Rivalry between the collective use of IT tools and working methods of design teams

Comparison of research outcomes

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Key words: Rivalry between IT tools, collective use, team communication, team performance, working habits, preferences, working methods, 2nd order of change

Abstract: Nowadays a high variety of IT tools is available for communication purposes in design processes on individual and group level. Despite this, the exchange and sharing of design documents collectively in design and engineering teams might be limited mainly, due to habits, preferences, working methods and rivalry between the collective use of IT tools in such product development. Changes in habits and preferences for collective use of IT tools might be realized by training and management power. However, adoption of collectively to be used tools, like project websites, is depending heavenly on the attractiveness for users in daily work. Based on empirical research outcomes it is indicated that rivalry between collective used tools and differences in working methods of users might be main barriers for attractiveness of these tools in daily work. Applying a framework for analyzing and categorizing of the frequency of use of IT tools for team communication, the authors explain the appearance of rivalry between tools, limiting the effectiveness in daily work and not affecting team communication and performance. By comparison of working methods in different sectors authors explain the necessity of changes in working methods in design and engineering in the building & construction industry on organizational and inter-organizational level for successful adoption of collectively to be used IT tools in team communication.

1. INTRODUCTION

1.1 Collective use of IT tools in design and construction teams

Today, for members of design teams in building and construction projects a growing number of IT tools is available for communication synchronously and asynchronously (Davenport, 1997; Dainty et al., 2006). By the use of the mobile phone or internet-Skype, team members communicate synchronously at different places or with a short delay using messenger-services. Asynchronously, communicating on distance at different places, the use of email has become as normal as telephone use for team members. These tools are used individually and with high or low frequency depending on the preferences and habits of the user for daily communication. In general the adoption of these tools happened in a short period of time in various communication cultures worldwide. It appeared to be mostly a matter of time and availability of the technology. Collective to be used IT tools for synchronous and asynchronous communication by design teams show much lower attractiveness to users and consequently lower adoption curves (Emmitt et al, 2007). Research projects to the use of such tools in daily work indicates that due to working habits, preferences for specific means or tools and rivalry between IT tools teams do not use these tools collectively in the same way on a daily base (Abadi, 2005; Otter, 2005; Adriaanse, 2007). Changes in habits might be realized by management intervention and training although preferences for individual communication and dialogues between team members in practice is difficult to change if all communication tools stay available in the work environment (Otter et al., 2007).

1.2 Design team members

Usually, design team members are used to work in different groups in different settings and projects depending on the project work breakdown structure made by the client and the project managers. Such groups can be defined as temporary, multi-disciplinary and network based organizations collaborating on inter-organizational level. These groupings of specialist designers (Dainty *et al.* 2006) are usually managed by one of the team members delegated by the client. Depending on the competences needed for this task, the architect or structural engineer is asked by the client or a specific project manager. A specialist designer can be an individual, independent designer or the representative of a collaborating design organization. Usually, these are designers having additionally a management

task, or managers with an additional designing task, that can be characterized as Schön (1987) did: being creative, visionary, spatially aware and abstract thinking practitioners with a high level of technical knowledge and experience.

Due to the multidisciplinary aspects of architectural design, the growing number of participants, the increasing legislation and governmental rules, task complexity of the individual team members is increasing. Members of a design team repeatedly generate new knowledge about the design by collecting, sharing and transforming information (Lawson, 1994; Luck, 2006). Although team members usually work on design tasks themselves in their design offices, team communication via face-to-face communication is essential to facilitate and stimulate design processes. Thus from the perspective of the design team, specialist design knowledge usually is embedded in the team and needs to be communicated to become useful knowledge for the design to be produced. To distribute generated design knowledge among design team members for the progress of design, they need to process their own specialist data before useful information can be delivered to others. Designers participate in various ways in the team and are depending on each other's output. Many participate as individuals, working alone for crucial periods and then return to the network process (Latour, 1987; Kvan, 1997; Dainty *et al.* 2006).

