Visualization tools for self-representation in healthcare design

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Abstract Healthcare space is designed based on representations of activity - such as types, organograms, or workflows — that often do not match the real activities of nurses, doctors, and technicians. This is not necessarily a problem, since activities can adapt to new space, but there is a risk of hindering activity development while operating in unsuitable space. The design of new space can actually be an opportunity for activity development, provided that healthcare activities are able to represent themselves in that process. Activity self-representation has been studied in the design of a medical imaging center and the conclusion is that visualization tools are very important for that. Visualization tools should be easily manipulated by healthcare professionals, and allow shifting the levels of analysis from operations to actions, and from actions to activity. Furthermore, they should allow manipulating activity and space in the same representation.

Fig. 1 Subjects from different activities self-representing with a visualization tool

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Introduction

Current debates in healthcare design highlight the use of evidence from care activities to back up and guide the design of space (Joram Nauta, 2009; Pati, 2011). Evidence based design is a response to the complaints of healthcare professionals that architects design based on common building types, with no attention to the particularities of work activities. Advocates of Toyota's Lean approach in healthcare go as far as to say that architects may not even be necessary since overloaded activities can be improved without building more space (Grunden & Hagood, 2012, p. 19). Extending space in healthcare design is not seen as an easy solution for activity development, since it can just reproduce the same state of development.

Instead of extension, what healthcare space needs is expansion. Expansion does not mean necessarily enlarging the physical space occupied by an organization, although that could be a part of it. Expansion means becoming more developed in a psychological sense: more adapted to the environment, more knowledgeable, or more resilient. This kind of development requires learning something that is not yet there, something really new, so the knowledge to be learnt must be created while learning (Engeström, 1987). The space where expansion takes place is described as a zone where individuals and collectives represent and discover their proximal development. Development in healthcare activities may happen through innovative ways of using existing buildings or through designing new buildings.

The role of design in activity development has been critically evaluated by Henri Lefebvre (1991), who denounced the political role of representations of space. Nevertheless, much has been said about the representations of space and little about the representations of activity. Furthermore, no alternative practice to avoid oppressive spaces and to allow activity expansion has been elaborated so far. This paper proposes an approach called self-representation, which aims to support the subjects of an activity to create their own representations of space and activity. In healthcare design, that means doctors and nurses representing their current activities instead of being represented by a manager from the top of the organization or an external consultant.

A case study of a medical imaging center is included, where self-representation happened through participatory design workshops (Sanoff, 2000). Healthcare professionals received and reconstructed visualization tools such as floor plans, simulations, and games to envision their proximal development. Some of the tools let the subjects represent themselves, some did not. Even when they did not allow self-representation, activity subjects created alternative means to represent their activities. The features and shortcomings of the visualization tools used in the case are considered to elaborate guidelines for tools that are meant to support activity and spatial expansion through self-representation.

Expansion through self-representation

The term expansion comes from Activity Theory, where it is used to analyze activity attempt's to reconstruct itself in a more developed form, for instance, through learning (Engeström, 1987) or through design (Engeström, 2006). An essential part of the process is to reconstruct old representations of work and generate new ones that can improve coordination between multiple activities. During the encounter of different activities, the subjects of one activity are often surprised to realize the aspects of another activity that they never imagined to exist. The relationships between the activities reconsidered in face of the emergent representations.

Suchman (1995) names that process self-representation, while Engeström (1999) names it expansive visibilization. Engeström prefers the term visibilization instead of visualization because "*the latter is often associated with the idea of illustrating and making more accessible some aspects of a message by means of visual images – clearly an insufficient notion for the purpose of understanding what is at stake when work is rendered visible*" (Engeström, 1999, p. 92).

In this paper, we argue that visual images can be appropriate for making work visible, provided that they are constructed by the represented. We distinguish between visualizations that are made to represent an activity and visualizations that are made for an activity to self-represent. In this way, we hope to keep the bottom-up approach of Engeström (1999), while adding a practical discussion on how to create instruments of expansion. We prefer here to use the term self-representation of Suchman (1995) instead of expansive visibilization for the sake of clarity, although our work is more in line with Engeström (1999).

