Analyzing the Support for Large Group Collaborations using Google Maps

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***Abstract*—Group support systems are becoming quite popular. They are also instigating large groups of people into collaborative practices. But research on large group collaborations is still very scarce, making it difficult to assess the benefits and drawbacks. This paper describes an empirical study with a group of 48 participants who used Google Maps to accomplish a collaborative design task. The main research goal was to obtain quantitative and qualitative insights about large group collaborations. Various dimensions of group collaboration were studied, including group size, shared awareness, task monitoring, and coordination. The obtained results indicate that large groups face very significant coordination problems and difficulties converging and handling the volume of information. But the study also points out that large group collaborations stimulate participation and task synergy through positive reinforcements, constant feedback and peer pressure.**

***Index Terms*—Group support systems, geocollaboration, large-group collaboration.**

I. Introduction

The study of large group collaborations is relatively recent, with researchers traditionally favoring smaller groups. For instance, one of the most comprehensive reviews of Group Support Systems (GSSs) reports that only 4% of the 200 studies considered group sizes with 10 or more people, and that 40% used group sizes with 4 or fewer members [1].

Nevertheless, GSSs have in general been considered beneficial for medium and larger groups, from 6 up to 20 people [1]. One reason explaining the lack of studies with large groups is that traditional GSSs present important technical and logistical problems to experimental research [2, 3].

The emergence of a new generation of GSSs, where we may include Wikipedia, Facebook, LinkedIn, Doodle, Dropbox, Twitter, Zoho, Google Docs, and Google Maps, among others, completely changed the research panorama. All these systems rely on the Web infrastructure to support collaboration [4] and are popular, widely accessible, and always operational. Thus, many of the traditional logistical problems have been tamed.

In this paper we report on an empirical study in which Google Maps was used to support a large team (48 participants). The main purpose of this study was to obtain insights on the impact of a large group on collaboration support, including the identification of technical and conceptual limitations.

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The data collection was obtained from an experiment in which a team was requested to attain an urban design assignment. To complete the assignment, the team members had to walk around a city area, finding design ideas to improve the city living, sharing their ideas with the others, and then converging into a list with the 10 best ideas. Thus the collaborative setting involved what has been designated geocollaboration: the integration of spatial data with decision models, blending together the concepts of Geographical Information System (GIS) and GSS [5-7]. We will not discuss the specific characteristics of geocollaboration, as they have been discussed elsewhere [3, 8].

The analytic work in this paper is based on a collection of quantitative and qualitative data gathered from questionnaires filled out by the participants, and is grounded on a subset of the design dimensions defined by Driskell [9] considering, in particular, group size, shared awareness, task monitoring, and coordination.

The paper is organized as follows. In the next section we provide a brief overview of the related work. Section 3 describes the adopted research methodology. Section 4 describes the experiment. Sections 5 and 6 are dedicated to data analysis. Finally, Section 7 discusses the obtained results and future research directions.

II. Related Work

In this section we overview the main research lines underlying the relatively few studies on large group collaborations that have been reported in the literature.

One research line is related with conversational knowledge. Wagner [10] analyzed how various technologies support conversational knowledge creation and sharing, from email to Wikis. He characterizes collaboration support as a constant cycle of brainstorm/aggregate/feedback actions, emphasizing the difficulties finding knowledge, filtering knowledge from noise and dynamically changing knowledge.

Computer-mediated communication and virtual communities of practice share many research issues with conversational knowledge. But their main focus is understanding the benefits and drawbacks brought by the technology to social and cultural practices, encompassing issues such as group establishment, community sustainability, power relationships, behavioral patterns, and identity [11, 12].

Another research line is focused on social cognition to understand how people remember, think, and reason as a group [13]. One important function considered by this perspective is coordination. Sarma et al [14] identify several emergent coordination patterns ranging from communication and data/task management, information discovery and contextualization, and finishing with the ultimate goal designated continuous coordination, which is yet to be determined by research.

