

KNOWLEDGE SHARING AND MANAGEMENT IN ARCHITECTURAL DESIGN TEAMS USING A PROJECT WEBSITE

Ad den Otter ¹

ABSTRACT

In this paper the sharing of knowledge in architectural design teams using a Project Website is discussed. The results of multiple case studies, being part of a recently finished PhD research project to communication and performance of design teams using a Project Website, show that systems for sharing of knowledge in such teams are hard to change and better systems are difficult to implement for various reasons. Sharing of knowledge in such teams is important for collective understanding of a design during its development, to derive insight and overview on progress of design and to prevent misunderstanding and failures. Knowledge about a design is usually, implicitly stored in the participating designers heads, and explicitly as paper and (nowadays) electronic information on drawings, images, and documents. To improve knowledge sharing collectively during the design process, team communication and collaboration is essential. The best well known means for collective communication are face-to-face meetings and dialogues because of their possibilities for interaction and reaching consensus.

The use of a Project Website as a new means for collective communication and information sharing is advocated by its Vendors for greatly increasing collective communication and stimulating the sharing of design knowledge. The expectations of vendors are directly related to the characteristics of the means being an information vault that contains all the latest designs produced with the registration of owners and updaters and preventing failures by double and outdated information. The information exchange flows and the frequency of the use of means and tools in these teams were observed before, during and after the introduction of the Project Website. The outcomes of the multiple case studies show that full adoption of the Project Web did not happen and team members still used old, trusted systems despite various management interventions to stimulate use of the Project Web. Architects and structural designers showed to be slowest in adoption or did not adopt the new means, easily developing incongruent technological frames for use.

Basically it was concluded that the most stimulating management intervention during the adoption of the Project Website, were collective workshops, organized per team in which knowledge sharing could be optimized to show the benefits of the new means to the participants in daily work. The workshops resulted in substantial increase of adoption of the Project Website but not full adoption. Finally the development of incongruent technological frames in groups and levels in the organization and rivalry of tools will be discussed because of their importance for adoption of a new means for sharing knowledge by such groups with a high number of creative, visionary, abstract thinking, practitioners.

KEY WORDS

Knowledge sharing, knowledge management, integral design, technological frames, planning of change, team workshops.

¹ Dr.ir, Assistant Professor in Architectural Design Management, Technische Universiteit Eindhoven, dep. Architecture, Building and Planning, professional doctorate program Architectural Design Management Systems, The Netherlands, Phone: +31 40 2472367, a.f.h.j.d.otter@tue.nl

INTRODUCTION

Sharing of knowledge in design teams is important for collective understanding of the design during its development and to derive insight and overview on design progress, and to prevent misunderstanding and failures. Knowledge about a design is usually, implicitly stored in the participating designers heads, and explicitly stored on paper in drawings, images, and documents. Team communication is essential for collectively improving knowledge sharing during the design process (Emmitt, 2007). The best well known means for collective communication are face-to-face meetings and dialogues because of their possibilities for interaction and reaching consensus. Nowadays, most explicitly stored object design knowledge on paper is stored electronically at various places, mostly not centrally and exchanged by using various IT means. Sharing of knowledge in architectural design teams might be stimulated by using a Project website for team communication because of specific features this new means offer for collective overview on the most actual stored and updated knowledge about the design. However, the results of a recently finished Dutch PHD research project to communication and performance by design and engineering teams using a Project Website show that systems for sharing of knowledge for designing are hard to change and better systems are difficult to implement for various reasons.

The use of a Project Website as a new means for team communication and knowledge sharing is advocated by its Vendors for greatly increasing collective communication and information assimilation because Project Websites, in use by teams, are vaults that should contain the latest knowledge about the design in development. The expectations of vendors are directly related to the characteristics of the means being a vault that contains the actual knowledge of a design in development with the registration of owners and updaters. If the means is used as a central vault for all design knowledge produced it is a great tool for preventing failures caused by the storage of double and outdated information. Because of these attributes a Project website should be stimulating for collective knowledge sharing by members of a design team. Because of these expectations a PhD research project to the use of a Project website affecting team communication and performance was designed and executed in the period 2001-2004. The information exchange flows and the frequency of the use of means and tools in design and engineering teams were observed before, during and after the introduction of the Project Website.

