on how the use of CAM facilitated designers to critically look at their own work and the work of others. The asynchrony and serendipity of messages and comments helped design teams to reflect on their own work at the same time being able to learn and constructively criticize each other's work.

> "The system does help you to reflect on what you designed and what you wrote about it. At the same time what others have said about your work."

Reflections were triggered by the Tweets sent by the co-workers about some previous design activities. These Tweets, which contained comments and suggestions, then lead designers to critically look at their design sketches and other design artefacts. Sometimes, these reflections seemed to prompt decision-making and also lead to some face-to-face discussions between team members.

Moreover, CAM required designers to write down their activities in the form of messages. This actually helped designers to organize their ongoing design projects and to make themselves accountable. One of the team members said:

> "I think it might be a good thing if we can write down what we are thinking about during the process of making sketches. This would be a good practice as well."

5 Discussion & Conclusion

Traditionally, when we talk about boundary objects, we mainly refer to them within the context of a collaborative work that focuses on bringing productivity and efficiency. As we observed from our own (Vyas et al. 2009a-b) and others' field studies (Jacucci and Wagner, 2007) that creative work, especially within the design studio culture, is defined as much by experiential, aesthetic and explorative activities as it is by task and productivity-related activities. Given this scenario, how should boundary objects in creative work behave? Should boundary objects provide opportunities for explorations and a scope for 'trial-&-error' activities?

Should they provide ambiguity and provocation to stimulate creativity in design work? There is an 'interpretive flexibility' attached to the notion of boundary objects. By this different group of workers (communities of practices) can interpret the object in question in a way that can be useful to their domain of work. The work of Stacey and Eckert (2003) shows that ambiguity in design communication (e.g. through sketching) can lead to confusion and suggests that systematic use of meta-notations for conveying provisionality and uncertainty can reduce these problems.

By bringing a technological intervention into a Product Design studio, we attempted to understand how CAM could help the collaborative activities of design and the consequences CAM may have on the work practices of designers. As our results showed, CAM facilitated designers to utilize their design artefacts for 1) developing design narratives and stories, 2) expressing of the aesthetic qualities of the design artefacts, 3) providing communicative and coordinative resources, 4) providing exploration support, and 5) allowing designers to reflect on their own and other's work.

The use of CAM showed that design artefacts can expand their static and ordinary nature to become more dynamic and active objects. As we explored during our field studies, the design artefacts became "living objects" where designers could collect and send information. Design participants continuously scanned the barcodes to gather updates from different design artefacts and took advantage of the anonymity and asynchrony of CAM.

One of the important aspects of the "logs" generated by CAM was their communicative and coordinative abilities. Using their mobile phones, participants were able to read updates of different design artefacts and were able to get a sense of what was going on in the project. The "Planning object", described in Figure 12 was an example of a design team's organizing activities. These logs were also triggers for reminders and future actions – hence working as memory aids. Additionally, CAM was not just used for the sole purpose of storing information onto the artefacts. Design participants used CAM to establish a creative working culture in the design team. We observed that after reading updates from the design artefacts the participants were triggered to build on each other's work and learn from each other. The collaborative and social nature of CAM fostered creativity amongst the group of designers. Additionally, the serendipity and anonymity of Tweets played an important role in establishing curiosity and playfulness. Moreover, the designers were also triggered to reflect on their own as well as each other's work in a critical manner.

6 Acknowledgments

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Distributed and context-focused discussion on augmented documents and objects

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Abstract. We propose a combination of technologies for information encoding and for multimedia annotation to enrich interaction with paper documents and object labels, both in desktop and mobile settings. We argue that combining immediate access to online information from physical support with creation and retrieval of annotations, while keeping in focus the context of their creation, would increase awareness about products, processes and situations, and provide new ways of interaction based on tangible objects.

1 Introduction

Web-based documents are a way to distribute content among an arbitrary number of people, but their public nature does not make them a good candidate for cooperative discussion and development in restricted groups. On the other hand, email-based or forum-based discussions, even if restricted to stakeholders, are easily led astray by a lack of context, both physical and logical, necessary to keep them focused. Recent proposals such as GoogleDocs and GoogleWave, although effective in representing the evolution of a document or of a discussion, run the opposite risks of not making apparent which parts of the document need revision, or of disrupting the overall view of a discussion by presenting too many branches.

Moreover, in a ubiquitous perspective, differences in rendering, due to the heterogeneous nature of the interaction devices, do not guarantee that all users access the same presentation. This is particularly relevant when one wants to take advantage of the availability of information about concrete objects in everyday situations. We propose the combination of technologies for information encoding and for multimedia annotation, as a way to enrich interaction with paper documents and object labels, both in desktop and mobile settings.

The second author has patented the Cluster Pattern Interface (CLUSPI) paper-based technology (Kanev & Kimura, 2005, 2009): the physical support on which a document is printed is enriched with cluster patterns captured by a simple and usable input device (a scanning pen) and interpreted to provide contextual information (Kanev & Kimura, 2006). Typically, with each zone of interest a localization pattern is associated, so a user can receive zone-specific information.

We propose to extend this technology with the possibility of creating annotations on this content, accessible to any member of a collaborative group, thus relating each note to the context from which it originated. Moreover, threads of annotations can be created for one same context, either responding to an annotation, or creating a new one. Readers of a document could thus exploit several levels of reading: 1) reading the printed comment; 2) accessing additional information uniquely associated with parts of the document; 3) accessing annotations by other readers. These types of document usage do not interfere with each other, as one can choose which parts of this enriched content to exploit at any moment, and they are all accessible through specific supports.

The rest of paper proceeds as follows. We provide some additional information on the MADCOW system in Section 2 and discuss its integration with the CLUSPI technology in Section 3. Section 4 explores scenarios, both immediately realizable, and requiring simple extensions of the current capabilities of both systems. Finally, Section 5 discusses possible developments of the approach.

2 Annotation

We propose to exploit the existing MADCOW system, (to which the first author is collaborating), a system for annotation of Web content providing a uniform interactive approach to producing and using personal and public annotations on text, images and videos contained in Web documents within a standard browser (Bottoni, 2004; Avola 2010b). The client side exploits the bookmarklet technology, which is in principle platform-independent, barring differences in the Javascript interpreter. Currently, the MADCOW client is guaranteed to work with Mozilla Firefox, and tests are being performed on other major browsers.

In one of the scenarios discussed in Section 5, mobile access to annotations supports consumer-product evaluation and recommendation, so that a mobile browser version should be supported. For proof-of-concept experimentation, however, a Firefox browser on a small size netbook computer should suffice.

In a typical scenario, a user browsing a Web page can select any portion of text and click on the `PostToMADCOW` bookmarklet to open a pop-up window in which to enter the text of a note, give a title to the note, associate some tags with it and attach files in a number of formats. Metadata, such as the identity of the note creator, the creation date and a complete `XPath` description of the annotated interval of text, are automatically generated by the client, and the resulting *web-note* is posted to a MADCOW server. In a similar way, notes can be created for an image, or any area within the image, and for a video or any interval within it.

Existing notes can be explored via different mechanisms. Typically, a user visiting a Web page can inquire, through a `MADCOWNotes` bookmarklet, if notes exist for this page. The server will transmit information on all notes for that URL, and the client will highlight the annotated portions of text and mark the annotated images and videos. The user can access the actual content of the notes by clicking on the highlighted regions, and it will be presented in the same type of pop-up window, so that new notes can be added in the context of the previous ones. For complex notes, users can ask the server to generate a HTML page containing the web-note, so that this new page can be annotated in turn. Finally, users can access the MADCOW portal, to exploit its retrieval capabilities. For example, one can explore notes tagged with some set of terms, or created by some specific author or during some period. In general, several strategies of note exploration can be used, intermingled with normal browsing, within the same browsing session.

A *group* feature is being experimented (Avola, 2010a), where a creator makes a note public only to the MADCOW users registered to that group. Cooperative tasks can thus be based on MADCOW services, where users communicate by following threads of discussion on single topics, without having to set up elaborate schemes for securing the communication content.

3 The proposed architecture

Figure 1 illustrates the conceptual architecture for the proposed CLUSPI-MADCOW integration. A CLUSPI server maintains the relations between areas in a page and additional information, typically links to a HTML page. Additionally, the server is able to print, on normal paper, the unique patterns coding the information, and to superimpose the original content to them. A specialized portable scanner is able to recognize the patterns underlying significant areas and decode the link to the associated information. In a similar way, a MADCOW server is able to maintain the associations between HTML pages and web-notes on them.

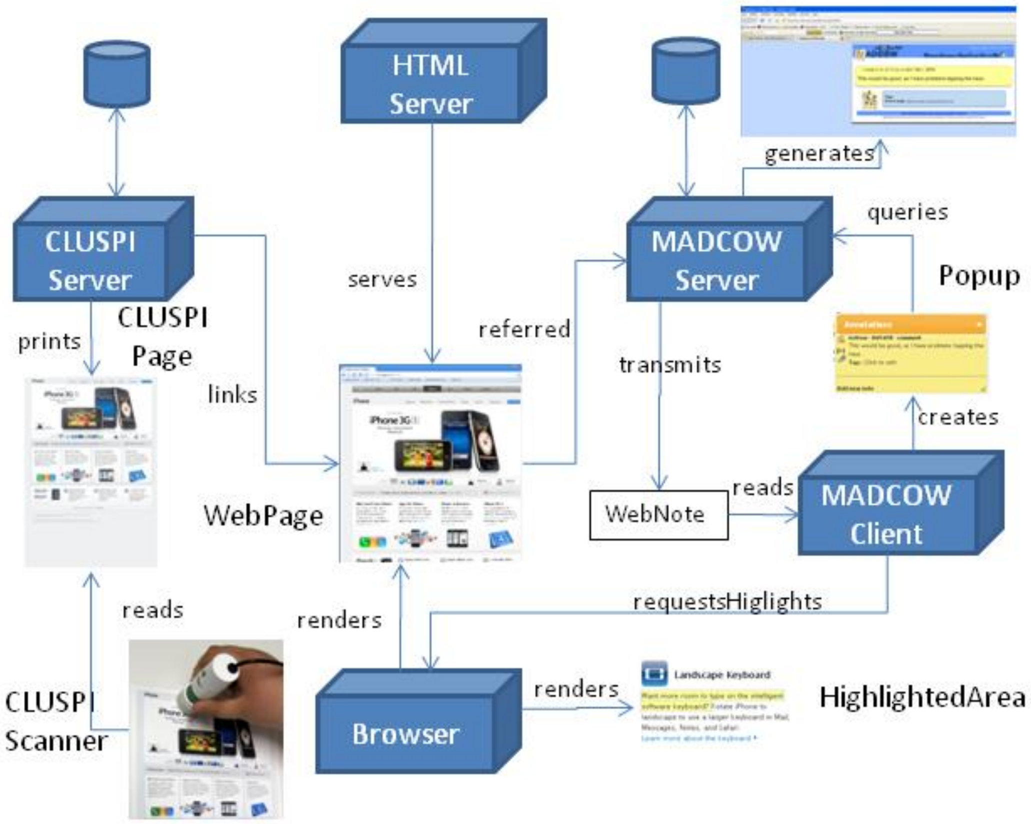

Figure 1. The conceptual architecture for the CLUSPI-MADCOW integration.

