Challenges and Solutions for Knowledge Sharing in Inter-Organizational Teams: First Experimental Results on the Positive Impact of Visualization

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Abstract: As pointed out by several scholars, inter-organizational collaboration is an important vehicle for knowledge creation. But the process of integrating knowledge across organizational boundaries entails great complexity. In this paper, we argue that visualizing knowledge in inter-organizational meetings is a conduit of knowledge sharing, and enables innovative re-combinations of organizational competences. We propose an experimental design to uncover the advantages and possible disadvantages of using visual techniques as a support for inter-organizational knowledge sharing. In particular, we compare the process and the outcome of knowledge sharing in inter-organizational teams supported with 1) software-based visualization, 2) poster-based visualization, and 3) text-based methods. The first results of our experiments suggest that software-supported teams outperform the control groups in knowledge-sharing tasks, and exhibit greater satisfaction with teamwork process and outcome. After discussing relevant implications for both researchers and practitioners, we point out limitations of our study and suggest directions for future research.

Keywords: Knowledge Sharing, Knowledge Development, Knowledge Visualization, Inter-Organizational Teams, Inter-Organizational Innovation, Experimental Research
Categories: H.4.3, H.5.3., J.4, L.2.3, M.0, M.2, M.8

1 Introduction

More than ever before, organizations continue to look for innovation opportunities beyond their organizational boundaries, therefore becoming involved in a variety of inter-organizational collaborations. A by-product of these arrangements is the formation of inter-organizational teams, set up by the partner organizations in order to make the collaboration operational. As a coordination mechanism between the partner organizations, inter-organizational teams should provide a communal medium where knowledge can be shared, integrated, and re-combined. However, team members may encounter considerable barriers to knowledge sharing, due to differences in the management styles, power bases, and cultures of the represented organizations. Failure to overcome knowledge boundaries may lead to frictions among team members, and eventually backfire on the collaborative agreement between the parent organizations [Fong, 03, Pearce, 09, Vlaar, 06].

A burgeoning stream of research [Bresciani, 09a; Ewenstein, 07; Whyte, 08] suggests that knowledge visualization plays a pivotal role in supporting knowledge intensive tasks in co-located work teams. However, none of these studies has specifically addressed the question of how visual representations can support knowledge sharing across organizational boundaries. In this paper, we propose an experimental approach to understand the advantages - and possible disadvantages - of using visual templates to facilitate knowledge communication in inter-organizational meetings. We structure the paper as follows: In the theoretical section, we take a closer look at the challenges of inter-organizational knowledge sharing, and we describe how visualization may mitigate such challenges. In the empirical part, we outline the experimental design that we have used to empirically test our hypotheses, and comment on the descriptive results of our first experiment runs. In the concluding section, we acknowledge the limitations of our study, and pinpoint avenues for future research on visual support for inter-organizational teamwork.

2 The Challenges of Knowledge Sharing in Inter-Organizational Teams

According to [van Wijk, 08], knowledge sharing refers to the process by which organizational actors - teams, units or organizations - exchange, receive, and are influenced by the knowledge of others. In their seminal study [Cook, 99] suggest that knowledge sharing at the team level is a powerful source of organizational innovation, since interpersonal interaction brings along the creative re-combination of knowledge. However, several scholars argue that knowledge sharing in inter-organizational teams is overly complex [see van Wijk, 08]. By virtue of their structural configuration, inter-organizational teams are faced with the dual challenge of overcoming both functional and organizational boundaries to knowledge sharing [Pearce, 09].

Along the functional boundary, team members are confronted with semantic barriers, namely the problems of understanding raised by the multi-disciplinary nature of inter-organizational work. Although semantic barriers are at work also in intra-organizational, cross-functional settings [Carlile, 02], they are deemed to assume a heightened relevance in inter-organizational contexts. In fact, inter-organizational teams are more likely to lack a shared language for interpreting, transferring, and integrating knowledge. [van Wijk, 08] have shown that knowledge ambiguity, defined as uncertainty about the underlying components, sources, and interrelations of knowledge, is more detrimental at the inter-, rather than intra-organizational level. In turn, this supports the notion that inter-organizational teams are endowed with fewer opportunities to eventually make sense of ambiguous knowledge.