Studies on virtual teams also give many insights about the mechanisms behind large group collaborations. For instance, Hara et al [15] used social network analysis to identify four factors affecting scientific collaborations: incentives, sociotechnical infrastructure, work connections, and compatibility. These factors may serve to explain why in some cases collaboration succeeds whereas in others it fails. Mark et al [16] also highlight the important role of information bridges, that is, people that help articulating work.

The studies on Collaborative Virtual Environments (CVE) emphasize the technological challenges brought by large group collaborations. For instance, Benford et al [17] discuss the impacts caused by scalability and distributed architectures. Large-scale collaborative games are perhaps the most demanding type of CVE. Benford et al [18] highlight again the technical difficulties in designing these systems.

The organizational studies of face-to-face and GSS meetings also contribute to understand large group collaborations. Thorpe and Albrecht [19] provide a good summary of this research line, emphasizing three critical problems: defining clear objectives for GSS use, aligning the technical possibilities of GSS with the organizational goals, and obtaining critical mass in GSS adoption.

The research community has also been studying classroom collaborations but the studies typically contemplate small teams (up to 5 students) working in large communities [20]. Alexander [21] recognizes that the lack of synergy is one of the main problems with classroom collaboration.

Collaborative design by large groups has also been investigated. In this context, Chiu [22] identified some of the fundamental technological requirements of design groups, namely maintaining data consistency, supporting team awareness, and visualizing processes.

We finish this overview of related work with a reference to the paradox of group size. As posited by Oliver and Marwell [23], the effect of group size on group activity is cost-based. If the costs of collective action rise with group size, then large groups will act less frequently than smaller ones. If the costs vary little with group size, then large groups will act more frequently than smaller groups. So, the impact of a large group on collaboration support will definitely depend on the costs brought by the technology.

III. Methodology

To obtain insights on the impact of a large group on collaboration support we chose a group decision-making type of task. The use of GSS for this type of task has been found beneficial for larger groups as participants tended to feel more satisfied and involved than when collaborating with fewer people [9, 24].

We also considered a geocollaborative context, having in mind the following points: a) the task would take place in a naturalistic environment, where it is easier for people to be more interested and participative, which led to the topic of urban design; b) the fact that people would need to wander around and be dispersed in an urban area favors the acceptance and use of information technology, and also facilitates the activity of larger groups, in contrast with room meetings where people communicate in a face-to-face fashion and the lack of space may be an issue; and c) the task would be conducted using Google Maps because it allows annotations to be associated with places, and also because of its continuous availability and popularity, requiring only the minimal amount of user training.

From these guidelines, we devised a naturalistic experiment and collected data from the questionnaires that the participants filled out at the end, containing a mixture of questions that required quantitative as well as open answers.

We organized the questionnaires and the subsequent analysis in five major categories, namely group size, information overload, awareness, usability, and participation, grounded on a subset of the design dimensions defined by Driskell [9].

The strategy we adopted to analyze the results consisted in starting with an analysis of quantitative data and then using the open questions to validate the results and find additional insights. The responses to the open questions were sequentially analyzed and coded in two rounds, the first one aiming to identify relevant codes and the second one to revise codes and improve the quality of the coding process.

The adopted coding strategy was a mix between grounded and start list [25]: the categories emerged during the coding process but they were confined to two master codes, namely positive and negative factors. After the second round, the number of occurrences of each code was counted. This served to quantitatively point out which codes were more relevant to the analysis.

IV. The Experiment

In this section we describe in detail the experiment that was conducted to study the impact of a large group on collaboration support. The experiment involved students from an undergraduate course undertaking a collaborative design assignment to identify problems and/or opportunities in the urban area where they study, and to propose innovative solutions based on information technology (IT). They were asked to accomplish the assignment using Google Maps. This assignment was requested during the third week of classes of a course given during the second semester of 2010.

A. Sample

The sample consisted of 48 students (26 were male; average age was 22.8) taking an undergraduate course on Computer Science, in the eight semester of the career of Information and Management Control Engineering, at the Faculty of Economics and Business of Universidad de Chile. The general objective of this course is to apply traditional and innovative IT in the implementation of organizational strategies.

