

Integrating ergonomics into the architectural design processes: tools for user participation in hospital design.

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Abstract

The aim of this paper is to discuss the application of ergonomics in a large-scale hospital design project, and in particular, the contribution of an ergonomic consultant in organising the participation of end-users. The difference in the architectural and ergonomic design process often makes it difficult to establish an ergonomic contribution in the pre-design phase of the building design. An ergonomic analysis which is focussed on the processes that have to take place in the building can be useful to bridge over these differences. Input of the end-users' knowledge of operations and tasks is an essential part of the architectural design process. Especially in the case of the complex processes in an operating suite. A particular point of interest in organising the participation of these users was their difference in interest and their inexperience in the review of drawings. The tools for user participation that were used in the design of an operating suite are illustrated in the paper.

Keywords: architectural design, hospital design, user participation

1. Introduction

In literature several examples of contribution of ergonomics to architectural design can be found. A lot of these contributions concern guidelines for separated elements of a building (such as the required dimensions of rooms). Considerable less ergonomic publications concern the methods to which consider the processes that have to take place in a building as a starting point for the architectural design (for example Harrigan [3] and Remijn [6]). This ergonomic approach is an approved method in many industrial engineering projects. Although good results of ergonomic contribution in the early phase of the design process are reported (for example by Engström et al. [2] and Villeneuve [7]), this type of contribution still is rather unusual in architectural design.

Often the ergonomist is asked to react on existing drawings. As the project is then in an advanced phase the possibilities to gain modifications are limited. Martin et al. [5] describes both the positions of 1) reacting to existing drawings and 2) ergonomic contribution to architectural programming. They emphasize the importance of insight in the organisation of the project. Especially this concerns:

- The different role of the actors in the project. Hertog et al. [4] present a good overview of the aspects of user participation in complex, large scale projects.
- The awareness that the programming is a continuous process, which does not come to an end when the drawings of the building are made. Dam et al. [1] present a good overview of this continuous programming process.

The content of this paper is based on practical experience in the design of an operating suite with eight operating rooms in a new hospital. The setting is a large community hospital in the Netherlands. The goal and challenge of the design process were to accomplish an operating suite that would specifically meet the hospital's needs: technologies and facilities fitting the hospital profile and the future task demands. High-tech operating procedures, communication, ergonomics and logistics were main points of interest in the architectural design process. In this case the ergonomic and end-user input was asked for in an early phase of the design process.

2. Ergonomics in building design

To explain the opportunities of ergonomic participation in building design it's important to understand the architectural design process. Box 1 shows an overview of the typical phases in the architectural design process. The design process moves from the macroscopic scale, 'the building as a whole', to the microscopic scale, the specific working environment.

Characteristic for this top-down approach is that it arises from goals set by management and general building requirements. Based on this information the architect creates conceptual layouts. In this schematic design phase the shape, size and the basic structure of the building are often fixed, without detailed knowledge of the activities in the building. Where needed the architect adds his own experience from other projects, which does not necessarily fit to the processes in this new project.

In the next phases the spatial and functional programme is fitted in the agreed conceptual layout and is worked out in detail, together with energy and climate systems. The further the plans are developed, the less the possibility to a substantial change of the overall layout.

Ergonomic systematic design approach

Box 2 shows a typical ergonomic systematic design approach. The ergonomic systematic design is a combination of a top-down and a bottom-up approach. The top-down method arises from project goals set by management. The bottom-up approach is complementary and delivers system tasks as the building-stones for the actual processes and activities that will be performed in the new building.

Box 1

Typical phases in the architectural design process are as follows.

1. Pre-design phase: definition of the project and goals of the organisation; establish project organisation; development of spatial programme; site analysis; feasibility study.
2. Schematic design phase: development of functional programme and the design of one or more conceptual layouts. The level of detail in this phase is minimal and a number of options are explored to focus the direction of the project.
3. Preliminary design phase: design of layout of a building, according to the functional programme (especially the requirements in size, shape and relationship of areas/rooms).
4. Design phase: continued development and expansion in more detail of the preliminary design.
5. Construction document phase: development of the design into a buildable structure. Decisions are made on structural, mechanical and electrical systems, materials, and such other elements.
6. Construction phase: actual construction of the building, review and supervision during construction.

Box 2

A typical ergonomic systematic design approach is summarized below.

1. Problem definition: problem definition (system goal, general constraints); orientation (expectations and possibilities of ergonomical input); structuring (fitting in ergonomical input); exploration (starting-points, system boundaries).
2. Analysis:
 - Analysis in existing situations (system description, task analysis)
 - Functional analysis - future situation (basis of design, system tasks, various design solutions, first task allocation).
3. Design:
 - Functional design (interaction tasks, second task allocation, choice design solution)
 - Detailed engineering (elaboration of functional design into: (1) information presentation, (2) working methods, functions and work organization, (3) workplace engineering.
4. Implementation: support contractors; ergonomical review.
5. Start-up and evaluation: support users; evaluate system operation.