Besides encountering semantic barriers to knowledge transfer, inter-organizational teams are confronted with pragmatic concerns related to the protection of proprietary knowledge against unintended leakages to the collaborating partners. In fact, team members may inadvertently trade away market insights that otherwise may have been an exclusive advantage of their parent company. In turn, fear of helping a competitor may induce opportunistic behaviours in knowledge sharing, and undermine the trust base of the inter-organizational team [Fong, 03]. This challenge is

not present in intra-organizational contexts, where the common organizational affiliation enables members to share knowledge without any appropriation concerns.

The organizational differences and the lack of trust may be even more prominent in the early stages of inter-organizational collaboration, when the team tasks are surrounded with ambiguity [Huiskonen, 02]. In the transition to a new relationship, team members do not know each other well and may look with suspicion at the agenda, values and beliefs of the partner organization. This may lead participants to develop different interpretations of the same phenomena, and increases the likelihood of misunderstandings in knowledge sharing [Vlaar, 06]. In the next section, we suggest that knowledge visualization may work as a conduit of knowledge sharing, and enable inter-organizational members to cope with problems of understanding.

3 Knowledge Visualization as a Conduit of Knowledge Sharing in Inter-Organizational Teams

The extant research on knowledge visualization consistently indicates that visual representations can facilitate knowledge sharing in the context of co-located team work. According to [Ewenstein, 07], visual representations are both communication devices whereby meaning is conveyed, and tangible artefacts whose manipulation affords the generation of novel insights. By virtue of their interactive property, visual representations can work as boundary objects, thus facilitating the creation of shared meaning across different practices. The interaction with visual objects enables individuals to make sense of their knowledge differences, and provides an infrastructure for translating knowledge across boundaries [Carlile, 02]. As boundary objects, visual representations should be particularly helpful in inter-organizational contexts, where the collaborating parties face multiple barriers to knowledge sharing. Along the semantic boundary, visualization may provide participants with a shared syntax for representing their knowledge, and learning about their reciprocal interdependences. Along the pragmatic boundary, visualization can contribute to address the appropriation concerns of the collaborating partners, by making explicit the border line between pooled and proprietary knowledge.

According to [Comi, 09a], visual facilitation may be particularly beneficial in the early stages of inter-organizational collaboration, where team members need to define interaction norms, and to concurrently develop mutual trust. Visualization may facilitate the decision to enter a strategic alliance, by enabling prospect partners to understand competence complementarities, and envision innovation opportunities. As put by an alliance manager interviewed by us: “Knowledge visualization is central in the early stages of a strategic alliance, serving not just planning purposes, but also mutual understanding and trust building”. While providing a means for sensemaking in collaborative settings, knowledge visualization is not without disadvantages [Bresciani, 09b]. In the transition stage to a strategic alliance, the persuasive effects of pictorial images may be particularly detrimental, inducing team members to overrate the value potential of the prospective collaboration. By engaging in the visual depiction of collaboration opportunities, team members may be cajoled by the image of a productive relationship, and develop excessive confidence in the alliance feasibility.

Although the current literature provides interesting insights on the advantages and drawbacks of visual facilitation, a systematic investigation of these phenomena in the inter-organizational contexts has thus far been absent. In addition, the current literature has largely left unaddressed the question of *whether the use of different media to convey visual representations bears an influence on knowledge sharing*. The information visualization literature suggests that software support provides a richer medium compared to printed support, but this assumption has not yet been tested empirically.

