Organizational Learning Supported by Design of Space, Technical Systems and Work Organization

A case study from an electronic design department

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ABSTRACT: Companies are seeking new ways to manage learning and competence in order to improve company performance and competitiveness. Researchers and practitioners alike appear to be reaching a consensus that organizational learning is a key strategic variable in order to cope with this shift. In this paper the organizational issues are also viewed in a technical and spatial context. According to earlier experience we looked for more complex interactions between the use of space, technical systems and the organization of work. Methods used are interviews, a questionnaire and a collective design process resulting in an actual redesign of the premises. The design activity was a learning process that led to better understanding and ability to continually manage and redesign organization, space and technical systems in order to reach the most appropriate combination between these dynamically dependent production factors.

ORGANIZATIONAL LEARNING IN HIGH-TECH PRODUCT INNOVATION PROCESSES

Background

The issue of creating learning organizations is on every companies' agenda today. And indeed it is a vital question in coping with the ever-changing environment in which companies perform their activities. Companies are seeking new innovatory ways to manage learning and competence in order to improve company performance and competitiveness. The awareness of this made the research team and two Swedish companies initiate a joint research project aimed at studying organizational learning and organizational competence in both production and innovation context. The project is financed by the two companies and a government fund for development projects in Swedish industry. This paper is based on a case study carried out in a design departement at one of the companies.

This paper examine how organizational learning in the product development process can be supported by managing the design of space, technical systems and work organization. It provides a mental model for managers and scholars by which they can relate support of organizational learning to the design of space, technical systems and work organization.

Researchers and practitioners alike appear to be reaching a consensus that organizational learning is a key strategic variable and one that drives competetiveness. Organizational learning has been called ”an underlying variable explaining performance in strategic actions”.[1] The business press worries that ”even in its current decentralized, lean and mean version” the traditional organization will not have the learning skills required to compete effectively in the 1990s.[2] Despite growing awareness of the importance of organizational learning, the business strategy literature has focused primarily on production oriented and individual learning. Within this domain ”learning includes the increasing efficiency of labor as a result of practice and the exercise of ingenuity, skill and increased dexterity in repetitive task situations”.[2] It is now being recognized that organizations have the ablity to learn through their innovation processes. The learning concept has so far been applied mostly to production issues, but it applies equally to innovation processes and its effectiveness. Organizational learning in innovation processes can be seen as a way to increase effectiveness of product development efforts in order to increase company performance and competitiveness.

Indications that organizations learn in innovation processes are found in companies’ increasing ability to master complex development projects and shifts in technology as well as in the ability of some firms to develop new products with more consistent success than their competitors.[2-6] This increasing success in performning product development, as mentioned above, can be seen as organizational learning in innovation processes. The purpose of this article is to discuss how this type of learning can be supported.

CHANGES IN COMPETITIVE PREREQUISITES FOR PRODUCT INNOVATION IN HIGH-TECH INDUSTRY

Development of new products has become a focal point of competitiveness in many industries in recent years as noted by many writers.[7-10] Besides the traditional factors of cost and quality, the influence of time is of increasing importance to the success of new product introductions. The time aspect is especially important when it comes to the development time and time of delivery.[7, 11, 12] An efficient development process and adequate timing are often closely related to new product success or failure.[11, 13-15] Many companies are now realizing that both the number and the success of new products depend on the performance of their product development process.[16] Successful product innovation is fundamental to business success in dynamic and highly competitive markets.[17]

Product development has during past years been characterized by a high degree of predictability and long development cycles.[18] Companies have been able to compete successfully in this stable environment with development based on linear predefined processes and stable step-by-step models with a high degree of top-down steering. It has been possible for few talented specialist to predict the development process and to optimize it in advance in order to give tools and techniques to the big mass of ordinary development engineers. Key competitive factors and order winning criteria have been factors such as product functionality, degree of innovativeness and development potential.[19]

In turbulent business environments, product and process forecasting is becoming impossible. Demands are being raised to shorten innovation cycles and to start development without having clearly defined objectives and specifications. Furthermore the design teams must be able to do instant adjustments in coping with changing prerequisites and handle parallel change requests. Changes and adjustments must bee done simultaneously during the ongoing innovation process. Top-down and specialist formulated step-by-step models can no longer predict all insecurities that meet development engineers during a development process, the very reason for this being that there is no normal state or conditions except that of continuous change.[12, 15, 20-22] Key competitive factors and order winning criteria are factors as flexibility, time of delivery, development time and development cost. Most companies compete with process effectiveness rather than degree of innovativeness and development potential.[19]

In short, it can be stated that product innovation processes are moving from a more technology driven, stable, and predictable context characterized by extensive prestudies and a do-right-from-the-beginning-mentality to a more market driven, dynamic and unpredictable context characterized by undefined specifications, change requests and a high degree of external involvement.

