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CBE
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TEAM SPACES AND COLLABORATION: LINKS TO THE PHYSICAL ENVIRONMENT

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Team workspace is a specific example of an alternative office design strategy to support the activities of highly interactive, multi-disciplinary teams of knowledge workers. The design normally provides individual workspaces for private, concentrated work combined with nearby shared open spaces that support group work. The move toward this combination of group and individual spaces is motivated by new work models that emphasize self-directed team based work processes and projects.

1. PROJECT SCOPE

This research project studied the impact of team workplace design on worker satisfaction and group collaboration. The two primary tasks were:
1) a review of existing research, theory and design strategies related to recent organizational and technological changes in the commercial office; and
2) a field study evaluating the impact of team workspace design on worker satisfaction and group collaboration in five California office buildings.

In June 1999, we administered a web-based survey to employees of Sun Microsystems in five of their California buildings. Sun Microsystems has been incorporating team workspaces of various designs in many of their office buildings. Their goal has been to increase collaboration by encouraging more frequent, spontaneous, and informal interactions among their workers. Their buildings provided an excellent test site for us to test new survey methods, and to explore the nature of workers' interactions and the extent to which the team spaces supported group activities. This field study investigated:

- Nature of work (creative, analytical, decision making, coordination, administrative, etc)
- Frequency of use and satisfaction with different kinds of interactions
- Satisfaction with design features of the team spaces (layout, furniture, writing surface, equipment)
- Satisfaction with and importance of visual and acoustical privacy in the team spaces and private offices
- Ability to concentrate in team spaces and private offices.

2. KEY FINDINGS

The literature review revealed that there is a significant lack of systematic research and data on team spaces that goes beyond anecdotal information. We also found a lack of connection between the different specialists interested in this field, in terms of research methods and shared knowledge. There is a need for more earnest integration between researchers and professionals in the fields of building science, social science, organizational behavior, workplace design, and facility management. By using a survey to collect data about team spaces, and collaborating with environmental psychologist Dr. Judith Heerwagen, this CBE research project attempted to fill these gaps.

The primary findings from our field study include the following:
1. Work was primarily solitary rather than group oriented.
2. The vast majority of interactions were indirect (phone, e-mail, etc.) or impromptu, rather than group meetings.
3. The team spaces were not used as frequently as other types of interactions; in fact, they were used less often than enclosed, reservable conference rooms.
4. There were problems with acoustical distractions, for both the team spaces and private offices.
5. Ratings of satisfaction with the features of team space suggested a lack of "fit" with functional needs, especially with regard to equipment and acoustics.

Review of the literature on knowledge work, types of teams and collaborative processes suggests that Sun's team space design does not adequately fit the nature of work there, nor do these space support the kinds of collaborative processes that are most likely to yield high value outcomes to organizations. The spaces, as designed, are more likely to support casual interactions than group-based collaborative work processes. Collaborative interactions require much greater environmental support (especially tools and equipment, as well as the ability to take over the space for a long duration) than is provided through the existing team spaces.

Future research should focus on the development of tools to assess group work *outcomes*, rather than just satisfaction and frequency of use of spaces. Methods for linking outcomes to the features and attributes of space also need to be more fully developed. Current research on teams is beginning to develop outcome metrics that could be usefully coupled with analysis of spatial attributes. While initial work in this area would focus on evaluative research, the ultimate goal would be to develop a software tool that could be used in design to link strategic organizational needs with team processes and spatial supports.

3. BACKGROUND: NEW WAYS OF WORKING

The l980's represented a period of intense soul-searching in corporate America. There was a sense, felt by many and given voice by Peters and Waterman (1982) that the American corporation needed to radically reinvent itself if it were to be competitive in the world market. American companies were considered bloated, hierarchical, inefficient, rigid, and uncreative. Hammer and Champy's best selling *Reengineering the Corporation* (1993) proposed a new model for how organizations should buy, make, sell, and deliver products and services. The new model was built on rethinking work processes, getting closer to the customer, giving more decision latitude to workers, performing work where it makes most sense, and moving from a hierarchical to a flat organizational structure that increased information flow throughout the organization and decreased top-down decision-making and management.

Cross-functional, integrated teams were touted as the vehicle for delivering the new work model. Teams with decision-making authority, it was argued, would speed the product development cycle by reducing the barriers associated with traditional departmental structures and their rigid layers of authority. The interest in teams coincided with the rise of information technologies that made it easier for individuals and teams to access databases, conduct market intelligence, interact with customers, track projects and exploit the Internet (Stewart, 1999; Cohen and Mankin, 1998). Collaborative groupware tools also made it possible for dispersed teams to work jointly on projects. Information technologies were seen as a vehicle for further flattening the organizational hierarchy by making information and knowledge widely available to everyone.

Teams are so pervasive now that it is difficult to imagine corporate life without them. According to Gordon (1982), 82% of companies with one hundred or more employees used teams, and 68% of Fortune 1000 companies used self managed teams in 1993 (Lawler et al, 1995). The numbers are likely to be higher now. New technologies and the economic growth in the 1990's have resulted in competition so intense that firms can never be assured of a market advantage for very long because their competitors soon match any advantage they produce (Galbraith and Lawler, 1998). Thus, the quest for continual collaboration, communication, evaluation, and creativity in organizations to assure the "circle of innovation" (Peters, 1999).

Innovation is a complex, dialectical process (Dougherty, 1996). It requires working around conceptual and organizational barriers, combining insights in new ways, and resolving conflicts of opposing mental models and ways of thinking. It is a messy, noisy, intense process. Teams engaged in collaborative, innovative work have frequent interactions in multiple channels (face-to-face, phone, electronic). Ideally, they come together to test ideas, to generate new ideas, to solve small problems before they become big, and to track project progress and milestones. True teamwork is not just about more frequent group engagement, but ideally produces a higher quality and more creative outcome.