It is expected that students at the end of the course are able to: a) detect problems and identify opportunities in the different components of the value chain of an organization, that may be supported through IT; b) manage an IT strategy that can introduce competitive advantages into an organization; c) design IT solutions; and d) develop communication and teamwork skills.

The students who participated in the experiment had already passed through courses on programming, information systems and databases. They were also knowledgeable about groupware tools; in particular, they were previously instructed on how to use Google Maps, during 20 minutes, as training for using groupware tools.

These students should be considered good users of computing technology for the following reasons: a) 15 students use notebooks in classes, 7 use netbooks, 25 have smartphones, all of them have a PC at home, and they also have access to computers at the Faculty; b) they regularly use basic software, such as text editors and spreadsheets, and specialized software like business process management tools, statistical software, database management systems and programming languages; and c) they use several social media tools like Twitter, Facebook, MSN and others.

B. Task Description

The task was performed collaboratively outside regular classes. All students were part of a single team. The teacher explained the task in the classroom, recommending the students to carefully observe the area surrounding the faculty and to identify problems, opportunities and ideas that may be addressed using IT.

The proposed ideas could be of various types, for example, how IT may help people managing their daily life, improving customer services in different places, supporting diverse tasks performed by citizens while moving, and more.

The problems, opportunities and ideas should be georeferenced in Google Maps. Each student should deliver at least two ideas. The students were also asked to discuss and give their opinions on the classmates' ideas; and they also had to collaboratively choose the ten best ideas by mutual agreement.

A document was given to the students describing the task:

> "*Task Instructions.* Go to the field (not necessarily with a computer) to analyze an urban area and bring new ideas about technology use (these are mere examples of possible technologies, more creative ones are welcomed: publicity, vending machines, information kiosks, interactive traffic information, etc.)."

The document also detailed several task requirements:

> "*Task Details.* 1) you must work on a specific area of Santiago; 2) you must use Google Maps in collaborative mode to georeference ideas; 3) the problems and ideas may be commented and supplemented with text, sketches and photos, as much as necessary to emphasize their importance; 4) the whole work must be performed collaboratively; 5) you must take a picture of the place or context where you identify a problem, georeferencing the picture; and 6) the list of the 10 best ideas must be accepted by consensus by all of the participants."

The students had one week to perform the task.

C. Technical Setup

The students were given no instruction regarding the type of hardware to be used for this task. Neither a certain type of coordination mechanism for selecting the best ideas was indicated or recommended. The students were just told they should use Google Maps. Roles, consensus, task awareness and coordination mechanisms had to be resolved by themselves.

D. Task Performance

Following the instructions, the students walked around the city area, identifying problems and opportunities, sharing their ideas with the others, and jointly setting-up a list of the best ideas. Most pictures were taken with mobile phones and uploaded in Google Maps later. The resulting documentation of the activities done with Google Maps may be seen in Figure 1**Error! Reference source not found.**.

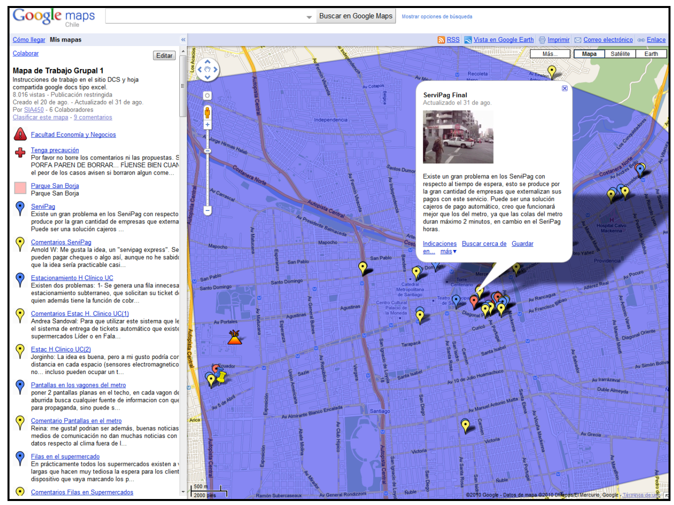

Figure 1. A Google map collaboratively georeferenced by the 48 students. On the left side, the list of problems, ideas and comments. Georeferences are displayed on the right side. Images are associated with problems.