In this paper, we therefore address the question of whether, and how, the use of visual facilitation - conveyed by diverse media - bears an influence over knowledge sharing in inter-organizational teams. In doing so, we deliberately focus on the transition stage to inter-organizational collaboration, where the adoption of visual facilitation is likely to deliver the greatest effects. We hypothesize that *visual facilitation brings a positive influence on the quality of knowledge sharing* (H1), and in turn leads to *greater productivity* in inter-organizational meetings (H2). We also assume that visual-supported teams will experience *greater satisfaction* with the meeting process and outcome, compared to non-supported teams (H3). However, knowledge visualization may exert a manipulatory effect, inducing inter-organizational teams to *overrate* the value potential of the prospective collaboration (H4). We tentatively hypothesize that the above effects - positive and negative - will present greater intensity when knowledge visualization is conveyed by means of *software*, rather than *printed* support (H5). By comparing the two support conditions, we should be able to assess the added value of software-based visualization, and to appreciate the combined effect of computer interactivity and knowledge visualization.

4 Simulating Inter-Organizational Knowledge Sharing through Realistic Experiments

4.1 Experimental Design and Participants

In order to test our research hypotheses, we have developed a *between subjects* experimental design, with participants being randomly assigned to three different modalities of the independent variable. The independent variable is visual support, and the corresponding experiment conditions are i) *computer-based support*, ii) *poster-based support*, and iii) *no visual support*. As dependent variables, we have measured knowledge sharing quality, team effectiveness, team work satisfaction and attitudes towards alliance making [see 4.3 for greater details]. The 86 participants were advanced students enrolled either in an Executive Master (N=67) or a Master of Arts (N=19) in Business Administration. Data was collected in the course of three experiment runs, carried out between June and December 2009 at the Universities of Geneva and St. Gallen (Switzerland). In total, we had 8 computer-supported, 7 poster-supported, and 7 control groups - a balanced distribution allowing for comparable results across the experimental conditions. The participants were given a hidden-profile, role playing case study containing detailed information as regards their organization, but only limited information about their potential partner. The case game [Comi, 09b] is set in the construction industry, and provides asymmetric

information about two building companies considering the constitution of a strategic alliance.

After reading the case study, participants were paired up into inter-organizational teams of 3 - 4 participants, and played the role of executive managers representing the two sides of the prospective alliance. The team tasks consisted of sharing knowledge in order to identify complementary competences (task 1) and to envision opportunities for collaborative innovation (task 2). Following the tasks instructions, team members designated a facilitator of the bilateral discussion, elected from the organization hosting the meeting. The facilitator documented the bilateral discussion with the support materials received from the organizers, namely i) software files, ii) poster templates, or iii) flipcharts depending on the condition of assignment. Whereas the control groups used a blank flipchart, the experimental groups received the same visual templates, the only difference being the type of medium support. The computer supported groups worked with digital templates loaded on the let's focus visualization software, while the poster-supported groups used post-its on printed templates. The visual templates used in the experiment were the competence complementarity chain adapted from [Pietroforte, 96] and the innovation opportunity map adapted from [Muller, 02]. The first template is intended to support the identification of complementarity areas, while the second one is suited to assist the exploration of joint innovation via the systemic recombination of the partners' competences [see 4.2 for greater detail].

At the end of the joint discussion, participants received a questionnaire where they had to express their attitudes towards the prospective alliance, and to evaluate the inter-organizational knowledge sharing process (self-reported measures). Finally, the experimenters analyzed the documentation of the joint discussion against the case study solution, and accordingly evaluated team performance (objective measures). In order to reduce the risk of experimenter's bias [Jung, 71], all the participants received written instructions of the experimental tasks. The experiment lasted for about 1 hour and a half (30 min. for case study reading, 20 min. for each team task, and 10 min. for filling out the questionnaire). The groups worked in separate environments in order to avoid contaminations between groups and across experimental conditions.