There are examples of product innovation processes that reach even further trying to cope with unpredictability, i.e. works without any predefined goals except for basic quality and functional prerequisites. In these cases cross functional design teams have been established to work without process barriers or predefined goals in order to continuously be able to chose the methods or models most appropriate for every given stage and situation in the process.[3, 4, 23-26]

ORGANIZATIONAL LEARNING IN PRODUCT INNOVATION PROCESS

To stay competitive in this turbulent context the importance of supporting organizational learning during product innovation processes increases. It appears that an emerging consensus is that organizational learning; i) involves the organizations positioning visávis the environment, ii) is distinct from individual learning and iii) interacts with contextual factors such as the organization strategy, structure, culture and its environment.[2, 27] Researchers and practitioners have worked extensively on production orientated learning but have done little systematic work on organizational learning in product innovation processes. One reason could be that learning often is defined in terms of results from a repetitive task and that production skills are in a better way possible to analyze from this standpoint. Nonetheless it seems clear that organizations learn in their innovation processes. Successful long term innovation and development projects not only depend on environmental factors but they are also due to management actions.[5, 28] Evidence show that companies can learn to innovate. Some companies are consequently more successful and meet fewer product failures than their competitors.[2, 5] Organizational learning occur when single individuals from their mental models and pictures of demands and environment, meets and detects a match or a mismatch with expectations and puts discoveries and evaluations of this in some form of accessible organizational memory. Organizational learning in product innovation processes can be seen as diffusing best practice and sharing good as well as bad experiences.[29] It also means using cross functional teams to increase effectiveness of product development efforts in order to reach better performance and competitiveness.[26] In short, organizational learning requires that information is being shared, stored and used in a form convenient to all organization members.[2, 5, 30]

Product innovation literature distinguish three levels of organizational learning; incremental, discontinuous and organizational and that each of these levels need different kinds of support.[31-35] Studies have shown that *incremental organizational learning* requires expertise focusing on operational levels and emphasizing integration of functions such as R&D and marketing. Incremental organizational learning can be seen as moving along an innovation curve to increased innovation efficiency and can be compared with single loop learning. *Discontinuous organizational learning* has shown to require external high level skills, a playful creative internal climate and works best in small cross-functional teams. Discontinuous organizational learning can be seen as moving to a higher innovation curve with increased innovation effectiveness and can be compared with double loop learning. *Organizational learning* involves learning how to innovate and examples have shown that it is generated through diffusing best practices, organizational memories, dealing with failures and organizational goals. Organizational learning can be seen as increasing both efficiency and effectiveness for incremental and discontinuous organizational learning and be compared with triple loop learning. At each of these levels, learning must be managed and supported; it is not automatic.[2, 29, 34]

SUPPORTING ORGANIZATIONAL LEARNING BY MANAGING DESIGN OF SPACE, TECHNICAL SYSTEMS AND WORK ORGANIZATION

As noted above there are both research results available as well as research needed regarding learning organizations. Even though the amount of knowledge is increasing, the fact remains that, learning organizations do not happen by themselves and there is no ”quick-fix” to achieve them. The learning organization as well as the learning process have to be managed and supported as pointed out by Jones and Hendry.[33, 36] There has to be a holistic view on the organization’s activities and an understanding of different factors and how they affect each other. This requires, among other things, a systems thinking in the organization when aiming at creating a learning organization.[37] Senge and a great number of writers, among others Galbraith and Pasmore, have focused on the organizational dimension as one of the major factors that support company strategy.[38, 39] The organizational isssues are of great importance, but based on earlier experience from Volvo, Bil&Truck, SKF and other companies, the organizational issues also have to be viewed in a technical and spatial context.[23-26, 40, 41] This has led us to look, not primarily for perceptional properties of the space, but for more complex interactions between the use of space, the technology in use and the organization of work.