During the week given to accomplish the task, the students had three sessions where they all met face-to-face. During the last 10 minutes of the second session, the students proposed and agreed on the ways to specify an idea (title, related discussion, use of color conventions, and how to elect the best ideas). Some ideas were also discussed during these sessions.

The students worked with the computers available at the Faculty and their own portable computers. Only five students indicated having used smartphones to georeference a problem in situ. The link to the georeferenced map of ideas created by the students can be found in http://tiny.cc/vdce4.

E. Task Evaluation

The course's lecturer evaluated the group outcomes considering the quality of the best ideas chosen by the students. The individual outcomes were also evaluated in the following way: minimum contribution of two ideas; quality of proposed ideas; involvement in the discussion; and quality of the responses to the questionnaire. The final mark for the whole team was 6 (in the range of 1 to 7).

F. Questionnaire

Our study is based on a questionnaire responded by the participants. Both quantitative and qualitative data have been collected and analyzed. The analysis has been fairly grounded on the design dimensions defined by Driskell [9], considering in particular the group size, shared awareness, task monitoring and coordination.

The questionnaire consisted of 36 questions. Of these, seven questions required answers using a 5-point Likert scale[1], four questions required yes/no answers, and the remaining 25 questions were open. The list of questions is presented in Table 1.

TABLE 1. QUESTIONNAIRE

Ref.	Question	Type
Q1.1	Easy of use of Google Maps?	Likert
Q1.2	Easy of use of Google Maps?	Open
Q2.1	Importance of georeferencing to task goals?	Likert
Q2.2	Importance of georeferencing to task goals?	Open
Q3.1	Impact of group size on task?	Likert
Q3.2	Impact of group size on task?	Open
Q4.1	Ease of collaboration support?	Likert
Q4.2	Ease of collaboration support?	Open
Q5.1	Did you feel involved in the task?	Likert
Q5.2	Did you feel involved in the task?	Open
Q6.1	Could you perceive the others' comments?	Likert
Q6.2	Could you perceive the others' comments?	Open
Q7	How were you aware of the other's work?	Open
Q8.1	Did you feel information overflow during the task?	Yes/No
Q8.2	Did you feel information overflow during the task?	Open
Q9.1	Did you use Google Maps at faculty?	Yes/No
Q9.2	Did you use Google Maps at home?	Yes/No
Q9.3	Did you use Google Maps in other place?	Yes/No
Q10.1	How much time have you spent in using Google Maps?	Open
Q10.2	How much time have you spent discussing?	Open
Q10.3	How much time have you spent in the field?	Open
Q11.1	How did you discuss the ideas face-to-face?	Open
Q11.2	How did you discuss the ideas by chat?	Open
Q11.3	How did you discuss the ideas by e-mail?	Open
Q11.4	How did you discuss the ideas by other tools?	Open
Q12.1	What ideas have you discussed most?	Open
Q12.2	What conflicts have you discussed most?	Open
Q12.3	What comments have you discussed most?	Open
Q12.4	What locations have you discussed most?	Open
Q12.5	What other things have you discussed most?	Open
Q13	How did you reach consensus?	Open
Q14	What did you do to discuss ideas?	Open
Q15	What did you do to collaborate?	Open
Q16	How did you select the best ideas?	Open
Q17	Do you feel represented in the list of best ideas?	Likert
Q18	Open comments about the tool	Open

V. RESULTS

48 students participated in the experiment and answered the questionnaire. The open questions generated a corpus with about 33.600 words and 163.000 characters (without spaces). Thus on average each open question received an answer with 135 characters, which indicates that the students carefully considered the assessment. The quantitative results are shown in Tables 2 and 3 while the qualitative results are summarized in Tables 4 up to 10.