RESEARCH METHODOLOGY

A multiple case study approach (Yin, 1994; Campbell, 1971) was used to monitor changes in communication and performance within design teams using a Project Website. The case studies were executed in a large real estate agency, consisting of a central unit and three regional operating units that used to deal with a number of building and construction projects. In each region a design team using the Projectweb and a team that did not use it were identified, giving six teams. Permission to research their activities in the workplace was sought and granted. Those that did not use the project web functioned as a control team to observe changes in team communication and performance in the other team caused by the use of the project web. Each design team consisted of eight people, including the project leader, and comprised a multi-professional group including architects, engineers and managers. In each region more than five of such teams operate concurrent on different projects. Measurement of design team communication was achieved by investigating the frequency of use of all available means for communication and comparison of results between the pairs of teams. Communication media comprised: face-to-face communication through formal team meetings, design dialogues, discussion sessions, informal meetings, telephone, facsimile, postal mail, email, outlook agenda, computer network and a Project Website.

Data were collected from participants about a) how they handle design communication individually and collectively; b) how they think about the effectiveness of the use of the various communication tools and experience this in practice and their preference for use of specific means; c) The actual use of the available means by the users. These data were gathered through: a1) structured interviews at three junctures; before, during and after the introduction of the project website; a2) self-completed check lists of participants about their use of communication means in daily work; b) monitoring team meetings and workshops; c1) analyzing the history log data (Wiegeraad, 1999) of Project website use by team members and, c2) by analyzing the filing of project paper documents. Changes in team communication and team performance were compared at the same points as the interviews, with the exception of the use of the Projectweb, which was monitored continuously from the start until adoption effects (Rogers, 2003) disappeared. By means of triangulation of the data of different sources, research findings were derived and explanations of effects on team communication and performance were developed.

RESEARCH FINDINGS

At the outset of the research it was assumed that collective use of a Project Website might enhance interaction between team members because of the better overview, status and information about changes and updaters of design information. However, the findings showed that the project website was not used as prescribed by management and users experienced fewer benefits than they expected. Only minor changes in team communication and performance were found after the implementation of the Project Website. The new means for team communication was not fully adopted, as a maximum five out of eight team members were observed, which is insufficient for effective team communication. The computer network file management package was used primarily for design information storage and the Website was mainly used as an electronic information archive. Thus less current information was stored in the Project Website compared to the computer networks and storage was dependant on the occasional copying activities of the team members instead of a routine activity in daily work.

TEAM WORKSHOPS

Team workshops appeared to be the most successful management intervention for implementing the Project Website. These were initiated by the central unit of the real estate agency and organized in each regional unit approximately six months after the introduction of the means. The main target for these workshops was to stimulate adoption of the Project web, to get team members more involved in the change in daily work due to the use, and to solve the continuous flow of reported use-problems.

Each workshop was managed and led by the Project web coordinator in the regional unit. In these workshops took part; all members of the team that was most positive about using the Project Web, the unit's systems manager, the application controller of the Project Website for all regions and the unit's CEO and representatives of central unit's management. Unit management selected the team of which members were most positive to take part in the workshop to have the highest possible chance on adoption. During the months before, introduction sessions for Project web use, held by the regional Project web coordinator, showed to be unsuccessful for adoption of the means by team members. Only a few team members started to use the means instead of all team members. Each workshop started with an introduction by a representative of central unit's management who explained why the Project web was chosen for implementation in the organization, their expectations on improvement of team communication and its benefits for integral design in the future.