Moreover, it can dynamically generate new pages to present the content of an annotation. The MADCOW client, installed on the browser, communicates with the server to retrieve existing notes on the page visited by the browser, highlighting them in place. It also generates pop-up windows, which become the source for new interactions. The whole process is completely transparent to any HTML server whose pages are linked, either through notes or through CLUSPI patterns.

4 Usage scenarios

We consider here some scenario for the designed combination of the CLUSPI and MADCOW technologies, so that users can employ mobile devices for accessing online product information and related annotations in a self-explanatory way, while moving in physical contexts where the received information can be relevant. Using the camera function in the device, a customer can take a snapshot of a product or of its label, triggering an event to directly open a product-related information page in the browser on the same mobile device. This functionality is already widely available in Japan, where many products on the market have printed QR-codes. Other types of barcodes and carpet encoding schemes can be considered as possible interface options (see Dimitrov, 2009). However, QR-code and other barcode-based systems have some limitations, especially concerning the number of barcodes associated with a given product. It is thus difficult to establish multiple associations with existing online content and corresponding annotations for one product. On the contrary, the CLUSPI method allows the creation of 2D maps of product surfaces with a virtually unlimited number of associations to online digital information.

In general, any partial snapshot of a product surface would allow extraction of both the product identifier and the relative position of the user's camera with respect to the product surface. Thus, it can be used to pinpoint any particular feature printed on the product label. For example, a consumer wanting to know more about the sugar content of some food can point the camera to the printed line showing it on the product package. If more general information is needed, e.g. producer data and references, one can point at the company logo.

Moreover, customers could obtain instant access to the MADCOW annotation database - to retrieve annotations on the product web page - or to a dynamically generated page, containing annotations on the product.

A different family of scenarios regards cooperative activities which could employ a combination of these technologies, and the underlying distributed, context-focused discussion approach. For some participants, face-to-face meetings and discussions might be the best option. For other, distant participants, remote collaboration should be supported, while for participants with time constraints, time-shifted collaboration would be needed.

A key point is that even in a face-to-face discussion environment, collaborators would employ a browser-based interface for annotating collaborative activities. Such an activity is quite similar to the way we usually take notes and does not impose an additional burden to the participants while ensuring smooth note distribution and sharing among all participants. Hence, distant participants can get timely access to newly created discussion content for active engagement in collaboration activities. Time-shifted participants, on the other hand, can use the annotation repository to follow discussions and add their notes at a later time.

The tangible physical interface underlying the CLUSPI technology plays an important role in the cooperative process. Through it, collaborators separated by distance and time establish access to shared representations of physical artifacts subjected to a discussion. As an example, let us consider a discussion on a specific commercial product or a set of related products available at local stores. Participants in the cooperative activities are free to purchase product samples at different, maybe very distant, shops. The purchased products can then be used as a reference during face-to-face, remote, or time-shifted discussions. Products with digitally enhanced labels can be employed as tangible interface components for accessing and controlling the web-based annotation. In this way, MADCOW annotations can be mapped to different label surfaces and directly linked to specific features of concerned products. No label reprinting is needed as long as the printed content is preserved. Related annotations, on the other hand, will naturally change over the time as participants add and modify them interactively.

Other scenarios may involve content updates and reprinting, either occasionally or on a regular basis. A typical example is the product sales chain, where product information prepared by a producer and tuned by store marketing staff is supplied to customers. Such product information usually comes in form of brochures, information leaflets, website content, supportive audio and video, etc. Strong competition in the product sales chain forces the marketing staff to continuously update product information and develop new promotion materials. In big chain stores, product promotion strategies are often a cooperative effort of sales professionals affiliated with different stores at large distances. The scenario described so far clearly shows the need of cooperation in a context-focused discussion between different parties separated in space and time. Collaborative results of such cooperation are product marketing strategies and promotional content finally delivered to potential buyers in digital or printed form.

To engage our proposed method in the above scenario we start with uploading existing product promotional materials to a web server and thus making them accessible to all collaborators. Uploaded materials can be further interlinked to additional digital content available online. From this point on, different stores can independently create sample promotional leaflets by printing the content on the web server. With the embedded CLUSPI technology, printed leaflets also become a clickable interface to product related online content. We illustrate this in Figure 2, where a digitally enhanced printout of the main iPhone3G web page is shown.

For clarity we have added to the figure dashed rectangles in correspondence of the top tags in the page, together with four click sensitive areas linked to additional online content. The corresponding area titles and URLs in the original web page are as follows:

- “Why You’ll Love iPhone” - http://www.apple.com/iphone/why-iphone/
- “Apps for iPhone” - http://www.apple.com/iphone/apps-for-iphone/
- “iPhone in Business” - http://www.apple.com/iphone/business/

- “iPhone OS 4” - http://www.apple.com/iphone/preview-iphone-os/

The above URL addresses are accessible by simply pointing and clicking with a specialized CLUSPI reader on the printed sample page of Figure 2. The digitally enhanced printed page can be used as a template for showing digital content with the iPhone device itself, if an appropriate application is developed.

Figure 2. Information about a product with CLUSPI patterns in the dashed rectangular areas.

Through the MADCOW functionality, annotation-enhanced web pages can be created and printed. Such pages, in addition to existing web page links, will also contain links to various public and private annotations. Since annotation visibility depends on the currently logged user credentials, group membership, etc., different users could automatically get properly customized versions of the product promotional content. Such content can then be printed again for creating customized leaflets, different for each of the stores in the chain. As an example, Figure 3 shows a portion of the page accessed via the pattern associated with the Features tag at the top of Figure 2, where a user has added some annotation. The annotated text is highlighted in the Web page and the content of the annotation is shown in the pop-up window.

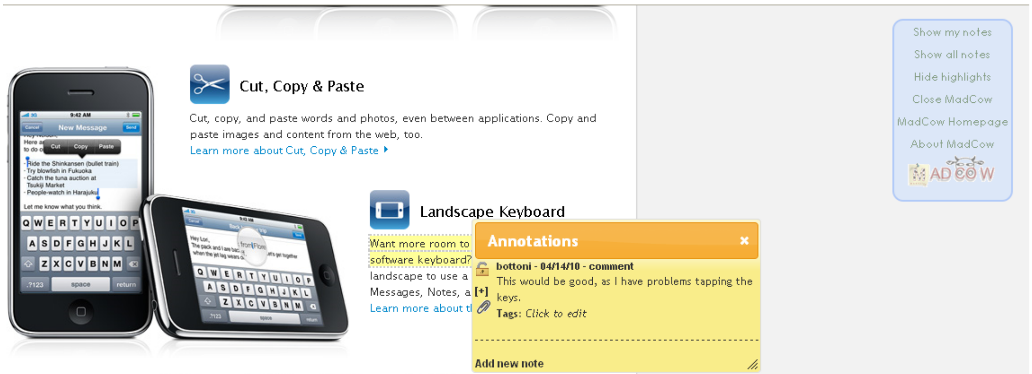

Figure 3. A note on a page accessed from a CLUSPI-enabled page.

In general, annotations can play different roles. On top of being a vehicle for distributed context-focused discussions, MADCOW–based functionalities can also support registration, management, and consequent access to independent product evaluations, recommendations, and user opinions. All such annotations can be accounted for in the printed versions of the product pamphlets through the embedded CLUSPI code. As an example, Figure 4 shows another page in the same website, where a user has added a comment to a previous note, providing a link to information relevant to the context, thus starting a focused conversation.

Additionally, specific product-related online sites could be accessed through a specialized MADCOW front-end, where customers can put and retrieve personalized annotations, or share comments, which can be made persistent and retrieved at any time, both in mobile and desktop settings. To further simplify customer input, one can adopt a menu-based product recommendation and evaluation interface that will further limit or even eliminate the need of typing.

The approach is potentially extensible to any kind of surface on which cluster patterns can be printed, embossed or engraved, thus giving access to information concerning tangible objects (Kanev 2008). The combination of these two technologies opens several scenarios for mobile applications. In particular, considering product evaluation, producers could use the cluster patterns to advertise their products and consumers could share and exchange opinions, express their (dis)satisfaction with the products, and/or recommend them. In (Dimitrov, 2009) the general issues of user awareness and mobility were discussed, and the major problems of mobile user access to product information outlined, adopting a client-server model for mobile access with Microsoft .Net Framework for the server-side.

Figure 4. A focused discussion on a product.

5 Conclusions

The “information overload” problem, even when filtering irrelevant or misleading information, is recognized as a serious problem to achieve the full potentiality of the Web. We need information which can be quickly found, easily understood and immediately used. In this direction, we have proposed the combination of two existing technologies, one for augmenting paper-based documents with access to digital information, and one for creating personalized and focused additional content to be shared with Internet users or within restricted groups, and we have shown several usage scenarios made possible by such a combination. We argue that combining immediate access to online information from physical support with creation and retrieval of annotations, while keeping in focus the context of their creation, would increase awareness about products, processes and situations, and provide new ways of interaction based on tangible objects.

In this sense, one interesting direction of development is the adoption of an open cross-media architecture, as advocated by Signer and Norrie (2009), where new formats can be readily managed, both as sources and content of annotations.

While the described scenarios can be immediately adopted by enriching existing content, the development and maintenance of active information resources should be jointly considered from very beginning. One way to guarantee quality and reliability of the information resources is to involve significantly sized groups of co-workers, collaborators, co-inspectors, etc in their development and maintenance. In a sense, a sort of open source development should be applied. Open annotation services are a promising technique to support such a style.

However, for each information resource some goals, orientations and corresponding guidance should be specified. In fact, this can also include specifications for cases with fuzzy goals, spontaneous and chaotic interactions to shape output, etc. In other words, the annotation service environment should integrate the Internet liberal behavior with some suitable rule and standard.

In particular, two levels can be envisioned for the specification of information to be retrieved, providing embedded clarity and applicability. The first, general level would be based on metadata descriptions, keywords, rules of digital libraries, semantic web relations, etc. The second, specific level can be based on multiple views of real object features, real-time communications between pieces of data representing the features, and locations of the data distribution.

Incorporating enhanced printed materials into "clickable" interface panels of web-based tools would introduce a new environment to support more direct relations of real and virtual world objects and to engage collaborators not only in the discussion of object features, but also in specific, practical decisions. It would also be a basis for creating information resources representing real object features and for immediate usability tests of the resources.

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Representations of a project process as a means for reflection

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Abstract. The technique of using timeline and experience curves as representations of a project process have previously been shown to be useful for reflection on the process in the project team. In an ongoing study, reflection workshops are introduced in a number of software engineering student projects, in the middle of the projects and at their end. The study investigates how the representations support the development of insights about project challenges and lessons learned. Preliminary findings suggest that the workshops have been useful for helping teams identify their project challenges. The relationship between the representations in the first and second workshops of a team can be used for learning more about the effect of the first workshops. Also, comparison of the representations can provide insights on the difference between memory of a project process from the point of view of its middle and its end.