So, based on the above description, team communication of a design team can be defined as the compilation of all processes for sending and receiving messages between team members individually and collectively, using all the available means of communication. Generally, design team management only partly organizes synchronous and asynchronous communication as part of their formal duties (Gorse, 2002).

1.3 Design team communication environment

The design process of build and construction projects might be characterized as a continuous process of change that has to be well documented and updated because typically many actors and stakeholders are involved in such a process. Specifically for team communication in integral design processes with a high level of concurrency, design information needs to be well structured. All recently generated and changed information needs to have the right status, version and information about creators and updaters to get overview and transparency on the current design process and progress. In such design teams, members need information updates and feedback from

other design team members in a much higher frequency, rather within hours instead of days to continue their work properly.

The communication environment of design teams can be characterized as a holistic environment because the key information carriers for team members to communicate are sketches, schemes, images, drawings, written descriptions together with explanatory stories (Lawson, 1994). In this environment we can discern an internal and external environment based on communication activities. The design to be made usually is visualized, updated, elaborated and discussed first by the experts in the design team before it is advised or discussed with the client in a larger setting with other stakeholders.

So, the internal environment is the team's communication environment in which collaborating design team members communicate both synchronously and asynchronously, using all the available communication tools formal and informal (Otter, 2001) to produce the design. In the external environment, design teams communicate with their client, users and other stakeholders (Figure 1). This communication usually takes place more formally, compared to the internal environment, through regular team meetings, paper publication of design information and negotiation, judgment and contracting activities. This kind of communication can also be both synchronous and asynchronous. So, in general, all synchronous and asynchronous communication for building and construction projects usually is not totally and formally organized by project managers or the client. Part of the internal and external communication takes place in an informal not organized way (Dainty et al. 2006).

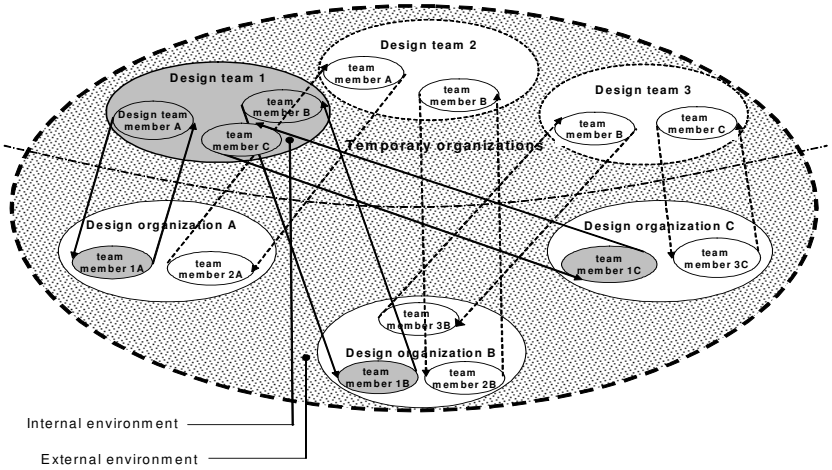

Figure 1. The communication environment of design teams

1.4 IT tools features for team communication

Based on time frequency and sexton's (2007) distinction to dynamic and static use of internet based tools, four modes of asynchronous team communication can be identified to show that time frequency of information sharing using collectively the tool is important for effectiveness of team communication affecting team performance (Figure 2).