4. THE CONTEXT FOR INNOVATION: ARCHITECTUAL RESPONSES TO NEW ORGANIZATIONAL MODELS

Over the past several years, the architectural and facilities management fields have responded gleefully to the new idealized organizational model by coming up with new idealized workplace models and design processes (see Sims et al, 1998; Becker and Steele, 1994; Duffy, 1997; Torgen et al, 1998). The new workspace models were given a boost by management consultant, Tom Peters, in *Liberation Management* (1992). Peters writes:

> Space management may well be the most ignored – and most powerful – tool for inducing culture change, speeding up innovation projects, and enhancing the learning process in far-flung organizations. While we fret ceaselessly about facilities issues such as office square footage allotted to various ranks, we all but ignore the key strategic issue – the parameters of intermingling. (p. 413)

Peters' comments are important because they represent one of the few instances in which organizational and management theorists have explicitly recognized the importance of the physical environment to business strategy. Peters' chapter on the physical environment cites numerous anecdotes about the innovation potential of increased interaction. He contends that space is a highly effective way to develop dense, local, learning networks that facilitate innovation.

The vast majority of research and theory on organizational change and management totally ignores the physical context of work (Heerwagen, Beach and Mitchell, 1985). The office environment has

been seen as a place to house the workers as efficiently as possible, with office size and location determined by the organizational hierarchy rather than work processes (Sundstrom, 1986). Hammer and Champy's (1993) call for an end to hierarchical decision-making suggested to many in the architectural field that hierarchical spatial arrangements also needed to be derailed. New work models needed a new workplace, one that was better linked to the nature of work and business strategy (Torgen et al, 1998; Sims et al, 1998; Becker and Steele, 1994).

These new, "strategic" office designs are organized around several key ideas:

- *Innovation thrives on communications and interactions of all sorts*. The key idea is that collaboration and innovation is enhanced when there are a greater variety of physical spaces that enable spontaneous interactions as well as formal planned meetings. Communications occurs everywhere, all the time.

- *Teams need "team spaces."* Because team members need to meet frequently, and often in unplanned sessions, facilities should devote more space to group work areas and group tools and should have team members co-located to enhance ease of meeting.

- *Work occurs anywhere/anytime*. Portable work tools (laptop computers, cell phones, beepers, etc) make it possible for people to work in multiple locations, freeing them up from reliance on one personal space.

- *Flexibility is king*. Teams, work processes, and work focus are constantly shifting in organizations. Thus, the environment needs to be more flexible, enabling rapid reconfiguration in accordance with organizational, customer, and group needs.

These principles have been implemented in numerous organizations in the US and elsewhere (see Sims et al, 1998; Duffy, 1997). Specific office features that respond to these ideas include:

- Increased opportunities for spontaneous encounters ("casual collisions") through the use of internal "streets" and "neighborhoods" with cafes and coffee bars.
- Increased space devoted to teamwork, with decreases in private office space.
- Informal meeting areas with comfortable furniture scattered throughout the facility to support informal meetings.
- Reduced visual barriers so that people are more likely to see one another and talk.
- Portability of furniture to support changes in group composition and size.
- Reduced storage space associated with the increased reliance on electronic means of storing and accessing information.
- Decreased reliance on the personal workspace as people move more during the course of the day to different areas for different activities.
- "Displayed thinking" spaces to make ideas visible to all. (Displayed thinking spaces include white boards and other mechanisms for keeping ideas and concepts visible to passersby.)

Many of the components of the new office models are derived from environment-behavior research that occurred much earlier. Of particular interest is the research of Tom Allen of MIT's Sloan School of Management (Allen, 1970; 1977; Allen and Gerstenberger, 1973). In the 1970's Allen was investigating how communications occurred in organizations and how it influenced innovation. The key insights from his work have had far-reaching effects on new office design even today. He found that innovation occurred primarily as a result of information flow inside the organization, rather than from information coming to the organization from external sources. He also found that unplanned interactions were a critical component of innovation, and that people

tended not to travel more than 90 feet to talk to someone spontaneously. They traveled farther for planned meetings. He also found that providing R&D engineers with increased ability to see one another as they moved through a building also enhanced spontaneous work, particularly when they were provided with work tools such as writing surfaces in many locations. And finally, his research on the non-territorial office showed that people used space differently for different kinds of work, and that the one size fits all approach to office design may not be as productive as people believed.

In addition to Allen's work, other researchers and designers were proposing new ways to support work, such as "activity settings," jointly shared spaces for team work and private nooks for focused work. (Stone and Lucetti, 1985) The Stone and Lucetti article is particularly interesting because its publication venue, *The Harvard Business Review,* made these ideas widely available to business decision makers.

The new office designs also draw on research from the 70's and early 80's on the ecology of work (Sommer, 1983; Whyte, 1980; Altman, 1975). These researchers found that interactions often take place at "natural" gathering places (such as mailboxes, copy machines, intersections and entrances), in places with food, and in locations where one could pull away to the side for a conversation without having to sit down.

5. PROBLEMS ON THE HORIZON: LIMITATIONS OF THE "NEW OFFICE"

Despite the intuitive appeal of these new office models, they produce a picture of work that is somewhat at odds with emerging research. For instance, the emphasis on team spaces, with a concomitant de-emphasis on private offices, is based on the assumption that significant amounts of time are spent in face-to-face interactions. Brill and Weidemann (1999) present a very different picture. Results of their surveys of more than 11,000 US employees show that people spend far more time in solitary work than in groups. This is as true for managers as it is for technical and professional staff.