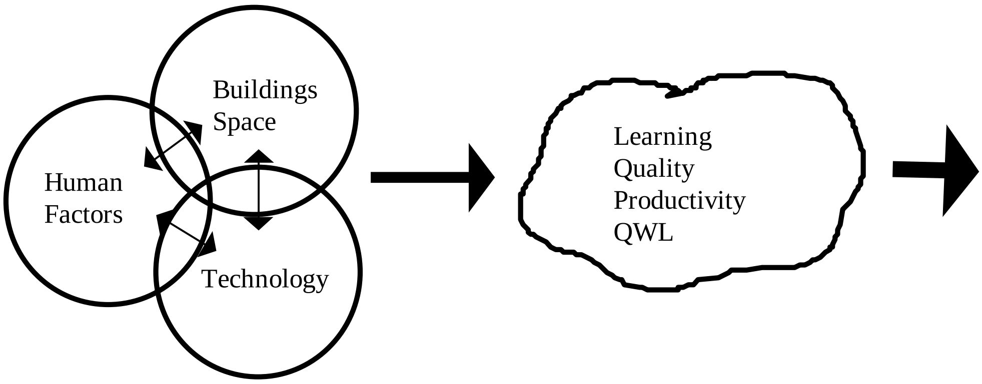

Figure 1. The three aspects, space, technical system and work organization symbolized in relation to learning and other qualities. This picture has been used to describe our model in discussions at the company.

Space for work

Creating workspace is not only a question of corporate identity or health and safety. Nor is it only a question of calculations on costs and benefits on buildings and property. Workspace is the actual place where the employees and managers are supposed to perform their tasks as efficient as possible, it is the physical setting for the learning organisation. Berg and Kreiner note that companies invest great sums in corporate identity programs with focus on physical apperance.[42] These investments are often intended to affect the companies’ external environment and do not reach all the way into the workspace. The styling of company profile supersedes the design of workspace and questions of intention and meaning in it. A different approach to workspace design which takes organizational and technical aspects into consideration is demonstrated by Granath in his description of the planning of the Volvo Uddevalla plant.[26] A similar approach is taken by Clipson and Kornbluh.[4] In both these approches learning is a part of the processes for development of production facilities.

Technical systems

Design of production systems has for a long time been a question of matching work organization and appropriate space with a predominant technical system. The most apparent example is the traditional assembly line which has implications on both the design of work organization and space for work, e.g. the form of the building following that of the assembly line.[43] Today´s production technology is becoming more subtle, and with FMS (Flexible Manufacturing Systems) also very expensive. In order to use the new technologies more education, training and competence is needed.[44-46] Furthermore modern technology, to a high degree in the form of computer based design and production systems, even creates new kinds of work which also sets the focus on learning. New strategies to meet a fiercer market and a constantly changing business environment also put strain on companies technological capabilities. Technical systems can no longer by themselves fulfil the demands of the market, they have to be an integrated part of the companies' system from innovative and conceptual phases to the very production.

Work organization

A vast amount of literature on sociotechnical issues, or anthropocentric, has discussed the interface between technical and social systems.[39, 47] Of increasing importance are the issues concerning learning as discussed above. This affects among other things work cycles and work content which has been described by Engström & Medbo but also the very way we look upon work.[48] Darrah means that the question that should be asked is not what kind of knowledge that is needed, rather it is in what context work is performed and what kind of conditions for learning the work situation provide.[49] Design of effective work organizations therefore need to have a broad view on the context of work as well as a relation to strategical issues. Furthermore it has to be recognized that the work organization is not non-spatial, it is existing, with its technical system, in its context having an assignment.

We mean that in order to support organizational learning the three aspects above have to be changed, designed and managed in conjunction with each other. None of these aspect can by optimization in itself create a learning organization. Furthermore they have to be related to the company´s strategy. It is necessary to find for each company a unique combination of its space for work, technical system and work organization. A tool for managing this is a collective design process, organized with cross-functional and cross-hierarchical participation, within the organization.[50] The collective design process is based on the expertise of the participants and supported by external professionals. The following case study describes such a process.

ORGANIZATIONAL LEARNING IN A R&D DEPARTMENT IN A HIGH-TECH ELECTRONIC INDUSTRY - A CASE STUDY

In the research project different studies have been done. The main study is focused on strategy and organizational competence as a basis for competitiveness, but this study, on which this paper is based, is directed towards ”space for learning”. It was known from earlier projects that the design and use of space had an impact on organizational learning.[23-26] In this study the interaction of design of space, technology and work organization was again put to the test.