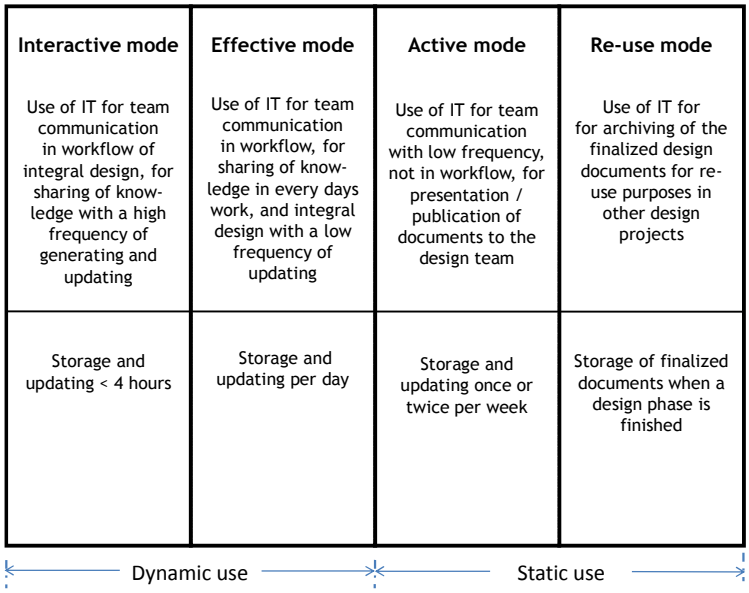

Figure 2: Asynchronous modes of communication

First, in the *Interactive* mode, actual design information is communicated with a high frequency. In this mode, information is stored and uploaded almost synchronously or within minutes or some hours and all changes in design are actually made which maximize tuning between design team members. Frequent feedback is expected by team members by updating the information or by sending messages. It is indicated by Moum (2005) that a groupware system or a collaborative used 3-D modeling package used in this mode can be highly effective for team communication and improves team performance substantially because of the up-to-hour status and overview of stored information.

Secondly, in the *Effective* mode, asynchronous communication is used to communicate and maintain actual design information within a time

frequency of 4 to 24 hours (within one day). It can be expected that groupware tools used in this mode will be effective for team communication affecting team performance because of the up-to-date status and overview of stored design information that is attractive for users as is shown by other commonly used applications in the Internet for advertising purposes.

Thirdly, in the *Publishing* mode, finalized design documents are stored regularly once or twice per week or with a lower frequency, for communication and publication purposes to the team, the client and other stakeholders. Feedback might be expected by using the email message facilities.

Finally, in the *Archive* mode finalized design documents are stored for re-use during the lifecycle of the project or in new design projects. A groupware system like a project website for instance can function in this mode as a digital library for its users. Both the publishing mode and archive mode can be categorized as static use of IT (Sexton, 2007) that however might stimulate team communication and affect team performance. The final storage of design documents for re-use might also be effective for maintenance and lifecycle purposes of the client and the design realized.

2. RESEARCH FINDINGS CONCERNING COLLECTIVE USE OF IT TOOLS BY DESIGN TEAMS

The outcomes of empirical research concerning the collective use in design teams of video conferencing (Mulder, 2004), project websites by den Otter (2005), intranet use by Sexton (2007) and to information and communication technology in the construction industry by Abadi (2005) and Adriaanse (2007) clearly indicate that the effective use of IT tools collectively by teams need reconsideration of working methods and re-design of communication and information processes to stimulate team communication that affects team performance. Neglecting these aspects show misuse of these technologies collectively by teams easily leading to incongruent technological frames that block effectiveness and performance improvement of teams and showing signs of the IT paradox as Brynjolfsson et al. (1998) defined.

Different mind sets of individual members of a group regarding the use of new IT tools in daily work easily will corrupt the collective use by that group. This specifically concerns the use of the tool in the same way in daily work. IT tools use need the collective adoption by a group to become effective for team communication and affect team performance. Making the

benefits of use and the added value explicit collectively for the group, will affect the individual mind sets positively as workshops for implementing project website use show (Otter, 2005). If group members afterwards still do not use the tool in the same way and with the same appointed frequency, the group itself will or might react to that because design team members are depending on each other's results in daily work (Kvan, 1997; Dainty et al., 2006). In multiple case studies to the use of project website use in a large real estate agency with regional units (REA), conflicts were observed regarding rivalry between IT tools but also with respect to the goals underlying collective use of a project website in daily work.