TABLE 2. LIKERT RESULTS

	Q1.1	Q2.1	Q3.1	Q4.1	Q5.1	Q6.1	Q17
AVG	3.979	4.261	4.553	3.771	4.438	4.362	4.063
STDEV	0.699	0.773	0.619	1.057	0.501	0.486	1.099
1	0	0	0	1	0	0	3
2	4	3	1	9	0	0	3
3	0	0	0	0	0	0	0
4	37	25	18	28	27	30	24
5	7	18	28	10	21	17	18

TABLE 3. YES/NO RESULTS

	Q8.1	Q9.1	Q9.2	Q9.3
AVG	0.729	0.792	0.917	0.396
STDEV	0.449	0.410	0.279	0.494

In the following, we discuss the combination of qualitative and qualitative insights regarding group size, information overload, awareness, usability and participation.

A. Group Size

98% of the respondents say that the group size impacts the task. This is the highest correlation in the set of quantitative questions shown in Table 2.

Q3.2 aimed to identify the main positive and negative factors brought by the group size. The obtained results, shown in Table 4, identify more negative than positive factors, thus confirming the perceived correlation. The most significant negative factors are the impact of group size on task coordination, difficulties reaching consensus and information losses due to uncontrolled rewrites of the participants' ideas and comments.

TABLE 4. GROUP SIZE

Group size Q3.2 - Impact of group size on task?	
Positive	**Negative**
5 Increases diversity of ideas	10 Impacts coordination
2 Better ideas	9 Hard to reach consensus
1 Improves productivity	8 Information is lost due to rewrites
1 More efficient than face-to-face	3 Hard to communicate
1 Would be impossible to know the others' ideas without the tool	2 Group impacts mostly when converging
1 More original ideas	2 Hard to share same schedules
1 Participants may contribute at their own rythm	2 Disorder
	2 Hard to follow all new comments
	1 Too many ideas
	1 Needs moderator
	1 Hard to reconcile too many ideas
	1 Individual errors impact the group
	1 Repeated ideas and comments
	1 Reduces task involvement
	1 Slow
	1 Synchronization problems

B. Information Overload

73% of the respondents felt information overflow. This may be associated with the group size and is consistent with 98% of the respondents saying that group size impacts the task.

Q8.2 gives a better understanding of the problem (Table 5). The qualitative responses indicate that the flow of ideas was very high, making it difficult to follow and easy to forget. Al-

[1] The Likert scale was the following: 5 – strongly agree; 4 – agree; 3 – neither agree nor disagree; 2 – disagree; and 1 – strongly disagree.

so, the number of repeated ideas was considered high. Very few comments were given on the positive side. The most relevant observation was that the participants liked having all information visible on the computer screen.

TABLE 5. INFORMATION OVERLOAD

Information overload	
Q8.2 - Did you feel information overflow during the task?	
Positive	**Negative**
2 Everything was available on the computer screen	19 Many ideas and comments
1 Work was carried out in an orderly fashion	4 Some contributions are duplicates
1 Easy to follow history of ideas	2 Considerable flow of ideas and feedback
	2 Difficult to understand the relationships between ideas
	2 Related ideas apart from each other
	2 Window full of similar objects
	1 Many uninteresting ideas
	1 Some comments were simply forgotten
	1 Some comments were very long
	1 Manual search was difficult

C. *Awareness*

The participants positively evaluated awareness support. 100% of the respondents say that they could perceive the others' comments and even 36% strongly agree with that statement.

Q6.2 gives more qualitative insights on awareness (Table 6). As expected, most of the comments were very positive, especially regarding the constructive approach that lead the participants towards improving the others' ideas, the focus on good ideas, and the synergy towards task execution. The negative factors were mostly related with information overload. We also note that the participants liked using colors and icons to distinguish comments from ideas, and also having an unobtrusive perspective of the ideas and comments being produced.