A major advantage of the ergonomic approach is the combination of an analysis of existing "reference" situations and the functional analysis of possibilities for the new situation. If these analyses are focussed on the processes that have to take place in the building this will create the possibility to review a conceptual layout with process demands and task demands. For example: in the hospital-case we were able to show in an early phase of the architectural process that it would be very difficult to design a suite with eight operating rooms in the proposed conceptual layout. Especially limitations in efficiency (routing, logistics, etc.) were to be expected.

3. Organization of the user participation

An operating suite is a complex design problem. The process flows of patients, personnel, operating materials and equipment are highly integrated and have a limited degree of freedom in planning. In a conceptual layout many decisions and choices are made by the architect and the hospital/project management to create a plan that fits to their knowledge and vision on the organisation of activities in the new operating suite. But especially in such a complex work situation it is plausible that practice differs from the expected situation by architect and perception of management. This can result in a layout that does not fit the future operating process and task demands.

End-users and ergonomic consultants are usually asked to participate at the end of the design phase. In this advanced phase of the design process a substantial modification of the plan is practically impossible. It will usually take too much time and (expensive) effort of the design team. That's why the input of user participation in this part of the design process often is limited to the constraints set by the preliminary design drawings.

In practice the input of end-users often focuses on detailed aspects of drawings. For many architects it is difficult to deal with this kind of contribution in the schematic design phase. They often prefer to present a layout with rooms and to adapt it to the wishes of the users. This results seldom in a best possible layout.

Additionally most users are inexperienced in the interpretation of a layout or drawings. They know what kind of activities they want to do in the new

building, but they cannot foresee the limitations that might occur in a proposed layout.

The diversity in user groups is a special aspect of user participation in operating room design. This can easily cause different points of view on the priorities in layout decisions.

– The surgeons are responsible for the outcome of a surgery and they are in charge of the operating team during the surgery. But they are only part-time present in the operating suite and have little knowledge of the activities in the rest of the operating suite.

– The surgical and anaesthesiology staff is full-time present. They also do the pre- and post surgery activities, in which they have to cope with the problems of the work environment related to these activities.

This clash of interests can result in a conflict, especially because the total area for an operating suite is limited by the Dutch government.

An ergonomic consultant, with experience in building design, is the specialist to cope with the above-mentioned problems. An ergonomic analysis will add bottom-up information to the design process. It will also result in an overview of the diverse process flows in an operating suite and the interaction between these flows. This will make it more easy for end-users to review drawings and it will reduce the risk on a clash of interests between the different user groups.

The results of the analysis will give a lot of information to illustrate the limitations to be expected in a proposed layout. This will give additionally help for inexperienced users to review a proposed layout.

4. Tools for user participation in building design

In the pre-design and schematic design phase of the operating suite design the emphasis must be on the requirements concerning the routing, relationship between areas, logistics and planning. The ergonomic consultant has to derive these requirements out of the user information. A basis tool for this user participation is an ergonomic analysis in which the users are interviewed and their task performance is observed.

The user information can be structured in process flow diagrams as a model of the functions in the