2.1 Rivalry between IT Tools

The results of empirical research to the daily use of IT tools and more specific regarding project website and Intranet use in construction (Otter 2005; Sexton 2007) indicates that this use faces competition from the more easy-to-use shared project disk and parts of network disks of which file management was facilitated by MS-Explorer. Increased rivalry was specifically reported in the multiple case studies in REA (Otter, 2005) when specialist software was used because of increased and annoying, additional handling procedures using the storage facilities of the software to store the output in the Projectweb.

This rivalry might be eliminated if MS-Explorer was closed for use in daily work by a design or project team. This is however difficult to realize because of the various links between the Windows operating system, the project website package and the extensive number of software modules having not all the same options for output, file storage and updating.

Rivalry between general available email packages such as MS-email or hotmail and the email messenger facilities provided by the projectweb package was observed in all units. Functions of the email facilities in such packages mostly show limitations and differences in use compared to the general available packages for instance not allowing messages to external participants or not able to use general distribution lists.

The use of parts of network disks obviously became a strong habit in daily work that cannot be changed easily. Because it may be difficult avoiding this type of rivalry by changes in the IT-environment, management interventions are needed. Due to the rivalry experienced by the users, projectweb adoption for re-use instead of daily use was promoted by a user platform created in one unit. Also, the collectively appointed instruction in one unit not to use the facilitated email-messenger may be indicative for the

use of the tool in archive mode. It might be that unit management lost or was not aware of losing control on user adoption by not leading the user platform and stay re-active regarding the collective adoption of use of the tool in daily work.

2.2 Mind sets and Technological Frames

Regarding the individual mind sets in groups and teams of designers, coordinators and managers, the statements of Orlikowski (1994) regarding the technological frames of groups and the individual members are of high importance: "Where the technological frames of key groups in the organizations, such as managers, technologists, and users are significantly different, difficulties and conflict around the development, use, and change of technology may result". The term *technological frame* is specifically used to identify the assumptions, expectations and knowledge that members use to understand the new technology. This includes not only the nature and role of technology itself, but also the specific conditions, applications and consequences of that technology in particular contexts. The three aspects Orlikowsky distinguishes: nature of technology, technology strategy and technology were analyzed in the multiple case studies in REA to the use of a project website in design teams (Otter, 2005).

Nature of technology refers to members' images of the technology and their understanding of its capabilities and functionality. Interviews, meeting reports and member checks indicate that in REA the dominant image of design team members and unit management regarding the use of a projectweb was that of an advanced tool for re-use of electronically stored information. This in contrast to REA's technologists (the projectweb-application manager and coordinators) who expressed in their meeting reports much more the image of an electronic communication tool for sharing documents by using effectively the project web's advanced database capabilities. The main image of REA's central management was that of an instrument, beneficial for integral design in the longer run. They explicitly promoted the projectweb at the start of the team workshops for using the Projectweb in daily work, as a tool for team communication that allows integral design.

Technology strategy refers to views of the various groups in an organization why the organization acquired and implemented the technology. It includes team members understanding of the motivation or vision behind the adoption decision and its likely value to the organization. REA's central management had the objective of stimulating in the longer run integral design. In contrast, it seems that unit management became primarily convinced of the benefits of the tool for re-use of information.

Other groups (team managers, team members and design group leaders) developed thoughts of the Projectweb package being a handy tool for the business department and unit management to get a better overview of workflow and design progress. Thus, there were conflicting views why the organization needed the new information and communication technology.

Technology in use refers to user's understanding of how the project web technology should be used on a daily basis and the actual conditions and consequences associated with such use. Findings in REA's multiple case studies show that user's understanding of project website use differs from the management view. This might be due to differences in interest between members in using the projectweb as shown by the non-adopters and laggards in two of the three units investigated (mainly architects and structural engineers). These team members continuously argued during the implementation period of one year, that the new IT technology was not beneficial to their daily work.

Team members in two units expressed during interviews and meetings their view that the projectweb and MS-explorer for the shared project disk were highly comparable, a view which was enhanced by the look-a-like interface. The same view was expressed by the project leaders of the third unit. In one unit, the project leader of the team that showed the highest adoption, expressed the idea that the projectweb better should be used for only storing CAD-drawings and not for all types of documents.