Furthermore, there is increasing indication that "true teams" are not as common as might be expected. Analysis of teams by their actual work processes reveals important differences in structure as well as process (Katzenbach and Smith, 1999). True teams are characterized by having a common purpose, mutual dependence, team performance goals, and common work approaches. Team members spend a great deal of time together, building shared understandings and shared mental models, gathering information, analyzing results, and developing solutions. However, many organizational "teams" are really working groups whose members are much more likely to work as individuals and come together in planned meetings for specific purposes, with interactions driven by agenda (Katzenbach and Smith, 1999; Wilkins, 1998). The differences between the deep structure of teams have important implications for spatial design, including co-location of team members, support tools, information sharing space, amount of space devoted to solitary versus group activities, the nature of boundaries and enclosure, and degree of permanence versus flexibility of spatial configurations. For instance, in one study, a team based environment with layouts that permitted people to see others' work had product cycle times 4.4 times faster than those with traditional layouts (Majchrzak and Wang, 1996).

Many new office solutions also derive from an overly optimistic perspective on people's willingness to change long-standing behaviors. One well-publicized example is the advertising firm, Chiat/Day, which implemented non-territorial workspaces in its New York and Los Angeles offices several years ago. According to a case study presented in

Sims et al (1998), the objectives of the Chiat/Day workspace redesign were to: reduce status distinctions, increase collaboration, build collective intelligence, improve quality of work, produce better/quicker products, raise the technology competence of employees, and give employees the freedom to work wherever they wanted. Employees were encouraged to store all information on their computers. If they had hard files, they needed to be returned to hall lockers each night and checked out again in the each morning. People moved files in portable holders and red wagons to a space where they wanted to work that day. There were team rooms, private spaces, club houses, and coffee nooks.

What were the results of this experiment? On the positive side, Sims et al (1998) identify: increases in communication, better coordination within groups, sense of team spirit, and increased access to employees at all levels in the organization.

However, there were also serious problems with the Chiat/Day workplace, identified in Brown and Duiguid (1999), that led to the demise of the experiment and a return to a more traditional office. These problems included:
- Employees did not want to move around as much as the organization wanted them to. In the New York office, "peer policing" prevented people from "nesting" – using the same place everyday.
- Because the spaces varied in their desirability, many employees arrived at work very early to stake out the best locations and thereby prevent others from using these desirable spaces.
- Employees, as well as managers, had difficulty locating one another because everyone was always in a different place. Thus, people spent a lot of time roaming around searching for colleagues.

Although the non-territorial nature of the Chiat/Day example represents an extreme case, many of the alternative office models do assume that human behavior is highly flexible, and that people will adjust to whatever conditions are provided. However, as noted by Brown and Duguid (1999, p. 72), there is a definite attachment to having a workspace you can call your own: "Desks are useful things and provide more than a surface to balance a laptop on. Moreover files, documents, and even those wobbly stacks people build on their desks often have a useful sequential order in their disorder (which is why tidying up can be so disruptive)"

In the quest for teamwork, flexibility, and communications, two other issues are largely ignored in many of the alternative office space designs: privacy and distractions.

As workspaces became smaller, more open, and more likely to be shared, numerous studies have found increased dissatisfaction with loss of privacy and increased distractions (Heerwagen et al, 1991; Klitzman and Stellman, 1989; Kupritz, 1998; Baron, 1994). Case studies presented in Sims et al (1998) also show that the "caves" and "commons" approach to teaming may work well for the interactive aspects of work, but it falls short for concentrated, individual work due to acoustic distractions experienced in the private work spaces (the "caves"). Noise distractions are not only annoying, they have been shown to decrease performance on a wide range of cognitive tasks (Baron, 1994; Kjellberg et al, 1996).

The impact of acoustic distractions may be strongly linked to physical layout. In a study using a geographical mapping process, Heerwagen (1993) found that response to acoustical conditions is localized: those nearest natural gathering points such as intersections, break areas, and main

circulation paths were most dissatisfied and those farthest away were the most satisfied. Kupritz (1998) reports similar results in a study of an engineering office.

Distractions from people are particularly problematic because they are difficult to resolve -- especially if one cannot close a door or if private offices are not appropriately sound proof. For instance, in a study of how workers cope with office discomforts and distractions, Heerwagen and Diamond (1992) found that people were very reluctant to ask their neighbors to be quiet or to tell people to move conversations to a new location. Their response to noise distractions was to try to ignore the problem and concentrate harder on their work – a behavioral response that was largely unsuccessful.

6. TEAM SPACE: CONFLICTING IDEAS AND MODELS

Research on team space is complicated by the fact that "team space" has multiple meanings – it refers to places for casual interactions as well as to dedicated "war rooms". The design goals for team spaces are often general, referring to the need for increased interactions and collaboration, as if these two processes were identical. However, increased interaction and communications do not necessarily result in increased collaboration (Schrage, 1998). Thus, it is important to distinguish between these and to be able to identify features and attributes of the environment that support impromptu interactions, casual meetings, and collaboration as distinct processes. To aid this distinction, we offer definitions of these three different processes and identify potential spatial implications of each.

Impromptu interactions are short duration face-to-face meetings that occur spontaneously when people meet in hallways or near a coffee pot. Participants are usually standing up or leaning against something. This enables any of the participants to easily break away and to talk without feeling that they need to commit themselves to a lengthy conversation. Whyte's work on small urban spaces provides numerous classic examples of this type of interaction (Whyte, 1980). Spaces that enhance impromptu interactions are likely to have the following cluster of features:
- They are centrally located, visual open, and have connections to many other spaces and to key organizational contact points (Hillier, 1996).
- They are located relative to the main corridors, which increases awareness of others and accessibility of the space.
- They are not located adjacent to private offices where people are doing concentrated work because the noise from conversations is likely to be distracting.
- They provide support for spontaneous ideation (Allen, 1973). For instance, white boards may be used to line hallways in certain areas that have high traffic and are likely to be casual meeting areas. Pull-away enlargements of the hallway would facilitate this without blocking movement by others.