4.2 Visual Templates

The rigorous selection of visual templates is of primary importance in order to ensure the internal validity of the research design, as well as the reliability of the experimental results [Bresciani, 09a]. We have identified the competence complementarity chain [Pietroforte, 96] and the innovation opportunity map [Muller, 02] by carrying out a literature review of graphical representations of inter-organizational competences. Afterwards, we have performed three experiment pre-tests (March-May 2009) to assess the suitability of the selected templates to support inter-organizational knowledge sharing. Based on the feedback received from the experiment participants, we have slightly adjusted the templates layout in order to correct minor usability problems. The visual templates used in the final experiment are displayed in [Fig. 1-2]: The left side shows the empty templates distributed to the experimental groups, while the right side displays the filled templates used to evaluate team performance. We have elaborated the filled versions in collaboration with a

consultant who had been personally involved in the strategic alliance described in the case game.

Both the visual templates are intended to represent the *collective knowledge* of the partner organizations, which is reflected in the *organizational competences* mapped onto the template canvas. The competence complementarity chain [Fig. 1] is a two-layers template where team members can display their organizations' competences along the industry value chain. By matching *core competences*, inter-organizational actors should be able to visually inspect *complementarity areas*, and to better assess the value creation potential of the strategic alliance. As visible in the filled template, team members should fill in the industry value chain (5 items) and identify 20 organizational competences, of which 3 are core competences (to be represented with arrows).

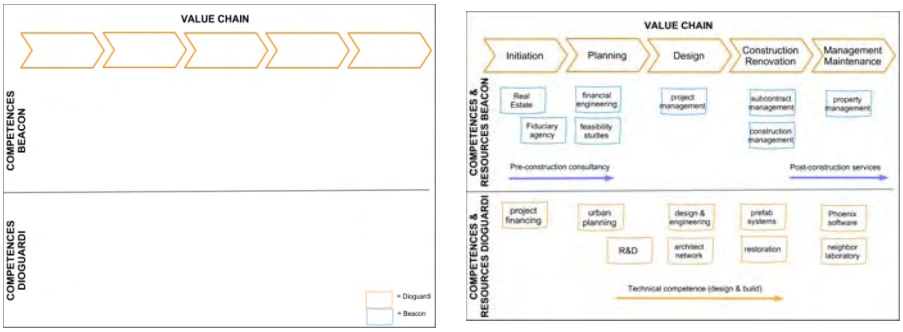

Figure 1: The Competence Complementarity Chain (for Task 1)

The innovation opportunity map [Fig. 2] is a three-layers template, displaying i) *organizational competences*, ii) *market needs and developments*, and iii) *joint innovation opportunities*. With the support of this template, team members can systematically recombine organizational competences to address market trends, and to envision corresponding opportunities for collaborative innovation. As shown in the filled template, team members should be able to generate about 7 innovation opportunities, intended to address 3 major market needs and developments.

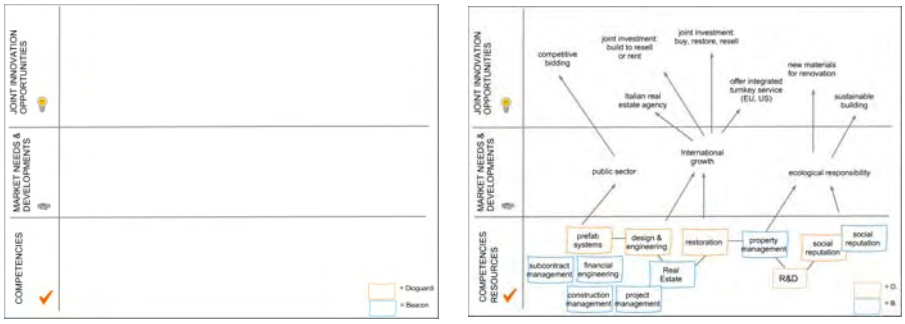

Figure 2: The Innovation Opportunity Map (for Task 2)

In summary, the first template supports the identification of organizational competences (task 1), whereas the second template facilitates the development of innovation opportunities (task 2). As mentioned above, the experimental groups are given the same visual templates, the only difference being the medium used to document team work (computer vs. poster support). The teams in the control condition do not receive any visual support, but are given the same labels reported in the empty templates as cognitive categories to structure their work. In this way, the control groups are in a fair position compared to the experimental groups, and the observed differences should be attributable to the intervention variable only. Due to space constraints, we cannot illustrate the experiment tasks with pictures of the teams' work results. However, relevant examples of team solutions produced across the three experimental conditions can be viewed online at the address: http://www.knowledge-communication.org/visuals.html.