Question Q7 inquired further about the strategies adopted to maintain awareness. The results (not tabulated) indicate a diversity of adopted strategies: using the left panel to follow comments, using the map to find new comments, checking only the last comment, and using colors to identify new information. However, the most cited mechanism was a sheet built with Google Docs to coordinate the group activities. Several participants referred that they checked the sheet various times a day.

TABLE 6. AWARENESS

Awareness	
Q 6.2 - Could you perceive the others' comments?	
Positive	**Negative**
12 Constructive approach	3 Too much information
4 Icons and colors	2 Repeated ideas
3 Global view	1 Unclear ideas
3 Positive reinforcements	1 Hard to follow discussion
2 Synergy	
1 Mechanism to aggregate comments	
1 Repetition indicates agreement	

D. *Usability*

For the purposes of this research we define usability as a combination of ease of use and collaboration support. The combined average score obtained by questions Q1.1 and Q4.1 was 3.88 in a 5-point Likert scale (standard deviation 0.90), which is relatively low. Furthermore, only 15% respondents strongly agree that the tool is easy to use; and only 21% strongly agree that the tool eases collaboration. This indicates a mild sentiment towards the Google Maps' usability.

Q1.2 gives more insights about ease of use (Table 7). It reveals several technical issues contributing to the perceived low usability. The most frequently cited one is a usability problem related with uploading photos. Two other ones concern difficulties discerning comments when their locations are very proximate, and lack of information regarding who deleted others' comments.

Within the collection of negative factors, we also find references to more conceptual problems regarding the task organization. In particular, the participants pointed out a disparity between mapping and commenting ideas, the fact that communication is not the primary focus of Google Maps, and the need to improvise collaboration strategies, since the tool does not offer clear support in that area.

TABLE 7. USABILITY: EASE OF USE

Usability	
Q 1.2 - Easy of use of google maps	
Positive	**Negative**
10 Easy to understand	4 Loading photos
3 Immediate visualization of new comments	3 Proximate comments are difficult to discern
2 Reference ideas in geographical context	3 Cannot see who deleted comments
2 Use of colors	2 Lacks coordination support
2 Integrates text and photos	2 Dispariry between mapping and chatting
2 Easy access to ideas	2 Proximate comments are difficult to discern
1 Easy to write comments	2 Slow
1 Use of icons	1 Lacks personal map
1 Searching	1 Cannot change message size
	1 Too easy to delete the others' comments
	1 Communication is not the primary focus
	1 Had to improvise to collaborate
	1 Difficult to aggregate comments

Q4.2 reveals a large set of negative and positive factors regarding collaboration support, although with clear emphasis on the negative side (Table 8). Within the negative factors, two of them were very preeminent: the group had to develop a coordination mechanism (using Google Docs), since the tool does not support one natively; and the problem that any participant may modify or delete comments without control or rollback.

TABLE 8. USABILITY: COLLABORATION SUPPORT

Usability	
Q 4.2 - Ease of collaboration support?	
Positive	**Negative**
4 Shared view of ideas	10 Alternative coordination mechanims had to be developed by the group
2 Avoids face-to-face interaction	12 Users may edit the others' comments
2 Gives feedback to ideas	2 Tool inadequate to discussion
1 Eases problem understandig	1 Difficult to converge
1 Facilitates viewing task progress	1 Required innovative solutions to organize work
1 Easy to communicate	1 Asymetric participation
1 Use of colors to organize comments	1 Lacks chat tool
1 Time management	1 Lacks personal comments
	1 Needs mechanism to understand who collaborates
	1 Slow

Within the positive factors, the most significant ones were the support for sharing ideas, obtaining and giving immediate feedback about the ideas, and avoiding face-to-face interactions.

Q4.2 also highlights that besides having to devise an alternative scheme to collaborate the participants also had to designate a facilitator to manage the task.