Self-representation in healthcare design

Self-representation is not a common practice in healthcare design. Architects often rely on available representations of activity, such as workflows and organograms that they collect from clients, but these representations usually do not describe how space is actually used. The architect has to figure out. The client provides help, but very often the client is a manager who has not detailed knowledge about how work is done on the shop-floor level, where space is the reality of the work condition, not just a plan.

When possible, the architect conducts interviews with subjects of the healthcare activities, asking how they use space. The problem in healthcare is that no single unit in the organization has a full account of the activities, since they change by localized contingencies. Requirements are very specific, often contradictory, and difficult to balance in an overall plan.

Self-representation arises as a possible way of coordinating activity and space by avoiding the information gap. The information source and the information user are the same. Information is produced as soon as it is needed, with the same degree of validity that spatial design has. Participatory design (Sanoff, 2000) and co-design (King et al., 1989) are practical approaches that integrate self-representation within spatial design. The architect organizes workshops with the so called users with visualization templates that are collaboratively filled with the user’s daily activities. In the meantime, architects and users generate design propositions based on the represented activities.

Visualization tools for self-representation

The visualization tools employed by participatory design do not only shape the design possibilities, but also the participation. Architects, for example, like to use hand draw sketches to envision the environment during design discussions (King et al., 1989), but this practice reduces the possibility of those who can’t draw by hand to directly manipulate the models and see the consequences. Healthcare research has a vision for enabling participation through simulators (Gaba, 2004), but they are not meant to design space. We can find simulators of space in Construction (Kumar et al., 2011), but they are meant to review an already designed space, with the single option for participants to leave a comment about it. There is a need for visualization tools that can support self-representation, but the criteria for them are still obscure.

Given the expansive nature of visualization tools for self-representation, we propose the following criteria for their capabilities: a) Easy Manipulation: they should be easily manipulable by participants with no technical skills; b) Level Shift: they should support shifting the level of analysis from activity to actions and from actions operations; and c) Multi-dimensional: They should allow designing space and activity at the same time. The following case-study analyzes how two different visualization tools have been developed to support a participatory design workshop. They are evaluated against the criteria and the consequences of meeting or not meeting them are discussed.

Case-study of a medical imaging centre

The project where researchers developed visualization tools for activity representation is a forthcoming medical imaging center in The Netherlands with state of the art diagnosing machines based on techniques such as Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET-MRI), Computed Tomography (CT), and Electroencephalography (EEG).

The researcher followed meetings of the construction team, analyzed design documentation, interviewed project managers, and joined the workshops as participant observer. The interviews and workshops were video-recorded for later analyzing the interactions between activity subjects, plus the role played by the researchers, using the Interaction Analysis method outlined by Jordan and Henderson (Jordan & Henderson, 1995). This case study covers a very small part of the design process: the evaluation and final adjustments of the floor plan, which happened between July and September of 2012.

The major challenge for the project is to combine research, technology development, education, and care in the same imaging center. The coordination between these different activities was considered non-problematic at the beginning of the project and the spatial design was developed to meet the requirement list. The installation of the machines presented complicated problems such as heavy weight, radiation, high energy consumption, and intense noise that kept the construction team busy for many months. The team was composed of the machine providers, structural engineers, installation advisors, architects, and the project managers. The design was developed very collaboratively among them, but the subjects of the activities that are going to use the space were not directly involved.

The project managers tried to involve subjects through individual interviews and regular meetings about the architectural program, but the most comprehensive document they could compile was a list of rooms with machines, square meters, daylight need, and the name of the user of the room. The connections between the rooms, the shape of the rooms, the plan for shared use, and many other details necessary to design was scattered among the activities, and often they disagreed. The project managers decided to organize a workshop where at least one subject of each activity would be there to evaluate the current design and make adjustments. They expected to settle down the disagreements and move the project from conceptual design to detailed design.