Casual meetings, on the other hand, are likely to be longer and to involve sitting down – for instance, at a table near a coffee bar or in a break area. They may or may not be spontaneous meetings. Such interactions are likely to be more common if:
- The meeting areas are centrally located and at key intersections where people are likely to pass by (Hillier, 1996).
- They have a good balance of visual access so that people can see out and enclosure to support privacy and encourage conversation (Appleton, 1975).
- They have comfortable, movable tables and chairs that can be used by individuals or groups (Whyte, 1980).

Collaboration involves more intensive interactions and meetings that occur over a longer period of time and which primarily involve team members. Collaboration is not a single event; it is a gradual unfolding of shared understanding and shared work processes toward a common goal (Schrage, 1998). The literature on teams, group work processes, and distributed cognition suggests that successful collaboration spaces will have the following characteristics:

- Spaces can be "taken over" by the team for the duration of its life. The work spaces of high performance teams often display team information, goals, concepts, data, progress toward goals, stories, slogans, etc. (Katzenbach and Smith, 1999).
- The space supports "distributed cognition" and shared knowledge. The display items on vertical surfaces and other artifacts in the room are used to hold the team's shared memory. These displays help to shift attention from individual knowledge and work to the team's joint work and products (Norman, 1993; Pea, 1993; Schrage, 1995).
- Teams will have "convivial tools' available for their use. According to Schrage, such tools are crucial for true collaboration. They include sketches, diagrams, maps, white boards, models, loose parts, and other artifacts that can be used to develop shared understandings and shared mental models that are necessary for collaboration.
- Such areas also contain all the tools necessary for "documenting, analyzing, designing and building prototypes. This type of area make sit easier for people to analyze problems together, build prototypes, and discuss their individual and group inspired ideas" (Majchrzak and Wang, 1996).
- Nearby spaces provide high acoustical privacy and ability to control distractions when team need to work by themselves (Brill and Weidemann, 1999).
- If individual, concentrated work is not as important to the specific kinds of tasks, then having workstation layout that permits people to see one another's to share tasks easily and to provide assistance as soon as soon as problems arise (Majchrzak and Wang, 1996).
- Team members are co-located, providing opportunities for frequent face to face communication (Allen, 1973).
- The team space is separated from other areas to protect confidentiality of work, and to keep meeting noise from spreading into other spaces and distracting occupants. Alternatively, the individual team spaces could be acoustically treated to reduce noise transmission into the space.

7. LEARNING ABOUT TEAM SPACES: THE CBE FIELD STUDY

Despite their popularity in corporations, there has been very little systematic research on team spaces. Much of the available information is largely anecdotal and is derived from interviews and focus groups. For instance, the case studies in Sims et al (1998) present numerous design alternatives for enhancing communication and collaboration. Yet, the information about the effectiveness of these spaces is stated in very general terms, such as improved communications, increased morale, etc. Although they are interesting, it's important to note that these case studies are typical of existing sources of information in that they provide no data on *how much* improvement there has been in communications or *how many* people were satisfied/dissatisfied with the spaces.

The CBE field study was designed to fill this gap. The objectives of this project were:
1) To study the impact of team workspace design on worker satisfaction and group collaboration
2) To test new survey methods and metrics for assessing the performance of team workspace

The study gathered data on the perceived effectiveness of team spaces at Sun Microsystems, in five of their California office buildings. These spaces were designed by Sun's Workplace Effectiveness

Group (Richert, 1998) based on a process that first identified a series of strategic outcomes, and then defined work practices and physical conditions that would help workers achieve those outcomes. The following statements summarize Sun's strategic objectives for their workplace:

1. Collaboration is of strategic value to Sun.
2. One of the ways to enhance collaboration is to provide more opportunities for frequent, spontaneous, and informal interactions among workers.
3. The work setting should provide team spaces as important places for these types of interactions to take place.
4. Team spaces should be designed as small, open, informal meeting places dispersed through the buildings. These should be readily accessed (no reservations, locations on hallways), making it possible for others to see and join in. Furniture in the space should be moveable to enable the space to be altered for different groups, and white boards are provided to support communication.
5. Team spaces should be adjacent to people's personal offices.
6. Personal offices should be enclosed, and are important for private, concentrated work.

The CBE web-based survey investigated people's work patterns, how the workplace design affected the nature and extent of different types of interactions, satisfaction with physical features of the team spaces, and other potential attributes of shared space such as visual and acoustic privacy, and workers' ability to concentrate. A total of 238 workers completed the survey.

Type of work
The survey asked about the nature of the work that people engaged in (creative, personnel management, decision making, administrative, coordination, editorial and production). Results show that 75 % said their work was primarily creative, which included software/product/services development, technical or creative writing, design, reflective thinking or reading, research, brainstorming, and evaluating. Thus, the sample of respondents clearly fell within the category of "knowledge" workers, for whom increased interactions and collaborations are deemed especially important.

Data also show that the vast majority of work was done by individuals working alone in their offices, as compared to being in meetings with others. 80% of the subjects spent more than 21 hours doing solitary work, and only 24% spent 3 hours or more in meetings.

Frequency of Interactions
Respondents were also asked how much time they spent in 5 different kinds of interactions, using the 7-point scale shown in Table 1 below.