E. Participation

We assessed participation as a combination of task involvement, feeling being represented in the task outcomes and the perceived value of tool usage. The combined average score obtained by questions Q2.1, Q5.1 and Q17 was 4.25 in a 5-point Likert scale (standard deviation 0.84).

Task involvement was the most positive factor identified by the participants, with 100% saying that they felt involved. But perceived value and representation were also very high, with 92% and 88% respondents saying these factors were high or very high.

The qualitative comments obtained with Q2.2 highlight the most significant contributors to perceived value (Table 9): the tool gives context to the problem, helps locating problems, and offers a mental image of the task.

TABLE 9. PARTICIPATION: PERCEIVED VALUE

Participation	
Q 2.2 - Importance of georeferencing to task goals?	
Positive	**Negative**
12 Give context to problems	1 Some ideas apply to several places
10 Locate problems	
4 Mental imaging	
2 Visualizing problems	
1 Global view	
1 Goal oriented	
1 Understand problem	
1 Non-linear access to information	

Q5.2 points out several positive contributions to the participants' involvement in the task (Table 10): there was a constant flow of feedback information between the participants and strong involvement in the ideas. It is also interesting to note that the tool seems to promote peer-pressure and a fast pace towards accomplishing the task goals.

TABLE 10. PARTICIPATION: TASK INVOLVEMENT

Participation	
Q 5.2 - Did you feel involved in the task?	
Positive	**Negative**
5 Constant feedback from others	1 Distance between ideas and comments
3 Constant involvement in the idea evolution	1 Often ideas get lost
2 Global perspective	1 Lack of face-to-face
2 Peer pressure	1 Not when others delete my ideas
2 Fast paced	
1 Fluid communication	

VI. DETAILED ANALYSIS

In Figure 2 we present a quantitative analysis of the results obtained by the experiment. It shows the differentials between the positive and negative factors discussed in the previous section, considering the number of occurrences of each coded statement, and averaging the several criteria adopted to analyze usability and participation.

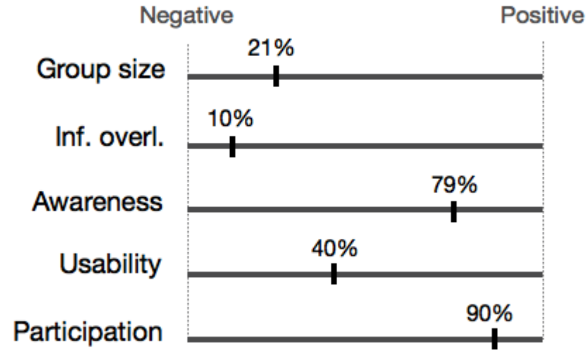

Figure 2. Quantitative overview of evaluation results.

These results show that participation is the most positive factor associated with the tool. The main reasons were attributed by the participants to the geographical context brought by the tool to the problem, associated with mental imaging and global perspective. But we should also emphasize that the tool seems to promote a constant involvement in the task through paced information feedback, to a point where the participants felt peer pressure towards task accomplishment.

The participants also regarded in a very positive way the tool's awareness support. Again, awareness seems to be a combination between technical features and social constructs. Within the list of technical features we highlight the use of icons and colors to differentiate ideas from comments, and the capacity to overview the task information in one single window. The social constructs resound the positive factors brought by participation, such as the capacity to promote task involvement and synergy. It thus seems that awareness and participation positively reinforce each other.

The most negative factors affecting the tool usage were group size and information overload. Although the tool supports large groups, it also seems to become affected by cluttered information and "laggy" interactions. Information overload emerges as the most significant problem associated with the tool, having received 90% negative assessments, the most polarizing of the criteria that have been analyzed.

But what is perhaps more surprising is that the tool seems to be affected by the lack of coordination mechanisms capable to manage large groups and considerable information flows. This is quite surprising if we consider that coordination management has been one of the foundational problems addressed by CSCW research, for which many solutions have already been experimented.