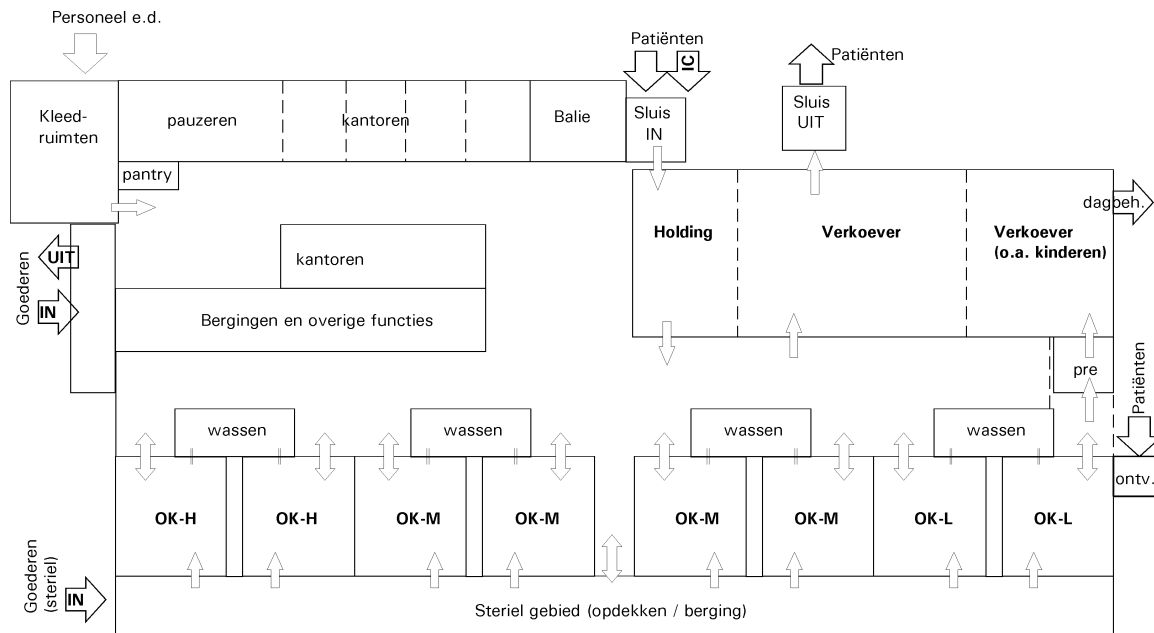


Figure 1: Example of a diagram which shows the relationship of areas in an operating suite (in dutch)

operating suite. By allocating the features of the work activity in the existing situation both the users and the project team have a good overview of the way these functions have to be realised in the design. Furthermore the process flow diagrams can be used to simulate the possible future changes in the activities and work organisation. For example: to optimize of logistics and planning.

Relationship of functions or areas

At the start of the preliminary design phase a diagram that illustrates the relationship of functions or areas is a helpful tool for users to discuss the global layout aspects. Figure 1 shows an example of such a diagram (in Dutch). The diagram is derived from the process flow diagrams and the additional features of the future situation.

It's the architects' task to fit such a diagram in a few different layouts to be discussed by the user groups. To support the users in the review of the design proposals the ergonomic consultant can generate a list of criteria to structure the process. These criteria will be derived from the results of the ergonomic analysis. Additional decision techniques can support an objective choice in layouts.

Layout on magnetic board

To investigate the demands for the layout of the operating rooms a magnetic board is used. All persons and objects to be placed in the room where made on scale (see figure 2).

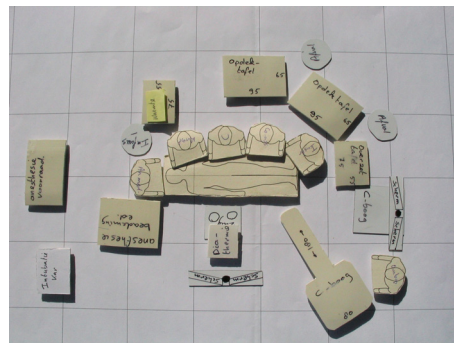


Figure 2: layout on a magnetic board

In diverse sessions with surgeons and surgical personnel the diverse layouts were discussed (what is the existing layout? what should be changed in the new OR?). The use of a magnetic board makes it easy to modify the layout.

The results were used to determine the required dimensions of the operating rooms and were also used as input for mock-up sessions.

Mock-up evaluation

A mock-up is a full size model, using simple (mostly wooden or cardboard) materials. This is a very useful tool in the design phase, for instance to examine the lay-out of an operating room. The mock-up must be constructed in a flexible way to enable testing of different layouts. Figure 2 shows an impression of the operating room mock-up. Based on the magnetic board sessions the end-users were asked to review a layout by performing predefined work-scenarios. This resulted in requirements for the design of the operating rooms.

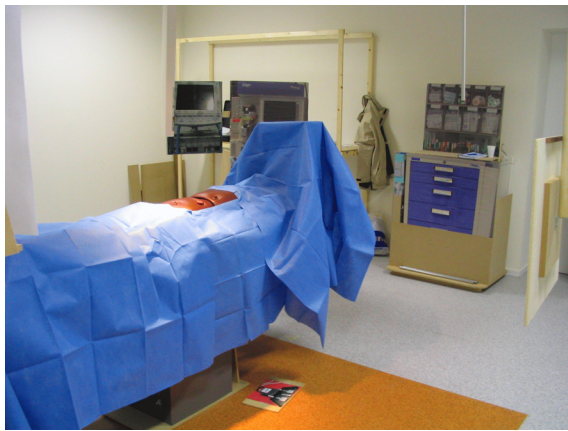


Figure 2: mock-up of the operating room

A special result of the mock-up sessions was that the end-users could really experience the dimensions of the proposed operating room.

The above-mentioned tools proved to be very helpful in building design, but the success of a design procedure lies not only in the organisation of the process itself. It is largely dependent on the way architects and design teams deal with the user input.

5. Conclusions

Our contribution to the design of the operating suite in a new hospital showed that an ergonomic consultant was a useful participant in the building design team. In this case the consulting started in the preliminary design phase. Input of the results of the ergonomic analysis in the schematic design phase might have resulted in an even better layout.

Diversity in user groups and users with no experience in the interpretation of a layout are some

of the specific problems in user participation in building design. The task-oriented ergonomic approach and ergonomic tools proved to be useful in organising the user participation in the building design process.

Our participation in the design of such a complex work-situation design case is a process in which a lot of problems and challenges occurred. Especially the support it gives to end-users, resulting in a useful input in the design process, makes it worth to promote ergonomic consultancy in an early phase of the building design process.

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