This case concerns a design departement, in one of the companies, an electronic firm. The purpose was to develop organizational and individual learning among electrical design engineers. The company designs advanced technical systems for microwave applications. The quality of the products are very high and the engineers are in average very well educated. More than 50% of the design engineers have master degrees and a few have a PhD.

There are approximately 120 people working at the department of which almost 100 persons are design engineers. The annual turnover is approximately 93 million SEK. (12,6 million $) The engineers belong to four different design groups. These groups are responsible for different functions in the finished products and have different professional skills. The *mechanical design group*, 12 persons, designs the chassis for the product but are also specialists on mechanical design for microwave systems. This group use PC-computers with AutoCad program as a design-tool. The *high frequency microwave designers*, approximately 40 persons, use workstations mostly HP with a special advanced CAD software. The *low frequency microwave designers*, approximately 40 persons, use workstation from SUN Computers with a customized software for their purpose. Finally there is a group commonly called *hybrid design engineers*, 8 persons, who designs multi chip modules and also do microwave hybrid design. This group use Intergraph Systems and X-terminals. In the first stage the company did not include the hybrid design engineers in the study, but added them later.

Early discussions within the company resulted in a program with the aim to create a learning organization. It was also stated that the ways, tools and means to reach this could be numerous. After initial discussions with the research team it was agreed that a study called ”space for learning” should be carried through. In this study the focus was on the physical environment of the designers as one aspect affecting their output. Expectations were that this study should contribute to better access, efficiency and competence in the use of their design tools. The ”space for learning” should be inspiring, support motivation and be given a central location in the building. They wanted to emphasize the importance and quality of the engineers, increase their self esteem and give visitors an impression of a very advanced group with high quality performance.

The company’s idea of this concept, ”space for learning”, was a room for advanced CAD-construction with a very high-tech image. A metaphor used was the control-room in a space-ship, the science fiction movie Star Trek was mentioned. The company’s conception of creating a learning environment simply by styling of an individual room was easy to ridicule. But however, it gave us a clue to some of their expectations and it was interesting in view of later reception of the study.

First Stage of the Study

The study was started with interviews with representatives of the four design engineer groups. The interviews were individual, not pre-structured and took about one and a half hour per person. We were interested in the employee’s own descriptions of their work, the dependence of and cooperation with other engineers within and outside the departement, their own importance and key competence and above all what situations they rated highest when it came to learning, i.e. in which situations did they really learn and what did they learn? The research group consisted of two or three researchers, one or two were architects and one economist, meeting one engineer. One of the researchers kept the conversation with the engineer going while the other two took notes and commented or contributed with follow-up questions. Seventeen persons were interviewed. Parallel to this we let all personnel in the department answer a questionnaire concerning competence and learning situations. The results of the interviews and the questionnaire were strikingly similar. In a few situations we could see from the interviews that the answers to the questionnaire didn‘t make sense. In these cases we could detect that the questions in the questionnaire had been formulated in a way that caused misunderstanding or allowed too many unprecise interpretations.

Result of the Interviews

With earlier findings as bench-marking we looked at the results from the point of view of space, organization and technology. We wanted to see if we could find any comments from the interviews or results from the questionnaire pointing at connections between technology and organization, organization and space etc. Furthermore we wanted to see in what way, and with which terms and expressions, the design engineers talked and commented their workspace, technology and work organization.

Organization of work. We found that some engineers were organized in functional groups, i.e. they are organized according to their profession. A part of the departement was organized in project groups, e.g. multi-disciplinary teams formed around the design of a special product. Those who are functionally organized could work with one, two or more products at the same time. In the multidisciplinary teams there are mainly more than one microwave design engineer but never more than one mechanical design engineer.

Technology. The high frequency and low frequency design engineers use advanced software on workstations. Of cost reasons the departement has a limited number of workstations. The engineers do not have unlimited access to their design tools, but have to reserve time in advance. They could reserve computer time in time modules of four hours each. The mechanical design engineers use AutoCad software on ordinary PC and have their own computer on their desktop. This group is however just about to get more advanced 3D-modeling software on workstations. The hybrid design engineers use X-terminals for their everyday work and have their own terminal on their desktop. For more advanced design the hybrid design group have a number of workstations at their disposal.