Thus, the data of REA's multiple case studies reveal the existence of incongruent technological frames within and between units that may contribute to the explanation of the technology paradox as Brynjolfsson et al. (1998) stated. The frequent discussions about the ambiguous, collective use of the new information and communication technology without a clear goal, between team members and project leaders in two units, support this conclusion.

3. RE-DESIGN OF WORKING METHODS

3.1 Second order of change

In REA's multiple case studies observing the use of a project website in regional units, due to the use, some units individually changed their paper based postal mail processes. Although this was considered by management as the start of a re-design of communication flows, this change in workflow

only started during the implementation in a pragmatic, linear way. The existing paper mail process was also not removed or blocked. By leaving this old manual process open for use it was ambiguous for teams and members, who operated in various teams, to change trusted work habits. In fact the change process was not considered to influence existing work methods but only as a linear order of change in use of packages on the work floor level. Levy (1986) claims that a second-order change in an organization, such as a change from normal routines and habits to the effective use of new routines and tools, needs both planning and management of change. Such change concerns new insights of the participants in working methods and processes of communication. It changes existing paradigms and creates new visions to work to be done and which balance in use of IT communication tools is most effective for that (Emmitt et al. 2007). A bottom up approach in management approach is needed involving users in the change process and to attract users to collective use (figure 3). With respect to the management of the change process, Lewin (1951) states that change agents are needed to 'unfreeze' the organization. Similarly, Tichy (1986) argues that the organization needs to awake by mobilizing driving forces of change, promoting the benefits of change, trainings to get the required user skills and the benefits in daily work (Kanter, 1992), removing restraining forces to change and making the change operational in the organization. After execution of the change, 'refreezing' the organization is necessary to establish the new routines as part of the organizational routines. It is also important to choose which tactics to use for change management: fast or slow change, changing a part of the organization or the organization in total, and focusing on change by individuals or by groups.

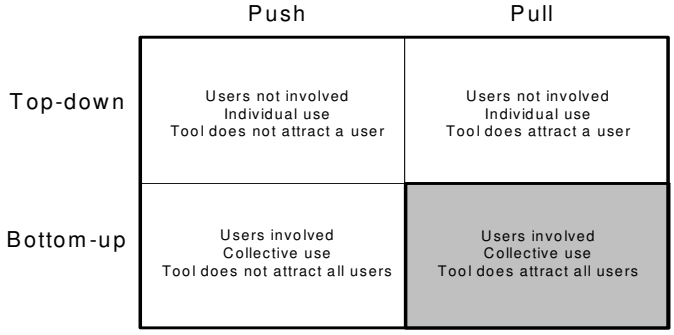

Figure 3: Management approaches and push-pull settings

3.2 Re-design of communication flows

Concerning the re-design and reengineering of an organization, Hammer (1993; 1998) argues that re-designing means much more reshaping of processes by differently organizing the work to be done. In planning second-order change, the radical re-design of existing information processes to effectively and efficiently use new tools should be a part of it. Re-designing should concern both the re-design of manual processes concerning tasks and responsibilities considering radical change, and re-design of communication flows. The move towards integral design as suggested by REA's central management, was supposed to be a first order change. However, observations indicate that a second order management of change might be more effective, because such a change in daily work for various participants is difficult to start as a linear, spontaneously change and non-adopters and laggards mainly communicated verbally and on paper. The management of one unit did not even consider the project website to be a part of an integral design concept. By defining and implementing the new processes as part of second order planned change and by indicating how and for which purposes to use these efficiently, designers (specifically architects and structural engineers) may easier discover the advantages of collective projectweb use in their daily work. This may also help avoiding the development of incongruent technological frames in teams and on unit level.