Self-representing using a printed floor plan

The workshop started with a quick introduction on the business model of the imaging center, the current project phase, and the importance of having the evaluation from the activities invited. The project managers fixed a printed floor plan on the wall, stood up beside it and explained the design rationale behind the floor plan, pointing to the areas on the floor plan as long as they were mentioned. The goal of the workshop was to improve the care logistics.

As soon as the discussions got more intensive, all the participants stood up and came closer to the floor plan fixed on the wall. They began to question the presented design by formulating scenarios of possible troubles. Participants represented their activities using verbal narrative while sliding their fingers over the printed document (Fig. 2). Every time an activity was brought to the discussion, it had to be represented again, since the floor plan was not being marked in any way. There were indeed some markers at the table, but the managers didn't offer them to participants.

Fig. 2 Participants in the first workshop slide their fingers over the plan to represent their activities

The floor plan was designed with the assumption that activities do not overlap in the same space. The university, the technology developers, and the two hospitals involved with the project, would use different diagnosing machines at different times. The discussion slipped away from spatial requirements many times, but it revealed overlaps on space and time. There was a major doubt if the capacity of the shared waiting and dressing rooms would be enough to keep machines busy with patients in every machine. The bottom line was that the activities intersect and the subjects were unaware of how they would interfere with each other. The workshop ended up with many open issues.

Self-representing with a healthcare simulator

The project managers asked the researchers for help organizing the next workshop. The researchers emphasized the importance of letting activity subjects represent their own activities and also change the design. The managers were afraid that the participation could slip away from the project scope, so the researchers suggested using better visualization tools than the printed floor plan to guide the discussion. The aim was to keep participants focused on the relevant aspects of activity and avoid generating too many changes in the space design.

The researchers proposed that the doubt on the number of dressing rooms could be clarified by simulating the care procedures with the number of patients expected per day by the business plan. They made a simple deterministic simulation of the scanning procedures using FlexSim Healthcare[1]. The simulation had the machines arranged in the same way as the spatial layout so as to take into account the walking time of nurses and patients in the performance measure (Fig. 3).

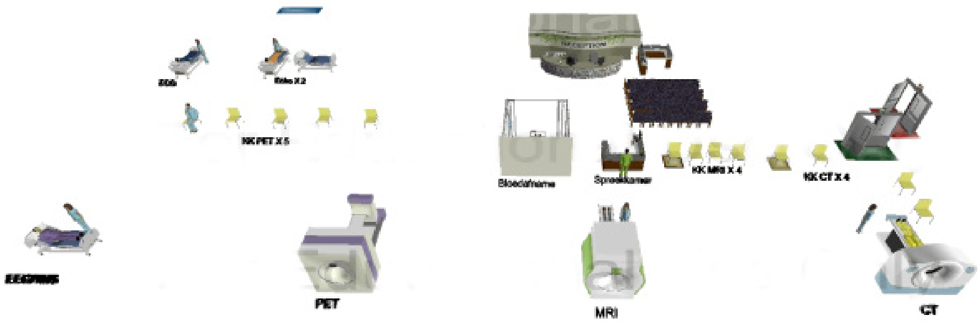

Fig. 3 Simulation of the scanning procedures of the imaging center made with FlexSim Healthcare

The activities were represented based on the project manager's knowledge about the activities. The main reference document provided to researchers was a linear workflow, with the steps that the patient and staff are supposed to follow for the scanning procedures of each machine. This document didn't specified where in space each step happened, so the researcher had to guess where to route patients and nurses.

The initial idea was to use this simulation for self-representation during the workshop. The activity subjects would be able to change the parameters of the simulation and check the consequences on the performance, but the user interface of the software turned out to be too complicated to be used without previous training. The option of having a researcher changing the parameters in real time during the discussion was discarded, since it would create an interaction bottleneck.

The simulation was finally shown during the workshop only to support the managers' argument that the number of the dressing rooms was enough for the expected number of patients.