4.3 Measures

Before reporting the first results of our experiments, in this section we briefly describe the operational definitions that we have used for measuring the dependent variables of our study. We have introduced self-reported measures for assessing individual perceptions of the team process, together with objective measures for evaluating team performance on the two experimental tasks. The self-reported values were collected by asking the experimental participants to fill out a questionnaire with items measured on a 7-point Likert scale. The objective values, on the other hand, were generated by the experimenters assessing the performance of each team against the official solution of the case game tasks [Comi, 09b].

4.3.1 Self-reported Measures

Team knowledge sharing quality. The quality of knowledge sharing in the inter-organizational team was measured with the interpersonal knowledge, skills and abilities scale (KSA) by [Kichul, 00], combined with two facets of the behavioral observation scale (BOS) by [Taggar, 01]. The interpersonal KSA is comprised of three sub-dimensions, i.e. conflict resolution, collaborative problem solving and communication (9 items), while the BOS facets are focus on task-at-hand and synthesis of team ideas (4 items). In our view, the selected instruments are suitable to measure knowledge-sharing quality, as they tap into the ongoing interaction among team members, with a focus on performing behaviours that precede effective teamwork.

Meeting satisfaction. The satisfaction construct was measured with a validated instrument [Briggs, 06], specifically tailored to the context of groups working with facilitation support. The selected instrument builds on a multidimensional concept of satisfaction and comprises two sub-scales, namely *satisfaction* with meeting *process* (SP) *and outcome* (SO), each measured with four items.

Team members' attitudes towards alliance making. For this construct, we have developed ad-hoc, single items whereby we ask respondents to estimate the value creation potential of the strategic alliance on a 7-point Likert scale.

4.3.2 Objective Measures

Team effectiveness. In order to assess this construct, we have developed a set of objective measures based on the solution of the two team tasks, reported in the teaching note of the case game [Comi, 09b]. As a measure of *team productivity*, we have counted the number of i) organizational competences, ii) market developments, and iii) innovation opportunities matching with the task solution. In parallel, we have elaborated a measure of *team precision* in solving the tasks, by dividing the number of correct items by the number of total items documented by team members. Moreover, we have evaluated the team's recognition of competence complementarities along the industry value chain (dummy coding, yes-no).

4.3.3 Control Measures

A number of factors pertaining to the characteristics of team members may influence the dependent variables of our study, therefore confounding the effect of visual support. To rule out alternative explanations, we have controlled for the following variables: 1) the cultural diversity of team members, 2) the facilitator's skilfulness, 3) the individual attitudes to teamwork, 4) the individual mastery of visualization techniques, 5) the individual experience with strategic alliances, 6) the individual knowledge of the building industry, 7) the individual mastery of the English language, and 8) the team collective effort in carrying out the experiment tasks. To measure control variables, we have developed ad-hoc single items - with the exception of teamwork attitudes (3) and team effort (8), for which we have used validated three-items scales by [Cunningham, 01] and [Campion, 93] respectively.

4.4 First Results

Thus far, we have collected data from 22 groups (N=86), distributed almost uniformly across the three experimental conditions (8 software-supported, 7 poster-supported, 7 control groups). A power analysis performed through G*Power 3 has revealed that the current sample is not sufficiently large to carry out an inferential statistical analysis. We plan to further replicate our experiment, since - assuming a moderate effect size of the independent variable - we will need about 60 cases per condition (N=180) in order to be able to detect statistically significant effects. In the meantime, we have performed a descriptive analysis of our dataset, and found initial - although statistically inconclusive - support for our hypotheses. In [Tab. 1], we report the descriptive statistics, produced by averaging the teams' self-reported and objective values in each experimental condition. We comment below on the most relevant findings, structuring our discussion according to the distinction between self-reported and objective measures.