1 Introduction

Learning from the experience of collaborative work and thereby improving the work process is often very hard. Project postmortem evaluations are arranged to help individual project participants, project teams and their organizations learn from the project experience and improve their work processes (Dingsøyr 2005; Kerth 2001). Visual representations are often used to aid the reflection. Among these are timelines of project events, and curves illustrating the experience of being in the project for each project participant. The study reported in this paper aims to develop the understanding of how these techniques aid the identification of project challenges and lessons learned, and how they may effectively be included and supported in reflection workshops with a restricted time schedule.

2 Background

In project retrospectives, visual representations are often used to aid the reflection. Among these are timelines of project events, and curves illustrating the experience of the individual project members (e.g. ups and downs) along the curves (Derby et al. 2006; Kerth 2001). This approach has been shown to be successful to aid project based learning (Thomas 2000) through short workshops in software engineering student teams (Krogstie and Divitini 2009). The drawing of timelines and curves helped teams at the end of their project reflect on the process and identify lessons learned.

One of the things that may improve the outcome of postmortem evaluations is access to better data about the project reflected upon (Kasi et al. 2008; Schindler and Eppler 2003). One possible source of such data are collaboration tools used in the daily project work, as these tools typically store data relating to, and originating in, the work process. A previous study showed that in a postmortem evaluation workshop at the end of a software engineering project, data stored in a lightweight project management tool through its daily use in the project helped team members recall projects events that they had not recalled by memory alone, and also helped them change their view of important aspects of their project process (Krogstie and Divitini 2010). Particular characteristics of the tool were found to be useful to aid reflection, particularly the chronological overview of changes to project artifacts. This use of collaboration tools can be seen as a way of bridging work and learning from work, which has applicability within the educational context of project based learning as well as in industry.

This paper reports ongoing work for which the original research agenda was twofold. Firstly, the aim of the study was to continue the work of developing efficient approaches to retrospective reflection in project-based learning, this time focusing not only on lessons learned but support for the ongoing process by aiding process improvement. Secondly, the aim was to see if the use of historical data in collaboration tools could be introduced into the relatively short reflection workshops and thereby improve the reflection. Introducing this tool use in the workshops could give an opportunity for research on the potential change in use of collaboration tools in project work when they also become tools for reflection.

As will be explained in what follows, whereas the study was originally designed to include both of these aspects, the second aspect had to be abandoned.

3 Case and research method

The case is an undergraduate project taking up 50% of the students' workload in the last (6th) semester of a Bachelor of IT program. The teams develop software for genuine customers, and the projects are intended to be as authentic as possible. Each team receives one grade and has a supervisor from course staff. Deliveries include a software product, a project report in several versions and an oral presentation. In 2010 there are 12 teams, most of which have 5 members. There are altogether 58 students in the course.

As part of the project course, retrospective reflection workshops have been introduced. The aim is threefold: helping the students learn from their project, providing the students with some hands-on experience with industry standard reflection techniques, and learning about how the organization of the course works. A technique of drawing project timelines and individual experience curves along the timelines had been adopted in the course with success in 2008. In 2010, it was decided that reflection workshops be arranged not only at the end of the course but also in the middle. The purpose of the mid semester workshop (WS1) is to help the project team identify challenges in their project work and ways of addressing them (i.e. appropriate actions), i.e. *process improvement within the project*. In the workshop at the end of the project (WS2), two months after WS1, the aim is to identify *lessons learned*, benefiting the team members' work in subsequent projects. The timeline and experience curve technique would be used in both rounds, and the workshop duration would be 90 minutes.

The author of this paper is the workshop facilitator with no role in evaluating the students. The setting of all the workshops is as follows: The participants sit by a table in a room with a large-size whiteboard. Each participant is provided with an A3 paper form containing a timeline marked with some major project events common to all teams (e.g. main deadlines). On top of the sheet is a smiley face, and at the bottom a sad face. Other equipment includes pens and whiteboard markers in different colors, and a flip-over.

WS1 lasted 90 minutes and was divided into three main tasks (see Table 1): Drawing the timeline of important project events (first individually on paper, next collaboratively on the whiteboard), drawing individual experience curves along the timeline (first individually on paper, next on the whiteboard, using colors to distinguish the individual team members; see Figure 1), and identifying project challenges (first individually then in a collaborative round), prioritizing them and discussing actions to address them. In the schedule, the duration of each task is approximate, allowing for some adaptation to the needs of the specific team.

The students got to keep the flip over sheets with the challenges and actions. Also, they got a picture of the timeline and experience curves on the whiteboard (sent via email after the workshop).

Table 1: Schedule for the reflection workshops (WS1)

Main activity	Activity	Equipment	Who writes	Duration
Intro 10 min	Intro/purpose • Explain about the purpose of the workshop and about the research agenda. Get written permission to record, collect and store data	Consent forms	Facilitator	10 min
Important events in the project (timeline) 20 min	Individual brainstorming: **Important events in the project** (mark along timeline on paper, individually)	For each participant: pen and paper (pre-printed timeline form)	Team	5 min
	Common brainstorming: Mark events on the whiteboard timeline (events listed around the table)	Whiteboard, pen and paper (pre-printed timeline form)	Facilitator	15 min
Individual experience of the project (curves along the timeline) 25 min	Individual brainstorming: **Ups and downs (job satisfaction) along the timeline**	For each participant: pen and paper (pre-printed timeline form)	Team	5 min
	Comparing satisfaction curves: Everyone drawing their line on the whiteboard and explaining	Whiteboard	Team	20 min
Project challenges & actions 25 min	Individual brainstorming: Write down the main challenges (1-3) in your project	For each participant: pen and paper	Team	5 min
	Making a shared, unsorted list based on participants' lists (around the table).	Flip over (NB whiteboard still needs to be visible!)	Facilitator	5 min
	Prioritizing: You have three votes; assign them to one, two or three of the challenges	For each participant: make three marks with your pen on the flipover Facilitator: Mark top 3 as **Challenges 1, 2 and 3.** Stick flipover sheet to the wall.	Team + Facilitator	5 min
	Discussion: which actions to address these challenges?	Round the table – what action(s)? Write actions on flipover, with reference to challenges.		10 min

An example of a timeline with experience curves is shown in Figure 1. The timeline belongs to a team which will be coined 'team X' here. The picture shows the left part of the whiteboard. The right part contained the (relatively empty) timeline for the remaining half of the project. The list of challenges identified by team X is shown in Figure 2. Among the challenges are (translated from Norwegian): "Attendance. Finding times that fit all" and "Coordination of tasks. Division, assignment, follow-up."

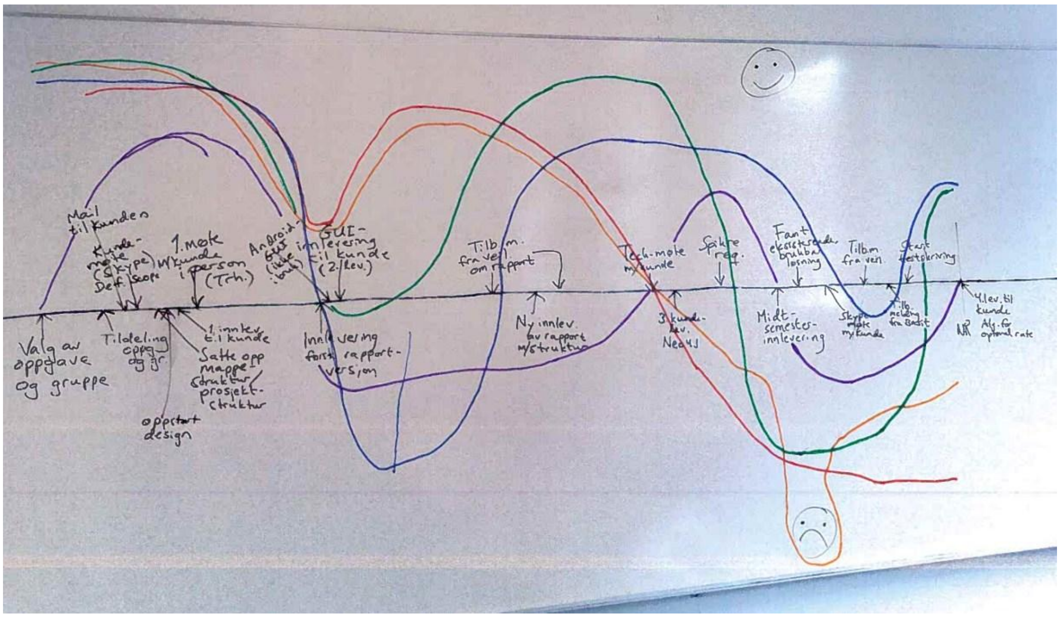

Figure 1: Timeline and experience curves for the first half of the project of team X (Photo of the whiteboard, processed by use of ink pens to make the curves more visible)

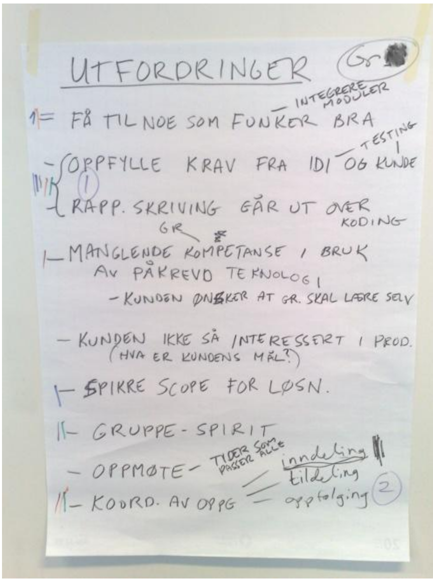

Figure 2: Challenges identified by team X and quickly prioritized for further discussion (In Norwegian)

All but 2 students showed up for WS1, which had been presented as mandatory.

The overall research approach of the study can be considered as interpretive (Klein and Myers 1999) and based on participant observation. The author's dual role of researcher and facilitator is considered, with heed to the pros and cons of doing insider research (Robson 2002). Data are collected, by participants' consent, by audio recording the workshops and taking photos of the flip over sheets and the whiteboard. Also, the individual paper sheets containing the individual timelines and experience curves as well as the challenges proposed by the team members, are kept as data sources. In addition, data about the teams and their supervision may be gathered from project supervisors at need, and administrative information about the course is available. Further, the team rooms have been visited to have a look at the whiteboards, but other observation of the work in the team rooms has not been planned.

4 weeks after WS1 a follow-up survey was distributed to the team members, mainly to get some information about the extent to which the workshop had had any impact on the work in the teams. The questions asked were:

1. Have you taken up anything from the workshop with your supervisor? (Yes/No)
2. Have you taken up anything from the workshop internally in the team? (Yes/No)
3. To what extent has the workshop had an impact on the planning of your further project work? (1-5; 1 = not at all, 5 = to a great extent)
4. To what extent has the workshop had an impact on your way of collaborating within the team? (1-5; 1 = not at all, 5 = to a great extent)
5. How useful do you think the workshop has been to the project? (1-5; 1 = of no value, 5 = very useful)

20 out of 58 students answered the survey (as of 23 April 2010). 10 out of 12 teams were represented in these answers.

4 Preliminary findings and discussion

The findings from our study are preliminary, analysis of WS1 not being completed and WS2 not yet conducted. This section is structured as a discussion around questions that seem pertinent at this point in the research process, starting with an overview of findings from the survey.