[1] http://www.flexsim.com/flexsim-healthcare [Accessed on 15/04/2012]

After the workshop, the healthcare professionals revealed that they did not understand very well the assumptions behind the simulation, but they decide to agree with the managers anyway. The simulation did not meet any of the criteria for self-representation outlined by this paper, and thus, failed for this purpose, however, it was not the only tool used during the workshop.

Self-representing with a knitting game

Being aware that the simulation was not suitable for self-representation, the researchers created a game based on the printed floor plan, with paper pins in each room and knitting strings that connect the rooms in the order the workflow actually happens. The subjects were supposed to tie and untie the strings while discussing how to optimize the workflow logistics. String colors represented different persons walking around the building. Drawing with the strings required more than two hands, what emphasized the collaborative nature of the representation. This tool was called knitting game, since the resulting image resembles a knitting texture (Fig.).

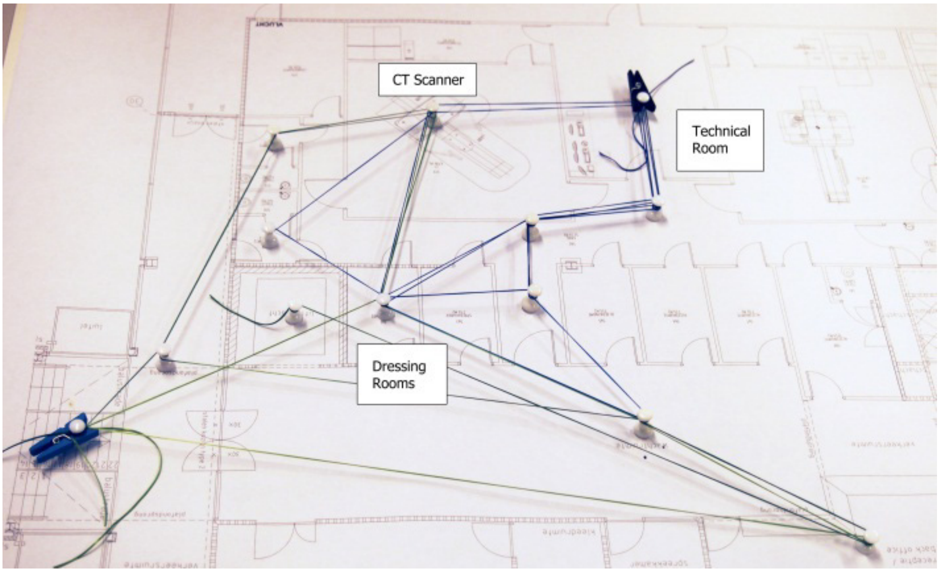

Fig. 4 Knitting game made by the CT scan activity. The blue lines are nurse movements and the green are patients

In the workshop, the game was introduced right after the simulation. Managers divided the participants into two groups, according to the activities under consideration: CT scan and MRI scan. The CT scan group visualized the central role of the dressing rooms in the process and realized the back-and-forth movement of the nurse between the technical room and other rooms (Fig.), but they didn't question the space design. On the other hand, the MRI scan group found so many problems on the spatial design that they refused to play the game. They said that it only makes sense playing the game after space design is consolidated.

The knitting game was easy to manipulate, but only at the activity dimension. The space dimension was inaccessible. It was, nevertheless, considered a partial success by the researchers in its purpose to represent activity in a participatory way.

Self-representing with paper sketches

The discussion was somehow stuck at the MRI group. The researchers suggested bringing the CT group game to the MRI group table to create a combined version. The completed game made the MRI group reflect in a more positive way towards the spatial design and at some point in the discussion, one of the activity subjects asked for a sheet of paper from the architect's notebook and sketched an alternative floor plan for the area between the CT and MRI machines. The subject with the pen and paper was asking other subjects for their contributions while drawing (Fig.).