TABLE 1. Frequency of Interactions

Type of Interaction	Percent Distribution							AVERAGE
	Never 0	Rarely 1	1-2/Month 2	Once/Week 3	Once/Day 4	2-3/Day 5	>3/Day 6	
Indirect	6%	3%	1%	3%	3%	14%	70%	**5.2** (~3+ /day)
Impromptu	0%	1%	4%	9%	27%	34%	25%	**4.7** (~1-2 /day)
Reserved Conference	3%	2%	7%	45%	27%	10%	6%	**3.4** (~3+ /week)
Unsched. Team Space	**7%**	**16%**	**20%**	**39%**	**13%**	**5%**	**0%**	**2.5** **(~3 /month)**
Sched. Team Space	23%	26%	22%	19%	7%	2%	1%	**1.7** ~1 /month)

As can be seen, the vast majority of collaborations are indirect (by phone, memos, e-mail, or fax) or impromptu (unplanned, casual contacts in the hallway, offices or for coffee). 87% said they used indirect communications at least once a day, and 70% said they did so at least two to three times a day. Impromptu interactions were the most common type of face-to-face interaction, with also 86% saying they did so at least daily, and 59% saying they had impromptu interactions at least twice a day.

With regard to spaces designed for group meetings, 43% met in reserved conference rooms at least once a day. In comparison, team spaces were used in an unscheduled, spontaneous manner at least daily by only 18%, weekly by 52%, and 23% said they rarely or never use these spaces. Although some people pre-arrange meetings in the team spaces, this is less common with only 29% scheduling their use of the team space at least once a week. These data show that time spent in scheduled or unscheduled group meetings is relatively modest compared to other types of interactions.

Further analysis showed that proximity between the team spaces and private offices may influence whether people utilize the team spaces at all. More than twice as many team space users were within two offices of a team space, compared to non-users. Among the team space users, however, there was no correlation between proximity and frequency of use.

Satisfaction with Spaces and Interactions

The survey also asked respondents to rate their overall satisfaction with the usefulness of the different types of interactions, with satisfaction/dissatisfaction marked as positive/negative numbers of the 7-point scale shown in Table 2 below.

TABLE 2. Satisfaction with Usefulness of Interactions

Type of Interaction	Very dissatisfied -3	-2	-1	0	1	2	Very satisfied 3	AVERAGE
Percent Distribution								
Indirect	1%	1%	2%	10%	17%	35%	34%	**1.8**
Impromptu	0%	3%	4%	8%	20%	39%	26%	**1.7**
Reserved Conference	0%	3%	4%	10%	22%	39%	21%	**1.5**
Unsched. Team Space	**4%**	**2%**	**4%**	**10%**	**25%**	**31%**	**20%**	**1.4**
Sched. Team Space	2%	2%	9%	21%	22%	24%	24%	**1.1**

As can be seen, respondents were generally satisfied with all of the different types of interactions, and the spread between the different categories was much less than what was seen for the frequency ratings. There was no correlation between frequency of use and satisfaction for any of the types of interactions, leading us to wonder why people aren't using the team space for frequently, given that they seem to be satisfied with them when they are used.

Satisfaction with Team Space Privacy

The team spaces were deliberately designed to be in the open for ease of access and ease of drawing others into a discussion. However, the openness could also lead to reduced sense of privacy because people going by or in adjacent offices could see and hear the people working in the team spaces. With this concern in mind, subjects were asked to rate the importance of, and their satisfaction with, acoustic and visual privacy in the team spaces. Tables 3 and 4 below present the scales that were used and the distribution of the data.

TABLE 3. Importance of Privacy in the Team Space

Type of Privacy	Not very important 0	1	2	3	4	5	Very important 6	AVERAGE
Percent Distribution								
Visual Privacy	19%	23%	10%	14%	17%	9%	9%	**2.5**
Acoustic Privacy	9%	10%	6%	16%	18%	27%	15%	**3.6**

TABLE 4. Satisfaction with Privacy in the Team Space

Type of Privacy	Percent Distribution							AVERAGE
	Very dissatisfied -3	-2	-1	0	1	2	Very satisfied 3	
Visual Privacy	4%	11%	11%	23%	16%	24%	11%	0.5
Acoustic Privacy	15%	15%	15%	18%	15%	16%	7%	-0.2

As can be seen, subjects rated acoustic privacy as more important than visual privacy. They were also more dissatisfied with the provision of acoustic privacy. These findings were also validated by the comments, which also suggested additional important issues involving visibility in the team space. For example, some people felt that they preferred team spaces to be open so that they could be seen by others when there were in there working, or they could see the activity in the team space when there were in their private office. Further analysis showed an inverse relationship in 2 different acoustical ratings - votes of high importance often went hand-in-hand with relatively lower satisfaction ratings. The same pattern was not found for the visual privacy ratings.
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Satisfaction with Features of Team Spaces
Subjects were asked to rate their satisfaction with four features of the team spaces: physical layout, furniture, writing surfaces, and equipment. As in Table 4, satisfaction was ranked on a 7-point scale ranging from -3 to +3. Analysis shows the highest level of satisfaction with the writing surfaces (mean = 1.7), which was not surprising given that all team spaces seemed to be well-equipped with white boards. The lowest satisfaction ratings were for equipment (mean = -0.3), and comments suggested that this was most likely due to the lack of computer workstations or telephones. The physical layout and furniture were only moderately satisfactory (mean ratings of 0.9 and 0.8 respectively).

Concentration in Team Spaces and Private Offices
Because the team spaces are not only open, but were designed to be near private offices, the
potential for distractions in either location is high. Thus, the survey asked subjects to rate the
importance of being able to concentrate in both the team spaces and private offices, and their level
of satisfaction in both spaces. The results are shown below in Tables 5 and 6.