4.4.1 Self-reported Measures: Descriptive Results

Team knowledge sharing quality. Contrary to our expectations, the highest value for *interpersonal KSAs* is found in the control condition, even though the difference with the other two conditions is only minimal. We may speculate that control groups perceived a more natural setting for knowledge sharing, since they did not have to deal with the appropriation of a support system. At times, we have observed that the

natural flow of knowledge in experimental groups was slightly inhibited by the need to learn how to use visual facilitation. On the other hand, *idea synthesis* was reportedly higher in the visual-facilitated conditions, therefore confirming the perceived helpfulness of visualization for streamlining knowledge intensive conversations. Also the reported *focus on task at hand* was higher in the software-facilitated condition, but exhibited slightly lower values among poster-supported groups. As a possible explanation, we may advance that poster-facilitated teams perceived visual templates with post-its as a bit playful, and occasionally went into off-topics discussion. There was also a tendency to focus too much on one's own post-its and listen less to the other team. If we average the three measures of team knowledge sharing quality, we observe mixed support for H1*(visual facilitation brings a positive influence on the quality of knowledge sharing)*. As visible in the row *knowledge sharing quality (avg.)* in [Tab. 1], the positive impact of visualization on team knowledge sharing is confirmed only for the computer-supported condition.

	Measures	**Software (N=8)**	**Poster (N=7)**	**Control (N=7)**
Self-reported*	Interpersonal KSAs	5.92	5.82	5.96
	Focus on task at hand	6.31	5.19	5.33
	Synthesis of ideas	5.70	5.63	5.52
	Knowledge sharing qual.(avg.)	***5.98***	***5.55***	***5.60***
	Process satisfaction	5.67	5.30	5.33
	Outcome satisfaction	5.87	5.39	5.30
	Meeting satisfaction (avg.)	***5.77***	***5.35***	***5.32***
	Alliance making attitudes	***5.46***	***5.26***	***5.21***
Objective	Competences†	11.3 (95%)	12.00 (83%)	8.13 (67%)
	Trends†	3.86 (92%)	3.14 (64%)	1.14 (56%)
	Innovations†	5.38 (92%)	3.14 (56%)	3.00 (72%)
	Complementarities‡	7 (88%)	6 (86%)	3 (43%)
	Team productivity**	***20.54 (93%)***	***18.28 (68%)***	***12.27 (65%)***

*All self-reported measures are on a 7-point Likert scale †Absolute count of correct items (team productivity) followed by percentage of correct items on total items (team precision) ‡ Number and corresponding percentage of teams who correctly identified competence complementarities **Sum of correct items followed by average of correct items on total items for *Competences*, *Trends*, and *Innovations* - *Complementarities* is excluded being measured as a dummy variable (yes-no).

Table 1: Descriptive Results (N=86)

Meeting Satisfaction. Satisfaction with process and outcome was higher among software-facilitated groups, while presenting comparable values across the other two conditions. The averaged values of meeting satisfaction [Fig. 1, row "Meeting satisfaction (avg.)"] provide preliminary support for H3 *(visual-supported teams will experience greater satisfaction with the meeting process and outcome)*, and suggest that the effects are slightly stronger when the visual templates are conveyed by means of a software, rather than printed support (H5).

Team members' attitudes towards alliance making. The software-based support also led to a more positive assessment of the alliance potential, although the reported value is still within the range of moderate to high. Therefore, we cannot derive strong support for our hypothesis on the cajoling effect of visualization (H4) and for the stronger effects of computer-supported visualization in this respect (H5). However, it will be interesting to test if the group mean differences - albeit modest - are statistically significant.