Of course the experimental results also highlight that specific measures should be taken to support large groups. It is particularly clear that the tool needs to promote strategies to reach consensus among large groups. And the results also point out very clearly that a large amount of information is difficult to follow and act upon. Thus again, the tool needs to promote strategies to handle large amounts of information.

The tools' usability also tends towards the negative side. However, in this case we should bring forward again the distinction between collaboration support and ease of use. Regarding collaboration support, the differential ratio is 70% on the positive and 30% on the negative side, while regarding ease of use the positive and negative factors are 50% for each side. We thus may say that the tool was regarded as having many usability problems that, to some extent are compensated by many advantages brought by collaboration support. The most important drawbacks brought by the participants consider, again, the lack of basic mechanisms necessary to coordinate users and manage shared information.

In Figure 3 we present a qualitative summary of the experimental results. This summary was constructed by analyzing the participants' responses at a second level of analysis, seeking for more generic meaning. In this second level of analysis we identify four fundamental forces influencing the tool's perception by the participants: global view, contextualization, information flows and coordination.

The global view is mostly influenced by the capacity to know the others' ideas while having access to that information in a non-linear way, supported by geographical references. However, having too many ideas makes it difficult to analyze and respond.

The relationships between mapping and communication contribute to contextualize the information, but we find the drawback that ideas may extend beyond one single place, or not be at all related with a place. The information flows contribute to create synergy among the group, where feedback information serves to build ideas upon the contributions from others, and serves to sustain the participants' commitment to the task.

Coordination also emerges in this qualitative perspective as a striking problem, not only because of technical limitations, which impel the participants to build social strategies to overcome them, but also because converging seems to be a difficult social process.

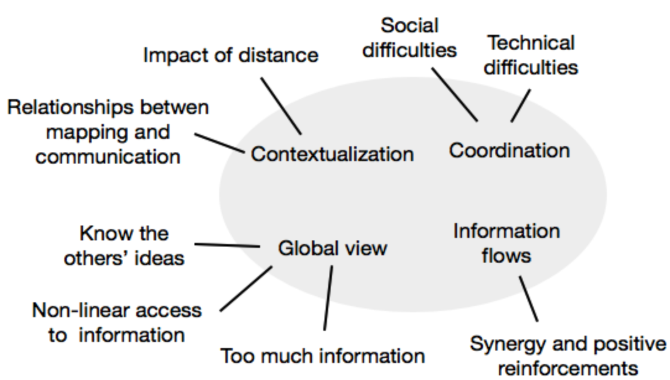

Figure 3. Qualitative overview of the evaluation results.

VII. Discussion and Future Research

We finally discuss the outcomes of this study and their possible implications for future research. Our first observation is that the impact of group size on the tool's functionality is very significant. As the group size increases, the problems start to emerge. And they do not only appear as technical problems but also as social issues. The lack of coordination support is representative of the former, while the difficulties dealing with large amounts of information and converging towards a common ground are representative of the later.

So, currently, Google Maps seems most adequate for small group collaboration. Yet, there are plenty opportunities linked with large group collaborations. From the experiment reported in this paper, it is striking to observe the value attributed to synergy, positive reinforcements, the constant feedback, the diversity of ideas, the peer pressure, and the fast pace set for collaboration. And all of these positive factors seem to be related with the group size.

The usability criteria used in our research, which we defined as a combination of ease of use and collaboration support, specifically addresses the challenges raised by combining the positive effects derived from large group collaborations with the negative effects caused by having so many interactions, large amounts of data and unsatisfactory data management. Future research in this area could attempt to derive a model and measuring instrument to formally evaluate the impact of group size on the usability of collaborative systems.

This research also points out some important challenges associated with the integration of map-based and communication-based collaborations. The experimental results indicate that maps provide a global and dynamic view of the problem, allow placing ideas in context, offer a strategy to aggregate comments, and at the same offer non-linear access to information. But the results also indicate that the users still find it unnatural to organize their discussions in a spatial context, especially when the discussions extend beyond a specific location. Further technical developments are also necessary to improve access to large amounts of information in small display areas.

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