Use of space. There are basically three different kinds of work places for the engineers, i) their individual workplace for administrative work and documentation with telephone and ordinary office equipment, ii) their CAD workspace that might be the same as their individual workplace or situated elsewhere and iii) the workspace in the laboratory. The high frequency engineers use workstations situated in a special room called the ”CAD-square” where they are sitting tight together, side by side, in a room with no windows and an overall very bad work-environment, regarding noise-reduction, temperature, ventilation and lighting. The low frequency engineers use decentralized workstations located one by one in the corridor, where the engineers are isolated from their colleges. The mechanical design engineers and the hybrid design engineers have their CAD-equipment on their desktops or just close by, within the group.

Competence and education. The most formally educated groups are the high and low frequency design engineers. Most of them have master degrees. The mechanical design engineers and the hybrid design engineers have generally lower formal education. The common education among this group is a high-school degree in engineering whereas some do not even have a degree in engineering but in more general subjects. They are mostly trained within the company. The design competence among the engineers, according to the company, is the lowest among the low frequency engineers and their ability to master their design tool is also the lowest.

Space, organization and learning. The project-organized engineers could be either spatially located in teams or spread out in the building and thereby just belong to a project team on the paper. Those project teams who are spatially kept together experience a strong project related learning. This learning is multi-disciplinary and object oriented towards the result of the design process. There is however a problem to keep up with the state of the art in the own profession and to keep in touch with what is going on in the rest of the department. The people already working in teams favored this form as strongly as those working in functional groups were sceptical to the team organizations.

The mechanical design engineers favor very strongly the functional location, even if they organizationally belong to a project team, and they have very little understanding of the single college who is spatially located in a team, something which he prefers. This group show to be very dependent of their engineer colleges in the group to keep in touch with the state of the art and to discuss design problems. It is interesting to note that the single engineer who is located in a team is a very qualified middle aged engineer with 29 years seniority. An important aspect is the social need to support each other because of the relatively low status the mechanical engineering group have compared to the low and high frequency design engineers. *The most prominent factors for learning* among the mechanical engineers is to be close to their colleges and to have their own computers. The access to a computer at all times gives them the possibility to experiment and it makes them very competent in handling their design tool. They have also accomplished to improve the tool by writing new procedures in order to make their design work more efficient.

The hybrid design engineers are special in the sense that most of them belong to many projects, because their contribution to a project is too small to occupy them for a longer period. Most other engineers only work with one project at a time. This has made the hybrid design engineers a sort of interface between the other engineers since they carry information about solutions or design problems that recently have occurred in other projects. This group is also an interface to production which sometimes makes it possible to produce more efficient designs.

Some of the microwave design engineers have their everyday workplaces located in teams and some are sitting together with colleges who belong to other project teams, and sometimes the high frequency and low frequency design engineers are sitting in the same room. *The single most preferable situation among the high frequency design engineers, in terms of learning, is sitting together in the so called CAD-square, despite the bad environment*. It is of course a nuisance to have to plan ahead and reserve time on a workstation. This however is highly compensated by the mutual learning situation that arises when they sit together with colleges from other projects while designing. This also shows in the company's monitoring of group competence.

The company did not have a working knowledge base for design. Information about earlier designs is crucial to the quality and perfomance of the product. We therefore asked the designers how it comes they do not ”invent the wheel” over and over again. A very prominent factor in learning about ”who-knows-what” and ”who-did-that-when” was what we came to call ”learning-by-walking-around”. The habit to drop in to someone and ask what they were doing and discuss some current problems had developed into an art. The spatious and open main corridor, the interconnecting stairs between the floors and the offices with glazed walls towards the corridor, together with an acceptance from the management, i.e. organizational factors that allowed this to happen, made this rational behaviour possible.

Organization, technology and learning. Both the interviews and the questionnaire indicate that there is an intensive neeed for coordination of work. They also show that the most effective way to get information and to acquire competence is to ask colleges during work. When using the design-tools, engineers often need to discuss design problems, user problems and each other's projects.

High frequency design engineers have their major need for interaction and coordination with other high frequency design engineers. In the first place this applies to design engineeers in the same project but they also share information concerning their profession, practice and experiences with high frequency design engineers outside their actual project. The need for constant change and improvement has triggered the most competent engineers to become technological gatekeepers.[51] This is not a company strategy, rather it is the result of the need for problem solving in the projects. Their dissemination of experience and knowledge supports the long term learning among the high frequency design engineers. High frequency design engineers only work with the other design engineer categories when they are in the same project. In that case the low frequency- and mechanical design engineers work as suppliers to the high frequency design engineers. An exception is the hybrid design engineers that work in parallel projects and therefore have the role of mediators between different projects. High frequency design engineers also have frequent external contact with suppliers, contract manufacturers and component engineers. Over the last years an increasing need for coordination and contact with production has been noted.