Each team member, the project leader included, had to execute essential Project Website tasks through using computers that were installed for the whole team. Different pre-planned tasks, identical in each workshop, were executed serial by pair of team members. Tasks for exchange and sharing files about a design in terms of actual drawings, excel sheets, word-documents. For instance the exchange of drawings between the architect and the structural designer for discussing the framework material and location of columns, exchange of spreadsheets between the quantity surveyor and the architect and so on. To be able to observe the results of these tasks in the Project Web and to get overview on the information handling, the team members that did not execute a task, watched the results on the webmasters screen that was projected by beamer on a large screen. By using this method a good overview on the executed tasks was provided. Each exchange and sharing task was executed by the specific members present and then discussed by the team in terms of effectiveness and efficiency and which difficulties appeared or might appear in daily work.

During these workshops, for the first time, unit and team management and team members had the opportunity to exchange and share knowledge and experiences about the benefits and problems of the new means in daily work. Specifically was discussed how other channels of electronic and paper communication could be blocked because of conflicting with the proper use of the Project Website. This was of great importance because the unit's CEO was present, who had the power to order such decisions and how management could control and check this in the organization.

The workshops had also to demonstrate to team members that the Project web could be used for all tasks without any problems. We did, however, observe differences in these workshops between unit management and workshop management concerning communication and Project website-commitment. The outcomes of analyzes of the history log of the Project Web showed that as a result of the workshops the number of team members that started using the Project web use raised within one month time from 2 to 7 in region A, from 2 to 4 in region B and from 1 to 6 in region C (Otter, 2005). Afterwards the number of users decreased because of the holiday period. Unfortunately, the number of users did not increase again after the summer period. Finally the highest number of members in a design team that was identified in the three regions as adopters and daily users was 5 out of 8 members. This number is insufficient for team communication. However, finally it can be concluded that the team workshops had a very positive effect on collective adoption of the new means although this was temporary and did not result in full adoption by a team.

As a result of discussions in the team workshop and to increase the attractiveness for team members to use the Project web, in all units, the systems managers stored a high number of documents of old, realized projects. Although this might enhance the attractiveness of team members in the regional units the attraction is focused to re-use of design knowledge instead of sharing actual knowledge during a design process. In one unit, some months after the team workshop, user meetings were organized by management to stimulate adoption and to discuss and eliminate problems that prevent adoption of Project web use in daily work. According the reports of these meetings, most discussions concerned the re-use of information as a benefit of the new means instead of the benefits in daily work and the sharing of knowledge during work.

So, although it might be concluded finally that the team workshop was very stimulating for adoption of the Project Web in design teams its effect was temporary and did not result in full adoption by all team members. According the results of triangulation of the research data this was mainly due to the ambiguity with other information exchange processes that still existed and were used and because of rivalry between the use of the computer network file management package and the Project web.

Thus, finally, in all units the network file system was the dominant means for the daily storing and updating of documents of the design instead of the Project Website. The proposed change in team communication and knowledge sharing using the Project Web stimulating integral design did not happen. The Website was mainly used as an electronic information archive for re-use of design knowledge in new projects.

TECHNOLOGICAL FRAMES

Project Website use needs the collective adoption by a team to become effective for team communication. Collective adoption needs shared values and understanding about the use of the means by all members of a group. In the real estate agency's regional units, during the adoption of the Project Web conflicts were observed in the technological frames of users being team members and team managers, the unit management and IT facilitating group in the regional units, for use and the purpose for use of the available IT tools including the Project Web and also with respect to the goals underlying collective use in daily work.

Orlikowski (1994; 2000) states, based on empirical research to the use of groupware collectively by teams in organisations, "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". Orlikowski uses the term technological frame to identify the assumptions, expectations and knowledge that team members use to understand new technology. This includes not only the nature and role of new technology itself, but also the specific conditions, applications and consequences of that technology in particular contexts. To analyze and discuss whether such technological frames between groups in an organization are incongruent, she distinguished three aspects: nature of technology, technology strategy and technology in use.