4.1 Preliminary findings

The following results from the survey indicate that the students generally perceive the workshop as useful (Figure 7). The majority says they have taken up issues from the workshop internally in the team (Figure 4), but only a minority has done so with their supervisor (Figure 3). The workshop is reported to have had some impact on the planning of further project work (Figure 5), whereas the impact on collaboration within the team is perceived to be low (Figure 6).

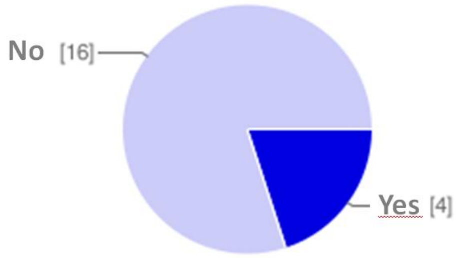

Figure 3: Answers to Question 1: “Have you taken up anything from the workshop with your supervisor?”

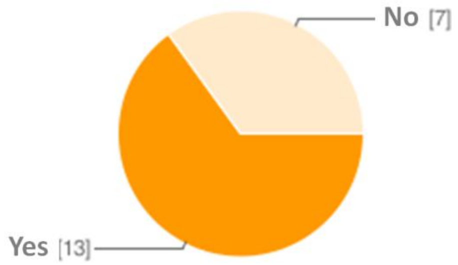

Figure 4: Answers to Question 2: “Have you taken up anything from the workshop internally in the team?”

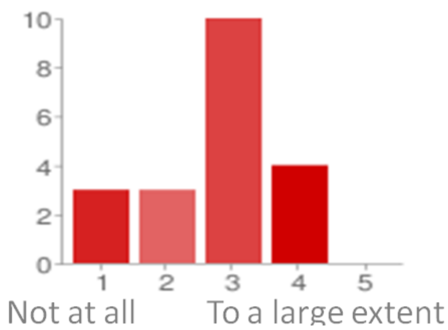

Figure 5: Answers to Question 3: “To what extent has the workshop had an impact on the planning of your further project work”

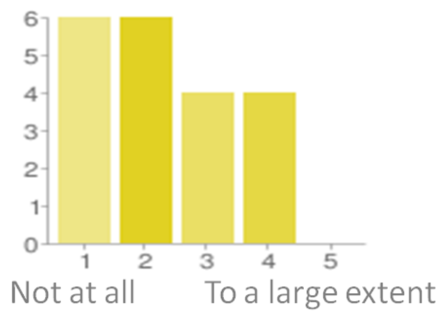

Figure 6: Answers to Question 4: “To what extent has the workshop had an impact on the collaboration within your team”

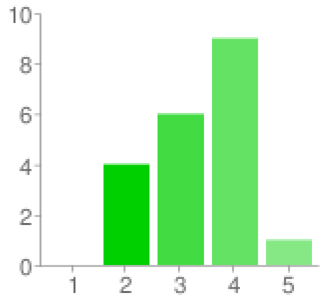

Figure 7: Answers to Question 5: "How useful do you think the workshop has been to the project?" (1 = Of no value; 5 = Very useful)

An example from the survey answers from a member of team X illustrates that the experience curves can help trigger insights and subsequent change in a project process. The team member reports, answering Question 3, that she had become "*A bit more motivated, saw that the others felt the same as I with regard to how well the work was going*". (See Figure 1, in which, at the end of the timeline (e.g. by mid semester), the curves all have a 'dip' and still show mixed – and partially very low - satisfaction with the project). To Question 4, she answers: "*4 - We have become better at giving notice when something is not working, and people tell if they are being late*" (addressing the team's identified challenges of improving attendance and coordination of work, see Figure 2). Finally, Question 5 is answered: "*4 – Good to have a summary in the middle of the project to see how the others feel the work has been*". While these answers indicate that, in the eyes of this team member, the workshop has been useful, they also indicate communication problems in the daily work of the team: the team member was possibly unaware of the strongly negative feelings in the team. In combination with the recorded data from the workshop the survey answers also indicate that the experience curves serve not only as a means for insight for the individual, but as 'supporting evidence' for team members' arguments. In this case, the team member was the project manager, eager to have the team's commitment to more disciplined working habits and better team-internal communication. This type of findings illustrate how, in this study, the data from WS1 and the follow-up survey can be used to gain better understanding of how the project process representations support the teams' collaborative efforts in the workshop.

4.2 What makes viable the investigation of historical data in collaboration tools as an aid to reflection?

The original workshop schedule contained a task of examining historical data in the teams' collaboration tools with the purpose of possibly enriching or adjusting the project timeline that had been reconstructed based on participants' memory alone. To this end, the teams had been asked to bring a portable PC with their project management tool or some tool they thought would help in showing what had happened in the project. The task was removed from the workshop schedule after the two first workshops, resulting in the modified schedule of Table 1. There were two main reasons for this change, which also implied a change to the research design.

First, there turned out to be too little time to meaningfully look into historical data in collaboration tools. The tasks of drawing timelines and experience curves together with the tasks of identifying challenges and actions easily required the 90 available minutes. Doing these tasks too superficially would negatively affect the learning outcomes – which was unacceptable given the researcher's obligation to also provide adequate facilitation - and thereby also the quality of the research data on the use of timelines and experience curves.

Second, almost all teams organized their work in accordance with SCRUM (an agile software development process). One implication of this was that the coordination of the teams' work to a large extent took place with the aid of whiteboards in the team rooms, the historical data being wiped out on a daily basis. The computerized tools contained less of the historical project management information, and no collaboration tools in the teams were clear candidates for attempts at informing the development of the project timeline.

A question that should be addressed based on this change of our study is: what does it take for the approach of investigating historical data to be viable in a reflection workshop? The duration of the workshop is one issue: probably, in most cases the workshop needs to be longer than 90 minutes. Also, should the approach be based on data in existing collaboration tools, based on current tool usage, or should tools and/or daily tool use be changed with the purpose of also supporting reflection by providing easy access to relevant data? If so, could the timeline representation serve as the 'backbone' of this design? Research has shown that information about users' activities can be gathered for the purpose of supporting many different aspects of work (e.g., (Aranda and Venolia 2009; Minneman et al. 1995; Omoronyia et al. 2009)). The gathering of relevant information may involve users' tagging of information that they see as important, an approach previously suggested to improve the utility of project wikis for retrospective reflection (Krogstie 2009). On the other hand, by imposing such changes, the simplicity of just utilizing existing tools in existing use, may be lost. Historical data to be used in reflection needs to be easy to access and navigate (Krogstie and Divitini 2010). In a real life case in which teams use different sets of collaboration tools, it is (unsurprisingly) not sufficient to ask the teams to bring a tool which stores data about their project management.

Even without the use of historical data in collaboration tools, the workshop may need to be longer than 90 minutes for the team to get the most out of the timelines and experience curves. Our findings indicate that most teams in their later meetings returned to the issues addressed in the workshops (see Figure 4), but we do not know how thoroughly this was done. An answer to Question 3 by one student illustrates the challenge: "*Our insights in the workshop were really things that the team already was aware of, but then again the workshop went a bit fast and it was hard to elaborate*."

4.3 What may be good approaches to get the most out of the second round of workshops, in particular to understand the role of the timeline and experience curve representations

In WS1, the identification of project challenges was achieved through the development of a number of representations of the project process, individual and shared. This is diagrammatically shown in Figure 8, in which the grey arrows inside the middle circle indicate transformations of representations in the retrospective reflection workshop. These transformations can be considered from a distributed cognition perspective (Hutchins 1995), or they can be seen as indicating how one representation serves to mediate (Vygotsky 1978) the work of developing the next. The insights on how this unfolds in the actual workshops, and the possible generalization of these findings into patterns of use of the representations, have to draw on detailed analysis of the available data.

The second workshop in each team (WS2) will involve largely the same use of representations, but the representations will be generated for the entire project process and not just the first half, and from the point of view of having finished the process (but not yet received an evaluation of the result). Also, it is lessons learned and not project challenges/process improvements that will be in focus.

The connection between the process and outcomes of WS1 and those of WS2 (diagrammatically illustrated in Figure 9) will be investigated in the study. We hope that the representations created in WS2 can tell us something about the usefulness of WS1. The perceived impact of WS1 on the project process may be discussed in context of the timeline in WS2. It will be interesting to see the extent to which the challenges identified in WS1 are revisited in the lessons learned in WS2. Are there many lessons learned addressing issues that were present in the first half of the projects but that were *not* explicitly addressed in WS1? Did the work with the timeline and experience curves and challenges in WS1 point to issues that turned out to be profound to the project result and/or experience, viewed from the endpoint of the project process?

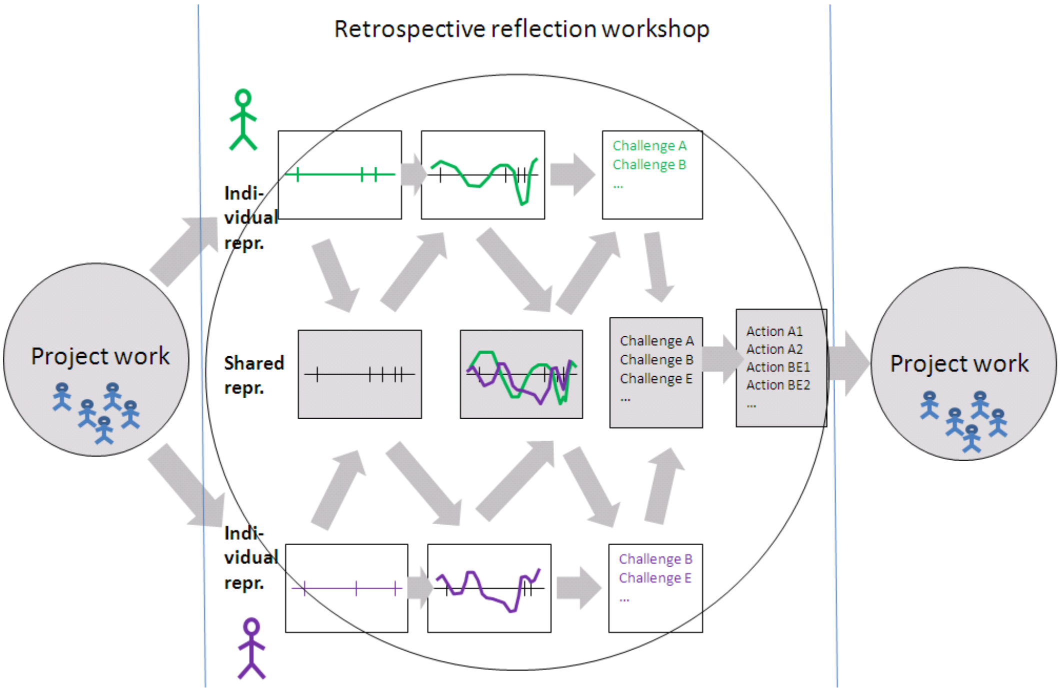

Figure 8: Transformation of representations involved in the first workshop (WS1)

Finally, comparison between the curves drawn in the two workshops, interpreted in light of other data from the workshops, can be used to investigate the research question of whether and how teams over time change their conception of early events in the project.