The low frequency design engineers mainly interact with other low frequency design engineers. They need most contact with other low frequency design engineers in the same project but they also have frequent contacts with low frequency design engineers outside their project. Professional issues, sharing of experiences and information of supporting functions are the main topics. The need for contact both within and outside their projects is due to the fact that they have the poorest performance regarding the use of their design tool. They also lack a common workspace to support communication and they do not work with the hybrid design engineers and consequently get no ”extra” information about other projects. Low frequency design engineers need to interact with mechanical design engineers participating in the same project, but need no contact with those outside the project. As for the high frequency design engineers they also have had an increased need for contacts with production.

Mechanical design engineers need to have frequent contact with both the high- and low frequency design engineers that participate in the projects they are assigned to. Contacts with design engineers outside their projects is scarce. At most times there is only one mechanical design engineer in the project teams. This makes him dependent on other mechanical design engineers for information concerning his profession and their design tools. He also has recurrent contacts with production units at this plant.

The hybrid design engineers participate in many projects at the same time and have frequent contacts with high frequency desin engineers and mechanical design engineers. They are also responsible for contacts with production in the projects in which they take part. This enables them to be some kind of mediators between different projects and design engineer categories as well as between different design projects and production. As in the case with the mechanical design engineers there is often only one hybrid design engineer in each project team. Accordingly they have the same need for interaction with other hybrid design engineers.

Technology, space and learning. Those who have access to a computer of their own learn how to master their tool very well, while those who have the opportunity to sit together and discuss with colleges while they are designing become very qualified in their design profession. The mechanical and hybrid design engineers both have these opportunities while the low frequency design engineers in general have none of these possibilities in their work situation.

As the design engineers move around a lot, both as a mean to get information and because they have several workplaces during the time of a project, there is a problem with accessibility and telephones. Very often they can not be reached and ringing telephones in empty workplaces are sources of irritation to their colleges. We therefore suggested that they should get portable telephones, a solution that would increase accessibility, and be in line with their habit of learning-by-walking-around as well as it would make the organization more flexible in the use of space.

Another technical problem is the diversity of computer hardware. The design engineers use four, and were introducing a fifth, software package for design. These softwares are run on four different hardwares and run under different operation systems or dialects of Unix. This cause a problem as some of the microwave engineers can use two different software packages, but can not run them on the same computer. This causes queues for every application and a need for more workstations than would be necessary if they were compatible. As the different design softwares partly are used in different phases of the design process, a number of expensive machines are unused at the same time as the design engineers have to queue up for the access to others. We therefore suggested the company to investigate however it was possible to run all software on the same platform. This would save money, give better access to the design tools and make cross-disciplinary interaction and problems solving possible. Thus enabling learning.

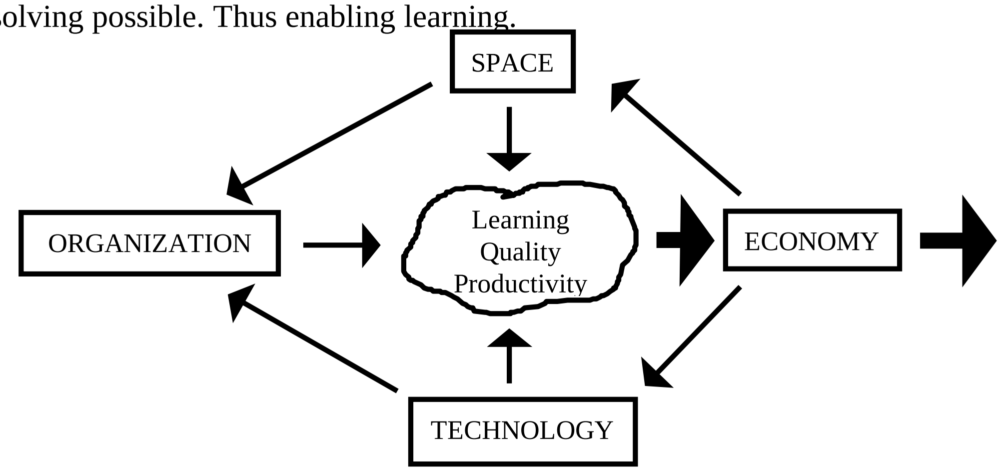

Figure 2. The relationship between the three aspects focused on learning with economical aspects added.