Nature of technology refers to members' images of the technology and their understanding of its capabilities and functionality. Triangulation of the structured interviews, meeting observations, meeting reports and member checks indicate that in the real estate agency the dominant image of design team members and unit management of the Project Web was that of an advanced tool for re-use of electronically stored information. This in contrast to the real estate agency's technologists (the Project web-application manager and regional Project web-coordinators) who expressed in their meeting reports much more the image of an electronic communication tool for sharing documents by using effectively the Project Website advanced database capabilities (Sutton, 1996). The main image of the real estate agency's central management was that of an instrument, beneficial for integral design in the longer run. They explicitly promoted the Project web at the start of the team workshops as a tool for team communication and sharing of design knowledge 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. The real estate agency'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 Project web 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 technology. Technology in use refers to user's understanding of how the Projectweb technology should be used on a daily basis and the actual conditions and consequences associated with such use.

Findings in the 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 Project web as shown by the non-adopters and laggards in units A and B (mainly architects and structural engineers) who continuously argued that the Project web was not beneficial to their daily work. Team members in all units indicated during the implementation of the Project Web that this means and the computer network filing system for the shared project disk were highly comparable, a view which was enhanced by the look-alike interface. The same view was expressed by some of the project leaders in all units in the interviews.

Thus, the data reveal the existence of incongruent technological frames within and between units, and the occurrence of rivalry between the Project Web and the computer network filing system that may contribute to the explanation of the productivity paradox as Brynjolfsson defined (1993, 1998). Specifically in two units, the frequent discussions between team members and project leaders about the ambiguous use of IT-tools without a clear goal support this conclusion.

DISCUSSION

The results of the multiple case studies in the real estate agency's regional units show that the team workshops were the most stimulating management intervention for adoption of the Project web by teams although it did not result in total team adoption of the new means. Specifically architects and framework designers were identified as laggards and non-adopters. Important reasons that full adoption did not happen were the development of incongruent technological frames and rivalry of tools (Otter, 2005) as explained, however these items might be part of more important aspect concerning the meaning and full understanding of the change to the use of a new system in daily work. Although the ideas for integral design were presented at the team workshops no working concept and no consequences and changes for the design process were outlined or discussed.

The results of the workshops show that a bottom up management approach was more successful compared to the top-down approach that was used before. This approach is especially important because design teams usually consist of a high number of creative, visionary, abstract thinking, practitioners as Schön states (1987). Reymen (2001) put forward the importance of structural reflection by such groups for changes in the design process. Burns (1961) concluded, based on detailed empirical research, that for changing conditions in organizations an organic management system is more appropriate instead of a mechanistic system. Mintzberg (1983) and Robbins (2001) also argued that in this type of organizations, in which small groups are doing their work for market oriented projects, management should support and facilitate these groups of high educated experts in achieving a higher task performance instead of prescribing tasks.

By using a bottom-up approach, management is able to involve team members and groups actively in the change process and could become more committed to the use of the new means as shown in the best performing regional unit. Although the results show that this type of management intervention was still insufficient to achieve full Project Web adoption in design teams, the bottom-up approach seems to be the best intervention strategy as suggested by Figure 1. Involving team members collectively in the change process and making them aware that the tool's features are beneficial in daily work stops high professionals from feeling forced to use a specific technology. Rather, regularly promoting tool features that are beneficial in their daily work may constitute a pull factor and make them wish to adopt and use the new tool.

| | Push | Pull |
|-----------|--|--|
| Top-down | Users not involved Individual use Tool does not attract a user | Users not involved Individual use Tool does attract a user |
| Bottom-up | Users involved Collective use Tool does not attract all users | Users involved Collective use Tool does attract all users |

Figure 1: Management approaches and push-pull settings

This is especially important in design teams configured for integral design in which the tuning and synchronization of knowledge and information flows is essential to prevent mistakes and misunderstanding and failures.

Regarding the issues discussed, the process of change using a new system for knowledge sharing in design teams might be better regarded as a so called second-order change (Levy, 1986). Levy argues that discrimination in planning of change between so-called first-order and second-order changes is important to identify the nature of the change. First-order changes concern changes that do not change the system's core. "First-order changes are linear and continuous. It implies no fundamental shifts in the assumptions that organizational members hold about the world or how the organization can improve it's functioning". Second-order change in contrast, is a multidimensional, multilevel, discontinuous, radical change involving reframing of assumptions about the organization and the world in which it operates (Robbins, 2001). For these reasons it might be suggested that the collective change to Project website-use by the real estate agency's design teams should be identified as a second-order change. The use of the new technology imply more radical and dramatic changes in information handling processes and working habits of users, who have to choose together to use the Project Web for knowledge sharing and who need to stop or change the use of other IT tools for that purpose.