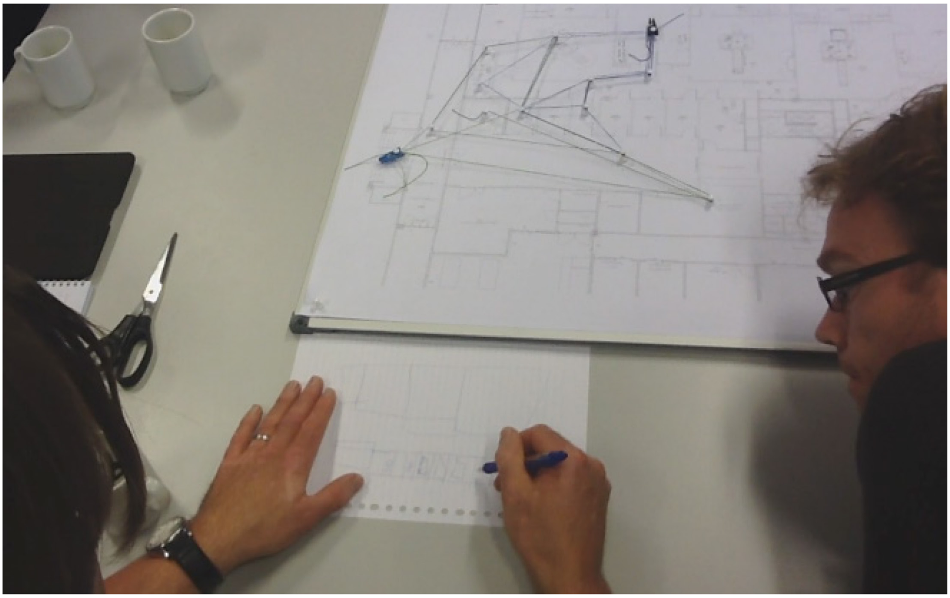

Fig. 5 Healthcare professionals sketch a new concept for the spatial design

Rethinking the floor plan was not what the project manager had in mind, but they realized that this was necessary to reach the consensus. They asked the construction team to incorporate the sketch in the drawings. While the healthcare professionals did a break to visit the construction site, the construction team made adjustments to the floor plan using thick pens. When they came back, the drawings were presented and a new round of discussions and adjustments went on. At the end of the workshop, the managers could reach the desired consensus with the adjusted version of the floor plan.

Conclusions

Architecture still struggles with the dilemma of meeting particular user needs or reproducing standard types (Lerup, 1977; Voordt & Wegen, 2005). The user might change after a certain period, but the building stays for hundreds of years, so it's hard to rely on particular user's needs. Activity self-representation can be considered an in-between: it deals with the collective affairs through individual practical action. Instead of a list of individually collected user requirements, the output is a rich visualization of how activities intend to use a certain space created by the same activities. The advantage goes beyond having more accurate information. The design gains commitment to implementation at the use level.

Although representation cannot fully stand for activities, they are the product of a collective effort to be accountable. The opportunity to self-represent strengthens worker agency and make expansion more manageable. It is an opportunity for activities to expand and design both in an organizational and spatial perspective, but that will depend on the kind of representation generated, and most, important, the process of representation.

The main contribution of this paper is the identification of an alternative process for representing activity in healthcare design, called self-representation. Self-representation happens when subjects of different hierarchical levels of an activity have the opportunity to participate in modeling their own work procedures. Visualization tools that are easily manipulable, that can represent activity in multiple levels, and still allow designing space, are very important in this regard. Currently, there are very good tools for planning space — like Autodesk Revit — and for planning activities — like FlexSim, but they don't afford planning both dimensions together. It is not possible to simulate activities in Revit, nor change the floor plan in FlexSim. We envision the opportunity for expansion in healthcare design with visualization tools that can combine both dimensions.

Despite the case-study evidence that visualization tools can be used for self-representation, it is important to highlight that they will not necessary lead to activity expansion. In the case studied, one visualization tool was rejected and a new one, unexpected, was created, based on the flexible matter of paper and pencil. The fact that an attempt to represent activity and space with modern visualization tools ended up in the traditional paper sketch makes it clear that there is still a long way towards easily manipulated, multi-level, and multi-dimensional visualization tools for healthcare design.

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