The design phase

The findings from the interviews were summoned up as above, but also developed and presented as five scenarios with different combinations of spatial, technological and organizational aspects. The engineers were invited to communicate their comments on our findings to us in any way they choose. They could use telephones, fax, letters, electronic mail or ask for a personal interview. A number of these options were used and it also resulted in eight complementary interviews. It was especially those personnel who were working, as well as located, in teams who felt that the qualities of this was not highlighted enough. They were therefore concerned that they might be forced to work in a functional organization in the future.

A collective design activity. As a result of the five scenarios presented and the discussion that followed, three scenarios were elaborated. One was an extreme project organization with multidisciplinary design areas equipped with their own laboratory space, another was a functional organization with everybody working in CAD-squares and the third was a mixture of these two options with workstations or X-terminals compatible with all software. At this stage we formed a collective design group of eight people among the design engineers, two from each category. Their task was to redesign their workplace according to the findings from the study just performed. The point of departure was mainly the third scenario above. They got a consulting architect and one researcher as resource persons to help them with professional advice regarding building design and collective design procedures. We also convinced the company to let us suggest a consulting architect who had the ability to listen to the design engineer’s own conceptions and let them do the design themselves, rather than trying to force a design solution of his own on them. We also explained to the eight engineers that it was their responsibility to brief their colleges and pick up their wishes concerning the design. We as external persons would however help them with information and presentation materials if they so wished.

The engineers proved to be very enthusiastic about the project and started directly to ask the architect to build them a cardboard model of the actual spaces. They themselves started to build model workplaces for CAD to furnish the model. At an early stage a young woman engineer from the hybrid design group took a strong grip of the group. This was very surprising since that category of designers had the lowest status and the woman in question had the lowest formal education in engineering among all design engineers. In the beginning the ideas were very creative, not to say extreme. One suggestion was to build a penthouse on the roof and move the whole design department there. Some of the suggestions were probably made, mainly because they challenged some taboos in the company. These early suggestions mostly involved moving groups or management people that were politically untouchable. The suggestions were an important step in the design process as they started a creative process and at the same time created a group identity among the participants.

As mentioned above the group had the third scenario as their point of departure. They however went further and emphasized cooperation between the engineering categories as the major driving force to achieve better time and cost management. The hybrid design engineers, the high frequency design engineers and the mechanical design engineers very soon came to the conclusion they had to interact more in the design process. They tried to convince the low frequency design engineers that they would benefit from further interaction with the rest of the engineers, but met quite a lot of resistance. The most important spatial and organizational change suggested by the group was to locate all categories of design engineers on the same floor or on vertically adjacent floors. This was a major change for the hybrid design engineers who were sitting in a former laboratory area, separated from the rest of the engineers by corridors and locked doors and without access to windows and in a generally poor work environment. The arguments were that closer spatial contact would increase the interaction in design. It would also be possible for engineers from different categories to sit together behind a computer and work with design problems concerning the interface between their professions. They were convinced that this was a key issue in getting better control of time, cost and performance of the design process.

The group choose a mainly open plan with permanent workplaces for hybrid and mechanical design engineers along the perimeter of the building. In direct contact with these workplaces on the core-side of the 14 meter deep building they placed the workstations in two new ”CAD-squares”, in which work environment had got drastically improved. A number of closed offices, for two to three people, were planned along the perimeter for those who disliked the open space solution. The floor had a size of 14x48 meters and as the closed offices, screens, flowers and other design elements subdivided it, it was possible to master the ergonomic and work environmental factors and get subspaces with a certain intimacy despite of the open floor plan. To master the noise problems with ringing telephones and increase the service level towards customers and external people, the group suggested portable telephones.

The design group went much further in terms of a solution that might support interaction and strategic learning than the company had expected from the beginning. As we mentioned the company had a vision of a high-tech space for the microwave engineers to increase their status. This solution took it‘s point of departure in the qualities of sitting side by side with colleges while designing, but at this stage it was mainly a cosmetic issue. The design group on the other hand involved organizational, technical and spatial matters in search for a better overall performance for the total design departement. They therefore suggested a solution that picked the best out of the existing and combined it with new solutions. They improved the CAD-squares and located them close to the other engineers they also were supposed to interact with, they made it possible to form project teams as before and they kept the functional groups together, in order not to lose professional learning and they still made it possible to increase the cross disciplinary learning.