TABLE 5. Importance of Concentration

	Percent Distribution							
	Not very important **0**	**1**	**2**	**3**	**4**	**5**	Very important **6**	**AVERAGE**
Team Spaces	10%	8%	10%	18%	21%	21%	12%	3.5
Private Offices	0%	0%	1%	1%	7%	11%	81%	5.7

TABLE 6. Satisfaction with Concentration

	Percent Distribution							
	Very dissatisfied **-3**	**-2**	**-1**	**0**	**1**	**2**	Very satisfied **3**	**AVERAGE**
Team Spaces	6%	8%	9%	24%	28%	21%	4%	0.4
Private Offices	3%	7%	6%	9%	13%	33%	28%	1.3

Not surprisingly, it was much more important to be able to concentrate in the private offices than in
the team spaces, and people were more satisfied there as well. One interesting pattern that emerged
is that, overall, users of team spaces were more satisfied with concentration in their private offices
(mean = 1.5), compared to the non-users (mean = 1.1). This may suggest that team space users
were more sympathetic to the potentially distracting noises from the team spaces outside their
office.

Based on the comments, people's dissatisfaction with the ability to concentrate in the team spaces
may have been related to their feelings that they were disrupting their colleagues in the surrounding
offices, and not necessarily the potential disruption to their own work. Further analysis showed
that people were less satisfied with their ability to concentrate in the team space when it was
immediately adjacent to their own personal office. This may be due to them being distracted by
hearing the phone in their office, or perhaps being disrupted by people coming by their personal
office to talk with them and then interrupting them while they were in the team space.

8. DISCUSSION: IMPLICATIONS OF KEY FINDINGS

Our analysis of the survey suggest that there are two key questions we need to address are: (1) why
aren't the team spaces used more frequently? (The fact that people who do use the spaces are
generally satisfied makes the low rates of use more surprising); and (2) How can a balance be
achieved between the desire for openness and proximity, and the need to be free from distractions?
There are two primary issues here:
- Factors related to the design

- Factors related to the nature of work at Sun

Each of these will be discussed in more detail below as we link the findings from our survey to existing theory from the literature:

Design features

Content analysis of the survey comments sheds light on the ratings of design features. (The full content analysis is available in Appendix A). Many subjects said the team spaces would be more useful if they had computer terminals or other equipment (such as Barco projectors); this would explain the low ratings for equipment. As noted by Schrage (1998), collaboration often requires tools that enable the transmission and sharing of concepts and mental models. The team spaces seem to lacking in what Schrage calls "convivial tools." Although many said the whiteboards were a very positive feature, these don't seem to be sufficient. Research by Majchrzak and Wang (1996) also supports the need for more technological supports for team work to enhance analysis and problem solving.

Other comments show dissatisfaction with the chairs, both in terms of the numbers (too few) and the specific type of chair selected for the space ("The little Rover Jr. chairs are very weird and uncomfortable…Please take them away and burn them.") Several subjects suggested that tables should be added because it is easier to spread work out on a table than on the small arms attached to the chairs. The difficulty of moving the chairs and arranging them optimally for interaction also appears to have been a problem. Research on communications show that movable, comfortable furniture and increased visibility of participants to one another influences the nature of conversations (Sommer, 1983; Sundstrom, 1986).

A much bigger problem, however, is the openness of the space. Comments show that subjects were acutely aware of the disturbances their meetings had for people in the adjacent private offices. Similar results were found by Brill and Weidemann (1999) in their research on more than 11,000 workers. In fact, Brill and Weidemann recommend that workplace design must support "undistracted groupwork" (underline in the original).

For instance, Sun employees described these problems in the following ways:

> *"The team space area is hard to use. The surrounding offices are not able to concentrate if some group is chatting in those areas."*
>
> *"The designated team spaces do not have sufficient privacy to be very useful. So I invariably end up grabbing any conference room that happens to be available. Only if there are no conference rooms available will I use one of the designated team spaces."*
>
> *"The open area feels too vulnerable for anyone to have a relaxed, informal meeting in – too many ears and too many eyes, so to speak."*
> .

Comments on problems concentrating in private offices echo the concern over acoustics:
> *"When people have heated discussions there, the noise filters into my office even when the door is closed. Given the discussion style of many people here in the building, even the most mundane conversations become somewhat loud events. People like debating everything here and that noise is sometimes intolerable."*

As noted previously, acoustical distractions are very common in today's office and are a growing problem with the move to increasingly open spaces with portable furniture (Klitzman and Stillman,1989). Sims et al (1998) also found that workers in private work spaces surrounding team areas experienced distraction problems.

There were also a number of comments about the ambiguous functionality of the space. As one person said:
> *"We need different spaces with different purposes. Casual sitting at natural meeting points (coffee bars), enclosed spaces with workstations and tables for team meetings. Each space is a vague mix of purposes, not good for anything in particular."*

Others noted that spontaneous interactions were less likely to occur in the team spaces than in hallways or offices, even though the offices are too small for meetings:
> *"Theoretically we should say, let's go talk in the team space. But we don't. The nearest one is too far away."*

Part of the problem, as expressed here, is the "overhead" associated with going to the team space to meet when a standing conversation in the hallway will do the job. As one person noted, "*going to a team space seems sort of wrong. It's like trying to organize and control spontaneity.*" Moving to a team space, rather than standing in the hallway talking, also implies commitment to an interaction or meeting. It is much easier to break away from a standing conversation (Whyte, 1980).

There is also a lack of congruity between the design goals for the space and the actual design features. The overall strategic intention of team spaces was to increase collaboration. Yet the team spaces do not contain the features of collaborative spaces identified in the previous section. The spaces are more like casual meeting areas than collaborative spaces. Missing features include: the ability to take over the space for the duration of a project, vertical surfaces and artifacts to support distributed cognition and shard knowledge, "convivial" tools to support creative interaction as well as to access other data and information, separation from other areas to provide confidentiality of work, and acoustical privacy for nearby private offices.