4.4.2 Objective Measures: Descriptive Results

Team effectiveness. The visual-supported groups outperformed the control groups on all the objective measures of team effectiveness, with the software-based condition yielding the highest productivity and task precision. In general, the descriptive statistics provide preliminary support for H2 *(visual facilitation leads to greater productivity in inter-organizational meetings)* while also confirming the superior effects of computer-supported visualization compared to poster-supported visualization (H5). A minor exception regards the competence counts, on which the poster-supported groups exhibited slightly higher results compared to the software-supported condition. On the other hand, the software medium provided the greatest support for the innovation task, leading to the generation of 2.25 items more than in the poster-supported condition. The task precision was consistently superior in the software-supported condition, where team members reported the largest percentage of pertinent items (92-95%) on both the experimental tasks. In turn, the poster-facilitated groups generally outperformed the control groups in terms of task precision, except for the documentation of innovation opportunities. We believe that the most interesting finding lies in the *superiority of the software medium for fostering divergent thinking (task 2), and task precision*. This suggests that - compared to traditional visualization - the software support facilitates both the generation of creative ideas, and their refinement into a set of highly pertinent items. This advantage can be explained with reference to the higher rigidity of the software medium, which forces team members to adhere more strictly to the received instructions. This is not the case with traditional media, which allows for greater flexibility in the appropriation of visual templates. For example, we have observed poster-supported teams using post-its beyond the template frames, therefore overloading the poster with redundant items, and in turn scoring lower in task precision. In another case, using the innovation template in the horizontal - rather than vertical - sense lowered performance on the divergent task, preventing team members from seeing the high-end chaining from competences to innovations. Finally, it is remarkable that *the majority of visual-supported groups (86-88%) correctly identified competence complementarities, while more than a half of the control groups (57%) failed on this performance measure.* The identification of competence complementarities represents the foremost stage of alliance making, and the fact that non-supported groups failed in this endeavour is a non-trivial result, with relevant implications for alliance practice.

5 Conclusions and Future Work

We have reported descriptive results of our experiment, which provide preliminary support for our hypotheses about the positive impact of visual support on inter-organizational teamwork. In particular, the descriptive analysis suggests that software support generally leads to superior results on both subjective and objective performance-related measures. However, these findings are non-conclusive, and present severe limitations in terms of external validity, being only applicable to a small sample of inter-organizational teams. In addition, at a descriptive level we could not control for team-related variables with a potential to confound the effects of the independent variable [see 4.3.3]. On the other side, the random assignment of experimental subjects to the different modalities of the independent variable allows us to rule out the risk of systematic biases in our data, such as participant self-selection.

As a next step in our experimental research, we plan to collect additional data - up to about 180 cases - in order to be able to test for the statistical significance of our results. Once we will have collected sufficient data, we will conduct an inferential analysis by using analysis of variance (ANOVA) in order to test for significant differences in group means. In parallel, we will use structural equation modelling (SEM) to detect mediation effects among the endogenous variables of our research model (e.g. knowledge sharing quality may mediate team effectiveness). We are also considering the possibility of applying a multilevel analysis, which would enable us to appreciate the individual level nested within the team unit.

While limited in terms of external validity, the reported findings confirm the feasibility of our experiment design, and suggest that assessing the impact of visual support on inter-organizational teamwork is a promising field of research. If our hypotheses will be confirmed, the ensuing implications will be relevant for both practitioners and scholars in the field of knowledge management and alliance management. On the one hand, alliance professionals may consider including visual templates in their toolbox for alliance management. On the other hand, interested scholars may adopt complementary methods to further investigate the role played by knowledge visualization in inter-organizational collaboration. As the experimental method is carried out in an artificial setting, this research could be complemented by qualitative studies, such as the participant observation of inter-organizational meetings facilitated by visual techniques. Future research may also attempt to identify which visual templates - besides the ones used in our experiment - are best suited for the purposes of supporting inter-organizational knowledge sharing.

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