RESULTS

The first step of the rebuilding of the premises was finished in January 1995. This step did only include the ”CAD-squares” and some upgrading of the space on that floor. The company had favored the interaction between low- and high frequency design engineering categories and especially the interaction within the low frequency design group as they saw this as a key factor to improve. The solution suggested by the collective design group aroused a lot of political turbulence among middle management and even among engineers. To mix the low status hybrid design engineers with the rest of the design engineers was politically impossible, even if there were strategic reasons to do so. The quality of the space in the solution presented by the design group came out far below the high-tech model that the company visualized from the beginning. But, on the other hand, it was in the new context with hybrid design engineers and mechanical design engineers involved impossible to accept because of it’s relatively high standard. To equip the engineers with portable telephones was also politically inappropriate as other departments would ask for compensation if one department got such a ”sign of status”.

Further studies

Parallel to this we have carried out two studies, one social network analysis of the interaction between people in the organization and one space-syntax analysis of the existing space.[51, 52] The social network analysis looked for contacts of three kinds, i) on-the-job contacts, ii) contacts to increase the competence and iii) social contacts. Three levels were interesting, i) intra, i.e. within the own group, ii) inter, i.e. with other groups in the department and iii) external contacts.

The Space Syntax analysis was used to analyze the relations between spaces and the overall pattern of alternative ways for communication between spaces. It also indicated the building integration core and made discussions concerning building configuration and degreee of enclosure and openess possible. A first processing of the two studies show us that those people who are in highest demand according to the social network analysis are spatially distributed within the space of the department. Further research will analyze and compare the whole pattern of choices made in the social network analysis to see if there are any significant patterns in the way the chosen and those who choose are located spatially over the department‘s area. It is for example interesting to see if there is a difference between the different sorts of contacts when it comes to dependency of distance.

We will also perform follow up interviews with the members of the collective design team to get their reaction on the outcome of the design work and their conception of their own learning in the process. We want to see how the design engineers, involved in product innovation processes, have dealt with new methods acquired in the collective design process. Earlier projects, mainly in production plants, have shown that people has acquired competence to change their workspace and worksituation with a broader view after participating in collective design processes.[26] This study will be done during spring 1995 and can be presented in early summer. Later on a new social network analysis and a Space Syntax analysis of the rebuilt spaces will be done to analyze the long term results of the project.

CONCLUSIONS

In this study it was evident that design of space has both general and specific implications on the performance of the companies. It is dependent on more general dimensions such as distance and its impact on communication patterns, how it affects human motivation and functionality and its impact on company culture. It is also related to more complex functions such as the relation between workspace and different workflow processes. All of these dimensions can support or prevent both individual and organizational effectivity, efficiency and performance.

It has once again shown that individual learning is necessary but not sufficient to produce organizational learning. A prerequisite for organizational learning is that knowledge, experience and best practice is accessible to others beyond the individuals, and it must be subject to application, change and adaptation by others in the organization. We conclude that organizational learning during a product innovation process, as in this case, can not be created, nor can it in a traditional meaning be managed. But organizational learning can be supported or in worst case, prevented, if only one of the aspects, pictured earlier in Fig. 1., is emphasized. Managing design of space, technical systems and work organization is an interactive process that can support organizational learning and that must be adapted to strategy and the specific culture in which the results will be used.

Furthermore it has to be noticed that the relation between the three aspects change continuously. Change in one aspect affects the two other and for a time one of the aspects might be governing the others, but they do always have effect on each other. It is a dynamic situation that has to be redesigned over and over again as a part of the organizational learning process. Best practice is change practice. Through the collective design process, a learning process in itself, new issues and combinations of different aspects have been brought to discussion. New demands for change can now be treated with the awareness of the relation between space, technical systems and work organization. The design activity was a learning process that led to better understanding and ability to continually manage and redesign in order to reach the most appropriate combination between these dynamically dependent production factors

For an external researcher in projects like the one described above it is not always the most obvious results that are of greatest importance. It would of course be satisfying if the company through this study would sky-rocket as the model for a learning organization. The case study presented in this text is not such a sucess-story regarding instant results, but what is more important, it has raised important issues among people involved and nurtured the ongoing process of creating and maintaining a learning organization.

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