5 Conclusion

This paper presented preliminary results from an ongoing study on the use of certain techniques for retrospective reflection on project work. Whereas some of the original research questions for the study had to be abandoned, other research questions have been expanded based on the opportunities offered by the case.
The early results show that the timeline and experience curve technique is promising as an aid for students to identifying challenges to their project process. Further analysis of the data from the first workshop as well as a comparison of results from the first and second workshops will further inform insights about how these techniques inform process improvement and the identification of lessons learned.

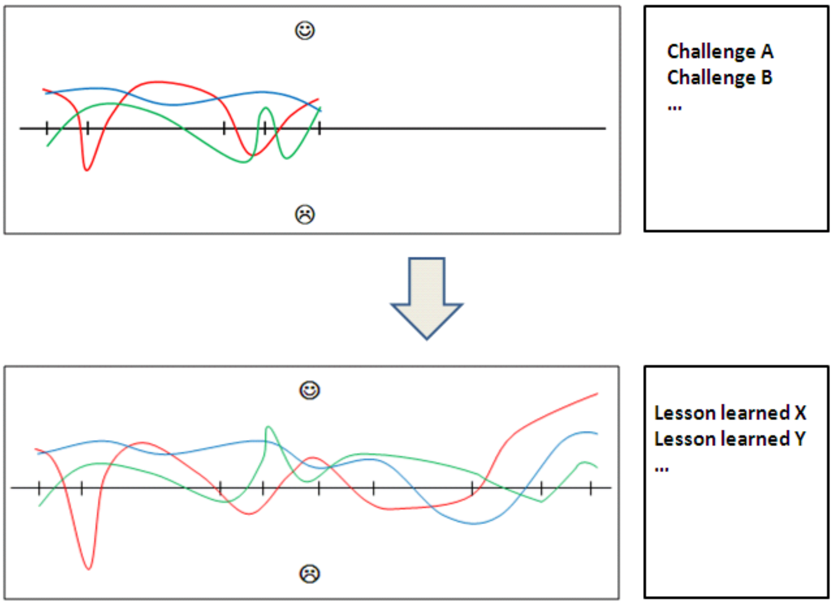

Figure 9: Representations created in WS1 and WS2: What are the relationships between them?

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Incentives and Motivation for Web-Based Collaboration (Webcentives)

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Abstract: Social Web and Semantic Web applications are based on large-scale user participation. Open Source Software projects (OSS), gaming and other online communities are constituted by voluntary engagement of contributors, almost self-organized and self-managed. Also large-scale intranet applications of business companies and non-governmental organizations are increasingly relying on Social/Semantic Web technologies and community-building.
The workshop focuses on motivation structures of users to participate in (online) communities and to contribute to collaborative content creation.

Social Objects and their Role in Building a Community

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Abstract. Building on the premise that thriving online communities are usually built around social objects, the paper discusses the motivations for participation in two communities based on the use of Facebook as a platform.

Keywords: Social networks, communities, motivation, social objects

1 Introduction

Online communities are elusive ensembles. Their members come and go, their involvement evolves over time, and their motivations are varied.

Open Source developers get involved in specific projects "to scratch their own itch"[1]. This basically explains the intrinsic motivation of many users of social media today: users of social bookmarking services like delicious, photo sharing applications like Picasa and Flickr or social citations services like CiteULike find value in using these applications for managing their own resources in the first place. The collaborative aspect is only coming second.

However, most of the social networking services that were adopted by large numbers of users and supported the formation of online communities are built around objects. Engestrom[2], quoting sociologist Karen Knorr-Cetina[3], talks about "*object-centered sociality*": photos, bookmarks, citations, music and activity streams are all "social objects" that serve as pivots for networking and community building.

In a paper presented in 1987[4], Jonathan Grudin stated: "When those who benefit are not those who do the work, then the technology is likely to fail, or at least be subverted", statement that became later known as "Grudin's Law". The beauty of social media applications is that the users are not coerced to "do the work". They are there by their own will, doing as much "work" as they want, and benefitting as much as they can of other users' work.

Social media applications have proven very effective lately in supporting the development of various networks and communities, both online and in the real world. Online communities develop and flourish quicker than ever, because social media applications and search engines have made it so easy to find other people who share one's interests. From knitting blog rings to patient support groups, forums for discussing online gaming mods, gardening wikis and dating websites for farmers, everything was enabled by the deployment of web 2.0 technologies.

However, the main problem for those attempting to either build a new social networking service nobody thought about yet, or build a community because they think one should exist, is how to attract users and motivate them to come back.

In our opinion, online communities are difficult to build. They have to be fostered, cared for, encouraged and supported continuously. Online communities cannot be engineered. Better collaborative tools will not simply make them happen. In order to come to life, an online community needs a reason to exist. Using existing tools, already embedded in the mundane practices of users, has resulted in numerous thriving communities. The role of community facilitators is often ignored, and it is often forgotten that communities are made of people. Some communities seem to appear naturally, while others need a lot of adjustments before they can function properly. In our paper, we would like to look at two examples where existing, widely used applications like Facebook, Twitter and blogs have proven efficient in building online communities. In section 2, we will briefly introduce these two cases and the methods used for data collection. In the following section, our findings will be presented in more detail. Section 4 is reserved for a discussion of successful practices in supporting and developing a community. We will conclude with a number of open questions that we would like to suggest for discussion at the workshop.

2 The Two Cases

The two cases are online communities the author has been involved in for the last 12 months. They were chosen because they illustrate two different approaches on building online communities. Both are based on Facebook, but they are using the functionalities offered by the social networking platform in different ways.

The first one is an online community of people with an interest primary in Italian food and secondary in local news. The community revolves around a local food blogger, Lorraine, who is the owner (together with her husband) of a small café in the vicinity of the University of Limerick. Instead of using her own name on Facebook, she preferred to speak in the name of their business, La Cucina Limerick.

The second community is a support group for patients with acromegaly, using a Facebook group as platform. The group was created as a companion for a website, AcromegalyCommunity.com.

For the past 12 months, the author has been doing participant observation in these two communities, writing notes, collecting screen captures and interacting with other participants. The purpose of the observation was to record the evolution of these communities and make note of various strategies employed.

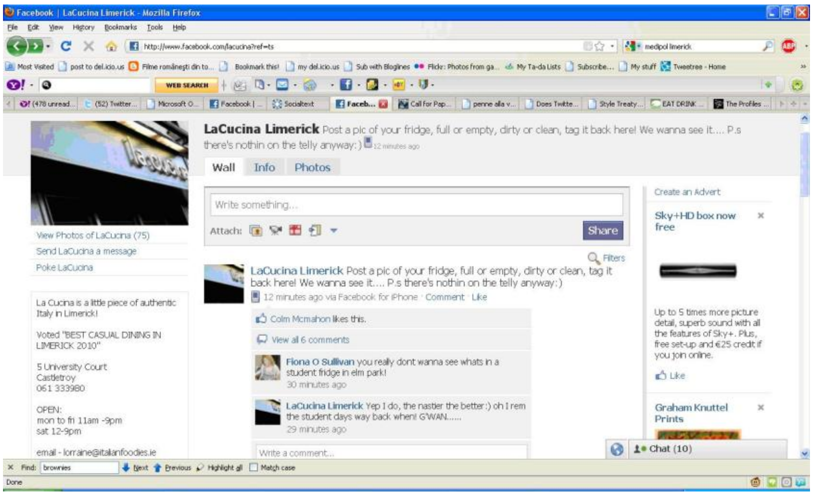
3 The Findings

3.1 LaCucina Limerick

La Cucina is a café situated in the proximity of the University. The Facebook profile presents it as “a little piece of authentic Italy in Limerick”. Lorraine, the owner of the café, started blogging in 2007 and acquired quite a large audience by posting Italian cuisine recipes accompanied by good quality pictures, and by regularly answering to the comments that were left on the blog.

Creating a Facebook account was a normal continuation of this interaction, accompanied by running an active Twitter account. Currently, all three platforms are used in combination and linked to each other, nevertheless avoiding content duplication.

The community has 2731 members as of April 10, 2010 – people and businesses who befriended the account on Facebook. Some of them are local, but many of the so-called friends are living abroad in places as far as New Zealand and share an interest in Italian cuisine.



The blog counter on http://italianfoodies.ie/ shows 198,000 hits (probably since the move from blogspot) last year.

What motivates people to participate here? The screenshot above is an example of the type of posts that encourage participation: ”Post a pic of your fridge, full or empty, dirty or clean, tag it back here! We wanna see it…P.s there’s nothing on the telly anyway:)” The suggestion sounds like an invitation to play an ad-hoc game, and people respond.

By analyzing the patterns of participation, we noticed that the mechanisms that seem to trigger the most responses are:

- offering a treat (free pizza, free tea pack);
- suggesting a cookalong (people are invited to cook following one particular recipe posted beforehand and are asked to post their stories afterwards);
- asking or giving advice regarding suppliers.

One of the most important factors that contribute to the creation of a sense of community is the fact that Lorraine answers to every comment and engages with the audience.

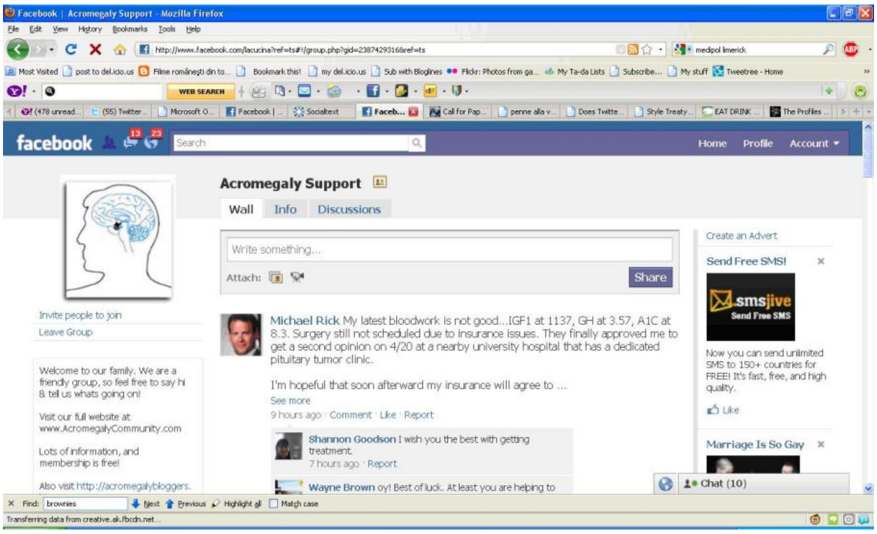
Their customers who visit the café tend to blog, tweet or post information on Facebook about the menu, the recipes and the owners. Social media consultants use them as an example in presentations.

3.2 Acromegaly Support

Acromegaly Support is a group consisting of patients and relatives of patients with acromegaly, a pretty rare medical condition. People use it to get in touch with other patients with similar problems to find out more about their condition and existing treatment.

It currently has 272 members from all over the world. Judging by the low incidence of the condition, the lack of awareness about it, and by the proportion of English speaking Internet users, the community seems quite large.

The group administrator spends quite a lot of time on it, trying to interact with every person who comes in looking for encouragement or advice. It is not the type of group where people hang out every day, they usually come looking for a particular piece of information or for moral support before surgery or radiotherapy.