Taken as a whole, the survey results and comments suggest that acoustical problems, inappropriate furnishings, and lack of needed equipment are key factors in reducing the use of the team spaces. However, it is also clear that people who did use the team areas were generally satisfied with interactions in these spaces. While this seems incongruous with the critical comments, it is clear that for some groups and individuals the spaces worked very well. It is possible that for these subjects, meetings produced useful insights or other outcomes that far outweighed potential problems with the spaces. In such cases, the frequency of use or general satisfaction are not as important as the creative process that takes place within the spaces. Although our data does not shed light on this issue, we identify it as a critical topic area that should be addressed in future research. The lack of attention, in general, to *outcomes* of group processes is a big issue in teamwork (Wilkins, 1998; Zobal and Wilkins, 1999).

The Nature of Work at Sun
The survey shows that work at Sun is largely individualistic, rather than meeting-centered, and takes place in individual offices by people who specialize in creative, knowledge focused tasks (such as product development, technical or creative writing, design, reflective thinking or reading, evaluation, etc.) Brill and Weidemann (1999) also found that the vast majority of work in offices today is solitary, rather than group-based.

Distractions are a particular problem for complex cognitive work that characterizes knowledge-focused, creative work (Kjellberg et al, 1996; Baron, 1994). At Sun, the ability to concentrate may be compromised by the lack of acoustic soundness of the private offices as well as by spill-over noise from open team spaces.

When meetings take place, they frequently occur in closed, scheduled conference rooms rather than in the unscheduled team spaces. This suggests that many of the "teams" at Sun may be more akin to work groups than to real teams (Katzenbach and Smith, 1999). The high degree of solitary work also supports this conjecture. As noted in the Katzenbach and Smith overview, work groups are more likely to engage in individual work and to use meetings as a way of coordinating work, rather than engaging in true collaboration. This may explain the high use of the conference rooms compared to the team spaces. Conference rooms support more traditional, agenda-driven meetings.

Another problem, pointed out in the survey comments, is that meetings in team spaces at Sun are often very noisy. This is to be expected when people get together to debate, critique, or discuss – especially given the intense competitive pressures in the high tech world. Everything is likely to seem urgent. The research by Brill and Weideman (1999) is relevant here. They asked their survey respondents to estimate how much time they spent in face-to-face interactions in or near their workspaces. They found that professionals and engineers spend between 22% and 30% of their time in "noise producing activities" in or near workspaces. The findings for Sun may be even higher because of the high level of impromptu interactions that take place, particularly if these occur in hallways or in someone's office. Almost 60% of the Sun workers surveyed said they had impromptu interactions at least twice a day, and a quarter said they had such interactions more than three times a day.

9. CONCLUSIONS & NEEDS FOR FUTURE RESEARCH:

The main findings of the CBE field study on the effectiveness of team workspaces were the following:
1. Work was primarily solitary rather than group-oriented.
2. The vast majority of interactions were indirect or impromptu rather than group meetings.
3. The team spaces were not used as frequently as other types of interactions; in fact, they are used less often than enclosed conference rooms.
4. There were problems with acoustic distractions, for both the team spaces and private offices.
5. Ratings of satisfaction with the features of team space suggested a lack of "fit" with functional needs, especially with regard to equipment and acoustics.

Our review of the literature revealed that alternative office designs have not received the kind of research attention they deserve. Given the enthusiasm with which these experiments are being tried across the country, it is surprising that there has been little systematic study comparing the alternative designs with traditional offices. Work that has been done has been largely anecdotal, with general summaries culled from interviews and focus groups. For instance, studies of team spaces in the US and Europe by Sims et al (1998) discuss numerous positive outcomes, such as increased communications, more rapid time-to-market, better work coordination. However, there is no data showing by how much communications increased, for whom, and why. There is also no discussion of survey tools, research questions, or observational methodologies that have been systematically applied across research sites. Part of the problem with lack of data is the

proprietary nature of many studies in this area. Work is performed for private clients and thus is not made available to the research community.

Our research also detected a need for a deeper and more substantive integration between the design professions, social science research, and organizational effectiveness. It is clear from the brief review of research in this report that people who specialize in office design, facility management, building science, organizational effectiveness, and work psychology don't have an adequate understanding of how these fields link together and influence one another. Specialists in each of these fields speak different languages and focus on very specialized aspects of work. As a result, knowledge is not jointly held. This makes it easier for research from one area to become overly simplified and trite when applied to other areas. For instance, consider the idea of "displayed thinking". Although the idea is based on theories and research in externalized cognition (Norman, 1993; Pea, 1993), it is applied in a very superficial manner. Displayed thinking often is translated into having organizational information displayed on a bulletin board. In fact, theories of externalized cognition and collaborative tools are based on knowledge of how the mind uses information and artifacts in the environment to aid memory, development of shared mental models, problem solving, and discovery. Although recent research in externalized cognition has focused on computer-aided collaboration, the theory and methods could be usefully adapted to design and study collaborative physical spaces. For instance, questions for future research include:

- What kinds of collaborative tools are most effective?
- How do group memory and mental models develop and what use do they make of the physical environment?
- How do social interactions aid group cognition?
- What kinds of spaces are most effective for different kinds of teams?

Another example of simplistically applied research is the concept of "casual collisions." This idea stems from research in environmental psychology that shows people tend to interact more at natural meeting points, such as coffee pots and mail boxes. Casual collisions came to be seen as a vital component of communications and collaboration. Yet, it is not at all clear what the links are and how one gets from casual interactions to the type of collaboration needed to generate innovation and productivity enhancements. This proved to be a problem for the Sun team spaces. The desire to increase communications by having open, informal spaces scattered throughout buildings was assumed to be a precursor to effective collaboration. Yet, the design assumptions did not explicitly identify how this was expected to happen. Nor was there a sufficient consideration of what "collaboration" meant and how it could be assessed. As a result, the CBE research focused on satisfaction and frequency of use. Future research into the nature of collaboration might explore:

- Should satisfaction and use be key indicators of the success or failure of a team space?
- Or is it more important to understand, and evaluate, the *outcomes* and *communications processes* associated with different kinds of spaces?
- Why are spontaneous encounters important? What value do they create?