3.3 Change of existing working methods

Changing existing working methods in design teams is usually difficult because of the interdisciplinary character of such teams, habits and preferences in individual work or conflicts in organizational information systems. For instance: implementing new electronic procedures for communicating changes or remarks on an inter-organizational need all participants to join. Differences in packages or procedures in the participating organizations might easily block such change. Mini cases performed to observe project website use in other sectors (Otter, 2005) show that some firms in the international operating offshore industry have been able to structure such sharing and exchange in multidisciplinary teams on inter-organizational level by abandoning paper postal mail and fully changed to electronic document exchange via internet facilities and product databases. Special software tools register all incoming documents, label these for search actions in the product database and add additional information if needed for asynchronous team communication in the

interactive or effective communication mode (Figure 2). This stimulated team communication and affected performance substantially. These organizations are able to check easily on extra work that has been done due to change in requirements that might influence the budget limits. Regarding the lifecycle of the finished products: offshore platforms delivered all over the world, these firms are able to re-built or deliver maintenance very quick and easily based on the available data in the product database. By reflecting on the actual information process and the electronic recorded design process history (Wiegeraad, 1999) processes and products can be optimized. Also the airplane building industry show that by using full 3D-models in CATIA software and BIM from the start of the design, design teams working on distance in various countries and continents are able to contribute to the design in progress that affected team performance substantially (Boeing, 1995). By using IT tools effectively and collectively, these organizations are able to optimize their product development processes on organizational and inter-organizational level for designing and engineering better and optimized products for the market.

4. CONCLUSIONS

By attempting to identify possible causes of differential adoption of IT tools and in particular project websites, we have discussed relevant concepts that may be useful for theoretically interpreting the observed differences. The comparisons between the observed real estate agency's units in terms of differential project web adoption suggest that a bottom-up management approach actively involving users in the change better stimulate collective adoption of the IT tool.

The observed rivalry between IT-tools, specifically between projectweb-use and use of parts of network disks proves to be an important cause for the non-collective adoption of the tool in daily work.

In particular, based on the results we suggest that IT tools for collective use should be implemented using a second order management of change process instead of a linear first order change. Ideally management style should show the key aspects using change agents and promotors of change, stimulating a higher level of interaction involving the ultimate users in an early phase of change.

Clear goals, tasks and responsibilities need to be defined for change promotors, involving team members and more specifically architects and structural engineers. In addition, where possible, change should be managed from a pull as opposed to a push setting. Rivalry of tools combined with insufficient user insight into the use of the tool in their daily work and

insufficient changes in workflow leave opportunities open for the development of incongruent technological frames between individuals and groups.

It can be concluded, therefore, that the productivity paradox comes about because of insufficient awareness on the various management levels (team, organizational and inter-organizational level) about organizing the change as a second order change process, managing the process of change on all levels. A bottom-up approach seems to be more effective because of the change in mind sets needed from the participants.

Moreover, re-design options to optimize IT use collectively for integral design, avoiding inefficiency and showing benefits in daily work need to be explored sufficiently, not leaving open ambiguous choices to team members. Also, change agents need the right level of functioning to be successful and need the necessary authority to correct discrepancies, showing pro-active behavior and promoting the benefits of change to all members.

These factors may be seen as being the most important ones as indicated in the described research projects. The building and construction industry might reflect better to the advanced communication and information processes showed in the offshore and airplane building industry to improve team communication using asynchronous IT tools collectively in interactive or effective mode (Figure 2). However, such integral and collective use of IT might be limited in the design and engineering processes of special buildings, although the design and engineering of buildings with a higher level of assembling prefabricated parts should be able to profit better from the features IT tools offered for enhancing information processes and team communication affecting team performance.

5. RECOMMENDATIONS FOR FURTHER RESEARCH

The empirical research to user adoption, implementation processes, change processes for communication and workflow show that although the advances of IT tools might be highly promising for improvements the effects still are very limited in the building and construction world. Further empirical research to understand and explain the limits for implementing electronic tools in design processes and on the other hand investigation to innovative processes and the effects of electronic, paperless design processes to the design

is necessary to improve performance and delivering better products to clients and users.

Regarding the rivalry between IT technologies as reported, main software developers like Microsoft should better investigate how linkage between operating systems, project websites, email facilities can be optimized and automated with better user friendly interfaces.

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