The motivation for participation in this community differs a lot from the first case. Here, participation is triggered by:

- the scarcity of information coming from real patients as opposed to that shared by medical staff and pharmaceutical companies;
- the difficulty of meeting people with the same condition in the same area;
- the need of patients and families to discuss with people who encountered the same problems and solved them;
- the availability of people who have gone through similar procedures to share their experiences.

4 Discussion

Obviously, the significance of the number of members of the two communities presented above is to be considered with care. Because it is so easy to make a "friend" or join a group on Facebook, many of these members are far from being active or getting involved. However, judging by the level of interaction reflected by the ongoing conversations, we are inclined to consider them successful, active communities. What motivates their member to participate? What are the social objects their interaction is built around?

In the first case, the social object is Italian cuisine. For some members it is a hobby, for others it is a business. Sharing "secret recipes", cooking "along", eating in the physical café following the recommendations of others and talking about the people met there seem to be what maintains the sense of community.

In the second case, the social object is a rare medical condition: acromegaly. Members come back to share their own experiences and to read about those of others.

Various media are used for sharing information. Although text is still the most frequently used, photos and videos are also posted and shared.

Both communities play the role of "third places": they are neither workplaces, nor homes. But they are inhabited periodically by users/members that choose to consume and generate activity streams. There is no pressure to contribute and free riders are welcome.

Some of the reasons why members keep coming back and new members continue to join are related to intrinsic motivations:

- the need to connect with other people, to experience trust, conviviality, joy;
- having and expressing an opinion;
- reaching out for a support network, and also being part of one.

But there are also a few extrinsic motivations that we observed and that are worth it mentioning:

- free, open, easy and voluntary participation; both communities make use of the Facebook platform, making joining and participating extremely easy for people who already have an account;
- getting a voice and being heard - in both communities, comments are answered and contributions rewarded promptly;
- winning a competition and the fun factor in the first case; being the centre of attention in the second case.

5 Instead of a Conclusion

Based on the two cases presented, we would like to suggest a few topics for discussion at the workshop.

- How can we account for the different motivations for participating in online communities of various stakeholders? (e.g. business owner and customers)
- What are the ethical implications of using social media for "befriending" customers? Is there a danger to abuse customer motivations and manipulate intentions and affect?
- In a context where the boundaries between use and design are blurred, with users as co-designers of continuously under development applications, how can be research methods adjusted to suit the dynamics of observed phenomena?

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Motivating Online Publication of Scholarly Research Through Social Networking Tools

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Abstract. We conducted interviews amongst the primary users of a social networking tool used by natural history scientists to share and manage information on biodiversity. Our goal was to understand the impact, motivations and barriers experienced by respondents. Results indicate that users are motivated to engage through the social and technical innovations offered to enhance collaboration. However, users struggled to engage and sustain these collaborations. In these instances communication of research became a primary motivator. In effect this system is being used by most respondents as a digital surrogate for paper publications, although a substantial minority do collaborate online. The primary barrier of use was the users' lack of time to engage with the system. We infer that this is due to a lack of institutional or career incentives. Motivating sustained use would be

most effective if the traditional principles of scientific publications could be integrated into the system.

1 Introduction

Recent years have seen the emergence of new ideas about the publication of scholarly research with talk of a 'crisis' in publishing and weaknesses in the peer-review system. As Open Access publishing becomes ever more widespread [1], [2] even more radical ideas for the 'opening' of scholarly communication are being proposed. One outcome is the notion of 'Open Science' [3] with its advocacy of more open scientific knowledge production and publishing processes [4], [5], inspired by discourses developed in 'Free/Open Source Software' and 'Creative Commons' movements [6], [7], [8]. Web 2.0 is widely seen as providing the technical platform essential to this 're-evolution' of Science [9], [10].

As an experiment in Open Science a team of scientists from the European Distributed Institute of Taxonomy (EDIT – http://www.e-taxonomy.eu/) have developed a Web 2.0 Virtual Research Environment (Scratchpads – http://scratchpads.eu) that enables communities to collaborate in the production of websites supporting natural history science. These cater to the particular needs of multiple research communities through a common database and system architecture [11]. Registrants assume responsibility for the contents of each site, which (on approval) are instantiated at web domains of their choice. This tool facilitates the rapid construction, curation and publication of content rich web pages about any taxonomic group. The framework currently serves more than 1,800 registered users across more than 160 sites spanning scientific, amateur and citizen science audiences. Sites range in function from supporting the work of societies and conservation efforts to the production and dissemination of taxonomic checklists, peer reviewed journal articles and electronic books.

Studies of biological taxonomy, systematics and biodiversity (herein referred to as 'natural history') are particularly suited to new forms of scholarly communication. The discipline has made considerable use of Information and Communication Technologies (ICT) in recent decades and its community of scientists is increasingly dependent on these systems. Databases for cataloguing specimen collections with their derivative data and computerized methods for inferring the evolutionary relationships of organisms are central to most aspects of natural history research. Databases have become a significant means of communicating taxonomic information, and latterly there exist many online taxonomic information services including online identification guides, natural history observation catalogues and nomenclatural resources. Dwindling financial support for natural history research has also been used by funding agencies to drive this transition, creating a motivated (albeit sometimes skeptical) community within which certain individuals are increasingly willing to engage with new forms of scholarly communication.

'Scratchpads' were founded in March 2007 and as part of their evaluation and monitoring processes a survey was commissioned to understand the i) impact, ii) motivation, and iii) barriers to the use of Scratchpads experienced by their user community. As part of this work we also sought to gain insight into the profile of users and evaluate the efficacy of the survey as a mechanism to generate these data. This report focuses on the motivation and barriers of use aspect of this survey which are central to user uptake and adoption by the scholarly community. A central goal of the Scratchpad development team was to build a system that could motivate individual researchers in the generation, management and dissemination of their own data for their own needs, while empowering a wider constituent of potential users who are free to repurpose this information. The survey was conducted to understand whether these objectives have been met, and to identify refinements in the technical and social functionality of the system that might be refined to better achieve the project's objectives.

2 Methods

Candidates for the survey were self-selected from the pool of Scratchpad site “maintainers”. These are a category of super user who usually instigate the site and have administrative privileges that enable them to invite other users to join the community. Maintainers set levels of access for other users and take ultimate responsibility for their site content. Each Scratchpad community has its own organizational structure and division of labour, with several sites forming “communities of one”. In these circumstances the site maintainer is the sole contributor to a site. Generally Scratchpad maintainers form a subset of Scratchpad users that engage with a wider range of Scratchpad functions and / or are more connected with the specialist users working within a particular community.

For the survey we used the maintainer contact list of July 2009. This included 107 Scratchpad maintainers caring for 129 sites (several users are maintainers for more than one site). All maintainers were invited to participate in the survey and invitations were sent by email. Interviews were booked using an online calendar that integrated with a Scratchpad, enabling users to quickly arrange a slot using a technical environment with which they were familiar. The survey was also announced on several websites, mailing lists and newsletters used by Scratchpad contributors and members of the European Distributed Institute of Taxonomy. Maintainers were incentivised to engage with the survey with the undertaking that feedback would directly influence the Scratchpad development team in the enhancement of the software.

Over a period of four weeks in September 2009, 46 maintainers responsible for 61 Scratchpad sites were interviewed by a sociologist (face to face and by telephone) applying a combination of 65 open and closed questions (see http://www.e-taxonomy.eu/scratchpadsurvey). Respondents included a small number of maintainers that had signed up to a site but later abandoned it (so called "leavers"). Interviews were structured around the following three themes:

1) How has this technology impacted on the way users communicate and collaborate with their peers, specifically with respect to the way users organize and publish their "data" in the broadest sense?
2) What is the general attitude of Scratchpad users towards new technologies in support of scholarly activities, as demonstrated by their adaptation and use of other virtual tools?
3) What are the technical and social barriers for adoption faced by users when working with the Scratchpads and other virtual research tools?

Questions were designed to capture current attitudes and patterns of adoption in addition to identifying problems, needs and aspirations of users. These were initially refined through test interviews conducted with a small set of Scratchpad users back-to-back with a Scratchpad training session in Leiden, Netherlands. Subsequent in-depth, semi-structured interviews were conducted with respondents in order to explore the uses they were making of the system, their experiences, motivations and their perceptions of barriers and drivers to adoption. Closed questions were used where possible, mainly to verify information already given or to test preconceived notions captured from a rolling program of user feedback and engagement with the development team. Open-ended questions were used to investigate user opinions and attitudes for issues on which we had no prior information and to ensure the interview process did not stifle their response. All interviews were recorded and responses were transferred to an online system for management and analysis including transcriptions of key points from open-ended questions.

Because Scratchpads are built, developed and used by members from the taxonomic community, and in particular by staff from Natural History Museum, London (NHML), the interviewer was recruited outside this community to guarantee impartiality and objectivity to data collection. In order to detect possible sampling bias, the respondents demographic data (age, sex, academic affiliation, country of origin, taxonomic focus of their Scratchpad) was compared with that of the total Scratchpad maintainer population, as determined from statistics captured during their point of sign-up with the system.

3 Results

Interviews had an average duration of 37 minutes (17m minimum, 90m maximum). No significant bias in the sampling was detected, with the notable exception of institutional and country affiliation. The strong user base of the Scratchpad system at NHML meant that a high proportion (26%) of all Scratchpad maintainers are based at this institution. Of these users 19 (41%) were included in the survey. This also created a bias in country affiliation with 31 (67%) of maintainers in the survey based in the UK, against a backdrop of 45 maintainers (42%) present in the overall Scratchpad maintainer population. Other demographic factors showed no significant bias in the survey.

3.1 Impact of Use

The results reveal that the most common reason maintainers registered for a Scratchpad is because they needed a tool for collaborative activities (37%). Additional reasons include the need for a tool to communicate research (24%), a general interest in bioinformatics (20%) and for data management purposes (17%). These data broadly match supplementary questions about how respondents use their Scratchpad. 67% report that they use their Scratchpad to communicate research and 64% see this as the primary benefit of their Scratchpad. 62% also report that their site is used for collaborative activities and see this as a secondary benefit. Additional uses reported include archiving individual data (33%); automatically generating data presentations from data records (21%); and blogging (17%), especially with respect to reporting narratives on fieldwork activities. Some users additionally participate in group blogs (7%), and a significant number (40%) use their Scratchpad to manage and collaborate in the production of shared bibliographic reference lists. Collectively these data counter the traditional perception of taxonomists as loners that are conservative in the research methods [12]. Indeed, some maintainers report using their Scratchpad to specifically learn about other researchers work.

When asked in an open question about spin-off activities that have specifically resulted from users working with their Scratchpad, narrative responses include invitations to give presentations, requests for joint authorship on publications and collaboration in writing grant proposals to seek further funding. 64% of respondents noted that they have yet to experience any spin-off benefits. Nevertheless, a substantial number of users report changes in their working practices. We asked "if the virtual tools used had changed the way respondents worked with others". Respondents were asked to compare this with their personal working practices before and to give their opinion of this change. The 38 responses to this question range from users reporting a "slight change", to collaboration as being "completely different". Significant changes reported include improvements in communication efficiency; scaling-up communication to reach a larger audience and the possibility to participate in complex communication processes with different groups of people across different document formats. One young respondent stressed that they would not have been involved in this research field without these tools on the Internet.