It is also important to better understand the cognitive and social nature of work. The CBE research provides a significant first step in this direction. While most research on work environments has asked people how much time they spend talking on the phone, reading, etc., the CBE survey was effective in beginning to identify the cognitive and social aspects of work. The Sun survey and previous work done by CBE could form the basis for developing a research tool that would more effectively characterize knowledge work processes and outcomes. People who engage in knowledge work don't sit around all day doing nothing. They produce *something* – whether it is an idea, a report, a position paper, a new way of looking at data, a strategic relationship, a new or better product, a better link with another department, or a marketing strategy. We need tools and

methods to identify these kinds of outcomes and processes. And we also need a better understanding of how these outcomes and processes are linked to the features and attributes of spaces for both group work and individual work. It is clear from the CBE research that people do both kinds of work, and that the conduct of one (team interactions) often interferes with the other (solitary work). Future research into the connection between the nature of work and physical space might investigate:

- How can spaces be designed and conditioned to enable effective group work adjacent to personal offices without creating distractions?
- Do people think and interact differently in different kinds of team spaces and with different kinds of support tools?
- Can we develop methods that can convincingly link knowledge work outcomes to the attributes and features of physical space?

A deeper multi disciplinary understanding of work and work environments will move us beyond the current "flavor of the month" approach to office design, and closer to the potential for "new office" design to live up to its promises of increased productivity and innovation.

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APPENDIX A.
CBE/Sun Survey: Content Analysis of Comments

Method. 180 individuals wrote comments on the survey.   This represents 76% of the total number of respondents. Rather than categorizing comments by question number, we created categories out of the entire comment. The broad topic areas were identified by reading the entire list of comments several times. Following this procedure, we then cut-and-pasted all of the comments into these broad topic areas so that they could be further broken down into these into subcategories. The tables below show the topic areas, and the subcategories for each. The category "usefulness of team spaces" has the greatest number of comments; these are divided into positive and negative comment tables.

Table 1.

Topic category	Number of comments:
Usefulness of team spaces	130
Distractions associated with private offices	60
Equipment in team spaces	39
Furnishings/arrangement of team spaces	34
Misc. comments about personal space/Sun	24

Table 2.
Positive Comments on Usefulness of Team Spaces

Comment category	Number of comments:
Good place to talk informally	8
Nice to have open space/aesthetically pleasing	6
Good way to attract passersby to conversations	4
Easy to get people together quickly	2
Good equipment (white boards)	2
Very useful to my group	2
Nice layout	1
Comfortable	1
Sends positive message about Sun values	1
Allows me to hear what's going on	1
Good for building team relationships	1
Can be used as "war" room	1
Total	30

Table 3.
Negative Comments on Usefulness of Team Spaces

Comment category	Number of comments:
Wrong kind of space*	25
Not private enough/ too open and distracting	23
Distracting to those in nearby offices when we meet there	19
Too seldom used	14
Didn't know "team spaces" existed here	8
Needs coffee/snacks	3
Waste of space	2
Reduces private office space	1
Total	95

* *"Wrong kind of space" - Specific comments include*:

The whole philosophy is wrong. People don't have meetings in hopes that others will just happen to wander by and join them.

It doesn't seem easy or practical to move to a team space when you can talk in the hallway because these conversations don't take more than 15 minutes.

Open areas near coffee bars seem to be better place to encounter folks and have a 10- minute chat.

Need different spaces with different purposes. Casual sitting at natural meeting points (e.g., coffee bar), enclosed spaces with workstation and tables for team meetings. Each space is a vague mix of purposes, not good for anything in particular.

The team spaces are not where you're likely to run into anyone, like near main entrances, near the offices of often visited people. Most people still talk to others in their offices. Chance meetings are secondary. Our offices are too small for meetings; theoretically, we should say, let's go talk in the team space, but we don't. Nearest one is too far away for that.

I use the team space only a few hours a week. I spend more time in hallways – 5-10 hours a week— having impromptu conversations, sometimes for an hour. When you walk down the hallway to get a cup of coffee, and see someone you want to talk to, you just spontaneously start up a conversation and get the answers you need right then and there.

Going to a team space seems sort of wrong. It's like trying to organize and control your spontaneity.

Team spaces might be more useful if we were in an active development mode.

The apparent functionality of team spaces overlaps that of conference rooms and offices so they aren't used as much.

For 4 or more people, we use a conference room. For 3 or less we use someone's office. There are not enough seats for large groups in the team spaces.

If the spaces were converted to enclosed conference rooms that did not require reservation, they would get greater use and people with offices around them would breathe a sigh of relief.

Use team spaces during critical times to track project progress; keep all informed of what's going on.

Table 4.
Distractions in Private offices

Comment category	Number of comments:
Lack of soundproofing; can hear conversations next door	29
Noise distractions from people in team spaces	23
Miscellaneous (HVAC noise, lighting, shared offices)	8
Total	60

Table 5.
Team Space Equipment

Comment category	Number of comments:
Team spaces need:	
Computer workstation or terminal	20
Phone	9
Barco projector	3
More markers/erasers	3
Electronic whiteboard	2
Overhead projector	1
Whiteboards are great	3
Unpleasant odors from markers	2
Total	43

Table 6.
Team Space Furnishings

Comment category	Number of comments:
Chairs:	
Don't like chairs	10
Not enough chairs	9
Like chairs	2
Rover Jr. chairs hard to move	2
Other:	
Need tables	5
Need chairs in a circle so people can see each other	5
Carpets/furniture pollute air	1
Total	34