CONCLUSIONS

Thus, it can be concluded that in the multiple case studies in the real estate agency's regional units, the Productivity Paradox is observed because of insufficient awareness at unit and central management level of managing the process of change as a second order instead of a first-order change. Other reasons that can be detected concern, not using a bottom-up approach for management interventions and insufficient introduction of the tool and training for Project Web-use. Moreover, re-design options (Hammer, 1993) to optimize Project website-use for integral design, avoiding inefficiency and rivalry of tools, were not sufficiently explored.

Basically it was concluded that the most stimulating intervention during the adoption of the Project Website, were collective workshops, organized per team in which knowledge exchange and sharing could be optimized to show the benefits of the new means to the participants in daily work.

RECOMMENDATIONS FOR FURTHER RESEARCH

Further research to the ultimate adoption of Project Websites by full architectural design teams is needed to prove the assumptions and hypotheses especially concerning the change in knowledge sharing in such teams and the planning as a 2nd order change.

In any case, the ultimate adoption and impact of new technology depends on the extent to which it is perceived as beneficial to design team members in integral design processes on a daily basis. In that sense it may be a more fundamental limit to the impact in professional architectural design teams.

REFERENCES

- Brynjolfsson, E. (1993) The Productivity Paradox of Information Technology: Review and Assessment, *Communications of the ACM*, 36:66-78.
- Brynjolfsson, E. & Hitt, L.M. (1998) Beyond the Productivity Paradox, Computers are the Catalyst for Bigger Changes, *Communications of the ACM*, 41:49-56.
- Burns, T. & Stalker, G.M. (1961) *The Management of Innovation*, Tavistock Publications, London.
- Campbell, D.T. & Stanley, J.C. (1971) *Experimental and Quasi-Experimental Designs for Research*, Rand McNally, Chicago.
- Emmitt, S. and Gorse, C.A. (2007) *Communication in Construction Teams*, Spon Research, Taylor & Francis, Oxford.
- Hammer, M. & Champy, J. (1993) *Reengineering the Corporation*, Nicolas Brealey, London.
- Kanter, R.M. (1983) *The Change Masters*, Simon & Schuster, New York.
- Kanter, R.M. (1992) *The Challenge of Organizational Change*, The Free Press, New York.
- Mintzberg, H. (1993) *Structure in five, designing effective organizations*, Prentice Hall, Englewood Cliffs.
- Orlikowski, W.J. & Gash, D.C. (1994) Technological Frames: Making Sense of Information Technology in Organizations, *ACM Transactions on Information Systems*, 2:174-207.
- Orlikowski, W.J. (2000) Using Technology and Constituting Structures: A Practice Lens for Studying Technology in Organizations, *Organization Science*, 11, 4: 404-428
- Otter, A.F.H.J. (2005) *Design Team Communication Using a Project Website*, PhD thesis, Bouwstenen 98, Technische Universiteit Eindhoven.
- Reymen, I. (2001) *Improving Design Processes by Structured Reflections*, PhD-thesis, TU/e-SAI, Eindhoven.
- Robbins, S.P. (2001). *Organizational Behavior*, Prentice Hall Inc, New Jersey.
- Rogers, E.M. (2003) *The Diffusion of Innovations (Fifth edition)*, The Free Press, New York.
- Schön, D. (1987) *The Reflective Practitioner*, Basic Books, New York.
- Sutton, M.J.D. (1996) *Document Management for the Enterprise*, Wiley & Sons, Chichester.
- Wiegeraad, S. (1999) *Development of a Design History System*, PhD thesis, Stan Ackermans Institute, University Press, Technische Universiteit Eindhoven.
- Yin, R.K. (1994) *Case Study Research, Design and Methods*, Sage Publications, London.