Overall, evidence for regular and sustained engagement with the Scratchpads remained high. 54% of users reported logging in to one or more of their sites in the past week and a further 20% logged in within the last month. Just 24% have only logged in between 1 and 6 months ago, and a single user did not log-in again after signing up. We attempted to speak with more Scratchpad maintainers that had abandoned their site completely. We found 4 “leavers” (included in the set of 46 respondents) willing to participate in the interview. Three of these four cited the complexity of the system as their primary reason for abandoning the site. Other reasons given include software bugs, limited time and the fact that the software did not conform to user expectations.

3.2 Attitudes to New Communication Technologies

We asked respondents about their attitudes to new technologies supporting the communication of their research, especially with respect to collaborative ways of working. Where appropriate, these questions were followed by supplementary responses or actions providing behavioral evidence of these perceptions. Exactly half the Scratchpads covered in the survey had just a single user (the maintainer) and no other active members of the site. However, 39% reported 2-10 users and two sites reported more than 10 users. These responses were validated by the interviewer examining the public statistics on the specific Scratchpad sites after the interview. Maintainers of single user sites were asked why they were the only active user. The three most common responses relate to concerns over the loss of quality control; that it was premature to invite others because the site was insufficiently developed; and because the maintainer perceived the potential community of contributors to be too small.

Supplementary questions were asked about how often respondents use other virtual research tools, patterns of off-line working, and general mechanisms for communicating their research. Perhaps not surprisingly, a substantial majority (83%) of respondents used other virtual research tools (specifically web based software other than e-mail or Scratchpads) as part of their research activities. Of these users, 87% access these virtual research tools daily and 83% use these to collaborate. These collaborative patterns of working are broadly mirrored by off-line activities. All but one respondent stated that they work off-line with collaborators at other institutions and most (78%) also work as part of local research teams, participating in local research networks.

Within the Scratchpads a majority of collaborations (48%) were with other specialists working on the same taxonomic group. Others were in support of more information driven curation activities focusing on particular categories of data (35%), while a substantial number (30%) were engaged in interdisciplinary virtual research working with other categories of scientist. Specific examples of interdisciplinary researcher collaborations included conservation biologists, ecologists, population geneticists and behavioral scientists.

A key component of the Open Science movement relates to attitudes concerning the publication of work in progress. 67% of Scratchpad maintainers said they use their Scratchpad to publish work in progress, either privately to students, referees or colleagues, or publicly and completely openly on their site. When asked about the benefits of such activities, examples given include the advantages of getting feedback from other people, increasing the visibility of their work, attracting new people to a project and publishing small amounts of information which in themselves are not large enough for traditional paper publication. Several users also specifically referenced Open Science and Open Access benefits as part of their response, referring to the Scratchpad's utility in publishing data rich resources that are not possible in traditional paper publications. Users also cited the fact that particular categories of data (e.g., bibliographies and interactive identification keys) are by their nature works in progress, which are constantly refined and updated. Scratchpads support this functionality in a way that traditional publications cannot. Only 24 % of respondents stated that they would not publish works in progress. Reasons given include that this was not the purpose of their sites, and that some maintainers are weary of people stealing their data and are uncomfortable publishing untested hypotheses.

3.3 Technical and Social Barriers of Adoption

We asked interviewees about possible incentives and barriers in their work environment that facilitate, motivate or hinder use of their Scratchpads. An overwhelming number of respondents (85%) referred to their lack of time to maintain content (i.e. insufficient time in addition to their other duties to add, update and maintain site information). A significant number also cited their lack of time to acquire the technical skills necessary to develop their site. Further investigation suggested that a quarter of site maintainers lack general level computer literacy (25%) and cite this as a problem, rather than specific technical skills required to use the Scratchpad. Some maintainers were unsure of whether their time investment will be commensurate with rewards from using the site (20%), and upon further investigation this was mostly due to lack of trust in the technical development of Scratchpads. Just two maintainers had concerns that their data may be misused if published on their site and only one maintainer cited concern that they did not receive any credit from their employer for their time invested in site development. Follow up questions on institutional support for using new communication technologies as part of the respondents scholarly research revealed that a majority of maintainers (70%) received no institutional credit or incentives from their employer for their online work. However, the corollary of this is that the remaining 30% do receive credit for this work as part of their job evaluation. This picture broadly matches the pattern of institutional technical support received by these individuals in their use of these virtual research tools. 68% said they receive no technical support, 24% said they did, and a further 8% said they did not know. Arguably, this gap is filled by help and feedback facilities built into the Scratchpads. These include instructional video screencasts and online forums that are integrated within individual users Scratchpads. 83% of respondents said they used these facilities and 46% said they were satisfied with them.

For many users a key impediment to their continued use of the Scratchpads was the fact that this tool is still in the development phase. 90% of maintainers think that Scratchpads need further improvement and only 7% were happy with current site functionality (2% did not know). The top three requests for enhancing the Scratchpads were i) improvements in the Scratchpads usability, specifically the sites need to be more intuitive; ii) the need for better tools to manage security levels for different members and different pages of the site; and iii) better management of taxonomic hierarchies. A regular comment was that the sites do not deal taxonomic classifications properly.

4 Conclusion

A primary motivation for traditional article publication is to demonstrate the authors' contribution to science. This attracts peer recognition that influences the authors' reputation, employment and research opportunities. Broadly speaking the survey reveals the same motivating forces are operating with the Scratchpads and in the on-line spaces created by other scholarly virtual research tools. The primary motivation for registering for a Scratchpad was the desire to collaborate over the Internet. In reality, many maintainers struggled to engage and sustain substantial research collaborations online. Consequently communication of information became the primary use for a majority of sites. These sites are in effect being used as digital surrogates for traditional research publications, and less so as tools to share or collaborate with data. Indeed, some maintainers actively cite concerns about sharing data as a possible barrier to continued use of the site. Experience by the developers has shown that many users try to add conditions of use to data on their sites that are restrictive or create obstacles to such use. This is despite the fact that Creative Commons licenses are enforced on site contributions as a condition of use. At the very least this suggest that many contributors do not understand Creative Commons licenses. This quasi-release of data by many Scratchpad users is not only contrary to goals of the Scratchpad project but also acts as a disincentive to others to explore the sites potential, or at least make use of the data.

These data suggest that motivating sustained and greater use of the Scratchpads and similar virtual research tools might be more effective if the traditional principles of publication, rather than just tools for data sharing, are built into the system. Article citation and journal impact factors are the most common metric of peer recognition and play an important role in evaluating the quality and impact of scientific research. The transition to new online forms of scholarly communication creates the potential for a rich and diverse set of new performance indicators that consider wider aspects of the process and are better able to predict and manage the outcomes of research. If a comparable metric could be brought to bear on content published in a Scratchpad, it follows that value of the online content could be similarly tracked to motivate authors.

Delivering methods to track online contributions is not technically easy, because they involve tracking diverse categories of contributions across multiple systems managed by many institutions and organizations for a potentially huge number of authors, each of which would need to be uniquely identified across these systems. Despite this challenge, some metrics such as the Scholar Factor (SF) proposed by Bourne & Fink [13] do provide a possible solution to this problem and should be investigated alongside methods for standardizing the citation and archival of online content. This approach would enable contributors to receive appropriate credit for their contributions and for peers to more effective measure these contributions as part of a researcher's scholarly activities.

The survey revealed a number of technical improvements to the Scratchpads that were previously unknown to the Scratchpad development team. However, the primary barrier to use cited by the survey respondents was not technical, but relates to their lack of time to expand and develop the site. This was closely followed by a lack of technical skill in reaching the full potential of the Scratchpad application. A likely interpretation of this response is that the respondents struggled with assessing the value of engaging with these activities and the necessary changes to their working practices, especially with respect to novel ways of organizing their data outside traditional paper based publications. As was revealed by the survey, the use of virtual research tools is not part of most respondent’s job evaluation and is not comparable with the value of traditional measures of peer recognition, such as obtaining papers in high impact journals. Top down incentives by managers will be required to change this perception, and this will require those managers to be convinced of the value in these online activities.

These data reveal that although some technical and social barriers do hinder uptake and use of the sites, even to the point that some users abandon their sites entirely, a majority strongly appreciate the possibilities that Scratchpads offer. These survey responses are backed up by site access logs which reveal that a considerable number of researchers have used their Scratchpads as part of their daily research routine, especially as a mechanism to deliver informal, rapid, open access publication of content. A smaller subset of users also reveal themselves as active collaborators, both off-line and online, operating in national and international research networks, and in some cases interdisciplinary networks.

This strongly counters the traditional image of research taxonomists and reclusive loners, reluctant to engage in collaborative research activities.

The survey was useful exercise for the Scratchpad developers in understanding the motivations, barriers and impact of the tool on their user community. However the ongoing agile development of the software coupled with constant refinements to the sites' functionality suggest this should not be a one-time exercise. Developments to the technology and continuous user feedback are necessary to cater for the diverse demands users place on the system. Study mechanisms are needed that are built into the Scratchpads. These need to be more agile, intensive and fun for users, rather than occasional labour intensive surveys such as the one reported here. The NHML Scratchpad team is leading a consortium that has recently obtained a further 3 years of EU funding, and as part of the project will develop online methodologies that embed these sociological study methodologies into the technology infrastructure. Our goal is to obviate the need for similar survey activities and develop a mechanism that more rapidly informs the development team of user impacts and functionality needs.

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User-Centered Design Goals for Motivating Participation in Socially Embedded Software Tools

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Abstract Encouraging users for participation in socially embedded software tools needs both the involvement of end users in the design process and in the consideration of some general design requirements. In this position paper we focus on general design requirements, i.e., design goals, to be considered in design the process, in order to design tools that encourage active participation. The design goals include Usability, Sociability, Human Value and Emotion and Enjoyment) and guidelines related to these goals. The guidelines are collected from the analysis of the relevant literature in the area of human-computer interaction.

Keywords Participatory Design, Design, User Participation, Usability Engineering, Social Software, User Experience, Intrinsic Motivation

1 Introduction

Motivating users to active participation during the use of a system is a challenging research issue. Involving end users into the design process of socially embedded software systems plays a significant role to strengthen or support user motivation for active participation. In addition, it is necessary to consider some general design goals in the design of a system and to embed some features that can motivate the users. In our overall approach, we propose both, i.e., a participatory way for designing these tools and some relevant design goals. These goals include not only usability and sociability aspects, but also human values, emotion and enjoyment.

In this paper, we first present our general framework for motivation for participation, focusing on two general motivation mechanisms. Then, we briefly describe the general design goals and related guidelines and principles.

2 Motivation for Participation

Figure 1. Motivation for Participation

Figure 1 shows our general framework. Simon (Simon, 1967) distinguishes between *external* and *internal* motivations to accomplish a task. External motivation mechanisms focus on supporting reinforcement i.e. additional salary, whereas internal or intrinsic motivation mechanisms focus on meeting individual needs. These two motivations can be supported in the design *process* (Process driven) and also in the design of a *product* (Product driven). To ensure the necessary affordance of socially embedded tools, users need to be directly integrated into the *process* of software development (participatory design) and in the development of appropriate organizational structures.

Besides participation in the design process, there are also motivational strategies to be considered in the design of the *product*. Figure 1 shows specific user-centered design goals as general requirements, which we describe next.

3 Design Goals

The general design goals or requirements include the emotional, cognitive, social and ethical dimensions. They are not necessarily independent from each other, nor are they systematically distinct and complete. They represent some samples of requirements, which have been suggested by different HCI scholars in recent years. Our position is that these design goals can be used for both designing and evaluation.

3.1 Design for Usability

Usability is an important consideration in the design of products. Products need to provide suitable functionalities (usefulness) and an appropriate usage of these functionalities (**usability**). Meanwhile usability has emerged as an attribute of quality that ensures that the users of products are able to work effectively, efficiently and with satisfaction (ISO 9241-11) to fulfill their tasks.

There are a set of general principles and heuristics suggested to design usable systems, i.e. to achieve the aforementioned usability goals. In the following we provide some examples of well-accepted principles and heuristics. For more information we suggest the following references (Nielsen, 1994; Nielsen, Mack, 1994; Preece et al., 2002; Koyani et al., 2003;Te'eni et al., 2007; Shneiderman, et al., 2009)

Jakob Nielsen's (Nielsen, 1994) heuristics are the best known usability heuristics for user interface design: Visibility of system status; Match between system and the real world; User control and freedom; Consistency and standards; Error prevention; Recognition rather than recall; Flexibility and efficiency of use; Aesthetic and minimalist design; Help users recognize, diagnose, and recover from errors; Help and documentation. The International Standardization Organization (ISO) presents a set of usability heuristics that applies to the interaction of people and information systems. The standard (ISO 9241 part 110) refers to this interaction as a *dialogue* and describes seven general *dialogue principles*: Suitability for the task; Self-descriptiveness; Controllability; Conformity with user expectations; Error tolerance; Suitability for individualization; Suitability for learning.

In addition to these general dialog principles, there are also guidelines for specific topics such as motivating reading, contributing or collaborating (Preece, Shneiderman, 2009).

For example, usability factors that may influence reading are:

- Interesting and relevant content presented in attractive, well-organized layouts.
- Frequently updated content with highlighting to encourage return visits.
- Support for newcomers through tutorials, animated demos, FAQs, help, mentors, contacts.
- Clear navigation paths so that users have a sense of mastery and control.
- Universal usability to support novice/expert, small/large display, slow/fast network, multilingual, and users with disabilities.
- Interface design features to support reading, browsing, searching, and sharing.

Usability factors that may influence contributing are:

- Low threshold interfaces for easily making small contributions, e.g., no login.
- High ceiling interfaces that allow large and frequent contributions.
- Visibility for users' contributions and frequency of views; aggregated over time.
- Visibility of ratings and comments by community members.
- Tools to undo vandalism, limit malicious users, control pornography and libel.

Usability factors that may influence collaborating are:

- Ways to locate relevant and competent individuals to form collaborations.
- Tools to collaborate: communicate within groups, schedule projects, assign tasks, share work products, request assistance.
- Visible recognition and rewards for collaborators, e.g., authorship, citations, links, acknowledgements.
- Ways to resolve differences (e.g., voting), mediate disputes, and deal with unhelpful collaborators.

3.2 Design for Sociability

Besides general guidelines for usability, participation support and *sociability* design should be taken into account. As experiences from Web2.0 analyses and Open Source Software projects show, socializing in user communities can be enhanced by respecting some general principles or guidelines. Sociality refers to the tendency to associate with or form social groups. Sociality, not functionality, is viewed as the key concept in social software systems. Bouman et al. (Bouman et al., 2007) suggested a design framework which could help designers and developers to create social software that invites and supports its users to engage in social activities online as well as offline, to associate with or form social groups, ultimately leading to seeking or enjoying companionship. They argue that designers of social software have to address in one way or the other the following issues:

- Enabling practice, i.e., supporting practice that exists or could exist within the social group that is the intended audience of the social software system.
- Mimicking reality, i.e., finding or creating metaphors that relate to the real world.
- Building identity, i.e., providing the community with the mechanisms that allow for the development of an online identity.
- Actualizing self, i.e., creating mechanisms that allow users to tap into the collective wisdom and experience and use it for their own benefit, learning process and self-actualization.

According to Preece (Preece, 2000), communities with good sociability have social policies that support the community's purpose and are understandable, socially acceptable, and practical. Success of an online community requires a blend of well-designed software (i.e., usability) and carefully crafted social policies. According to Lazar and Preece (Lazar, Preece, 2002), the following three broad categories of issues are considered as important: Registration issues; Trust and Security issues; and Governance issues.

Other recommendations for the support of end user participation are listed by Preece and Shneiderman (Preece, Shneiderman, 2009) as follows:

- Reading: issues for the attraction/motivation of end users to visit web sites and applications, to use web services, to read provided information, to consume multimedia content, to "stay" on the web site, to come back and to visit again regularly.
- Contributing: design recommendations for the abstraction/motivation of end users to edit web content, produce/generate their own content, contribute to web communities and collective repositories, etc.
- Collaborating: issues for the attraction/motivation of end users to collaborate with others in a user community; to coordinate their contributions with other contributors and so on.

3.3 Design for Human Values

Human values and ethical considerations are fundamentally part of design practice. Values are at play in all phases of designing, developing, deploying, and appropriating information technology. In all these activities there exists the need for explicit consideration of values, value tensions, and value trade-offs. Value Sensitive Design offers one viable principled approach to systematically considering human values throughout the design and deployment of information and other technologies (Flanagan et al., 2005; Friedman, 1997; Friedman et al., 2006).

Methodologically, at the core of Value Sensitive Design lies an iterative process that integrates conceptual, empirical, and technical investigations. *Conceptual investigations address issues such as:* How does the philosophical literature conceptualize certain values (e.g. trust, privacy, ownership)? Who is affected? *Empirical investigations* focus on how stakeholders apprehend individual values in the interactive context. Technical investigations involve analyzing current technical mechanisms and designs to assess how well they support particular values.

In several case studies Friedman et al. (Friedman et al., 2006) demonstrate the application of the Value Sensitive Design (VSD), exploring different values such as privacy, informed consent, trust and the democratization of the planning process. There are several techniques that can be employed to understand values in context, including value card techniques (Flanagan et al., 2005) or photo-elicitation technique (Le Dantec et al., 2009) as well as techniques for dealing with value tensions (Miller et al., 2007). In addition, current literature suggests specific guidelines for specific values such as trust or issues about web credibility or security (cf. (Fogg, 2002)). Finally, there are suggestions for discursive principles and mechanisms to be embedded in the interface of a system to enable critical reflections on values in use time (Yetim, 2010a/b)

3.4 Design for Emotion and Enjoyment

In addition to the abovementioned requirements, *hedonic* quality becomes more and more important in increasing good user experience. *Joy of Use* plays a significant role in the development of software tools. If the costumer experienced the product with joy and trust, he will most likely continue with the usage or use the product again. There it has been argued that, to maximize usage, the interfaces of the tools should be designed with focus on positive emotions in addition to usability, that is, the interface should be complemented with design features that create positive experiences, including *pleasure*, *enjoyment*, *fun*, which are to some extent related to user satisfaction (Agarwal, Karahanna, 2000; Tractinsky et al., 2000).

The topic of design for fun goes back to early studies of games, such as the work of Malone (Malone, 1982) on educational games. He summarized the design heuristics for enjoyable interfaces with these criteria: challenge, curiosity, and fantasy (which he tied to emotion and metaphor). The interest in pleasure and fun in relation to IT is now beginning to grow (Monk, Hassenzahl, 2002; Karat, Karat, 2003; Nielsen, 2003; Shneiderman, 2004).

Jordan (Jordan, 1999) constructs an explanatory framework and discusses four different types of pleasures: *Physio-pleasure* (derived from the sensory organs, such as quality materials to the touch); Socio-pleasure (derived from the product and how it affects their social identity or relationships with others); Psycho-pleasure (which pertains to people's cognitive and emotional reactions, for example, when things are completed in a satisfying way); *Ideo-pleasure* (derived from people's values, such as artistic quality in a design, or ecologically sound products.). These are derived from more general types of pleasure. Yet, they may well be used as a support in designing tests and analyzing data.

Hassenzahl (Hassenzahl, 2003) identified three needs people desire to fulfill. First, stimulation: Mankind has the inherent need to develop and move forward. Novel, interesting, and stimulation functions, contents, and interaction- and presentation-styles can attract interest or reduce motivation problems. Second, identification: People tend to use objects to express themselves. Products can help users to communicate their desired identity. Third, evocation: Products may able to provoke memories. Products can represent past situations or impressions, which are important for the user.

Based on this model Hassenzahl (Hassenzahl, 2003) introduced an instrument in order to proove these qualities. The AttrakDiff-Questionnaire helps test users to indicate their perception of the product by using pairs of opposite adjectives. The Questionnaire is built on the following four constructs: Pragmatic Quality (PG): The perceived ability to fulfill a desired task; Hedonic Quality – Stimulation (HQS): To what extent the product can support my personal development?; Hedonic Quality – Identity (HGI): To what extent the product allows me to identify with it?; and Attractiveness (ATT): What is the general quality perception?

In addition, Norman (Norman, 2004) distinguishes between visceral, behavioral and reflective levels of processing that are stimulated by appearance, effectiveness in use, and self-image respectively. Norman shows that the design of most objects is perceived on all three levels (dimensions). Therefore, a good design should address all three levels.

Shneiderman (Shneiderman, 2004) argues that designers must address three almost equally important goals that contribute to fun: (1) provide the right functions so that users can accomplish their goals, (2) offer usability plus reliability to prevent frustration from undermining the fun and (3) engage users with fun- features. For the third goal, designers are now beginning to develop theories of user engagement through fun-features: alluring metaphors, compelling content, attractive graphics, appealing animations, and satisfying sounds. Getting this right is difficult; too many designers go too far in using excessively bold colors, distracting animations, and annoying sounds.

Designing for enjoyment is particularly relevant for games. How can one create enjoyment in games? The psychologist M. Csikszentmihalyi (Csikszentmihalyi, 1996) talks about the flow experience where a person’s ability and the challenge he or she is undertaking are perfectly balanced. When people are in the flow state they suspend their fears, put aside their anxieties, and engage fully in the experience of the moment. The implications of *flow* are that challenges must be constantly moderated in order to match the individuals increasing ability. According to Chris Crawford, stalwart game theorist, the point of play is the challenge - not just the goal. Some categories of challenges to be considered are: *Cerbellar challenge; Sensorimotor challenges; Pattern Recognition; Sequential Reasoning; Resource Management; Social Reasoning*.

4 Conclusion

In this position paper we outlined some general design goals (usability, sociabilty, human values, and emotions and enjoyment) that can be relevant for encouraging end users to contribute actively in user-centered tools. We assumed that a solution aimed at satisfying emotional, cognitive, social and ethical needs will influence the internal motivation of users to engage in participation. In our overall approach, participatory design methods as well as the described design goals constitute a general framework that can be used by designers to analyze a real case study, define a set of requirements and develop a very effective solution. Neither the design goals are complete, nor are the goals systematically distinct. In our future research we will extend and refine these requirements.

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