Simulation with a Lego scale model and other intermediary objects

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Abstract. This paper presents the use of a scale model made of Lego and other intermediary objects used as support for physical simulations in ergonomics in a biotechnology laboratory complex project. The objective of this work is to depict the preparation and use of intermediary objects in a simulation in ergonomics. This work will display elements of simulation planning itself, such as working group formation, scale model preparation and information provided during simulations. Providing information to help ergonomists to prepare and organize their activities and simulations for design.

Keywords. Intermediary objects, collaborative design, simulation

1. Introduction

The use of simulation methods is one of the most used strategies that ergonomists uses to integrate the dimension of work activity in workspace design (Béguin et al., 1997). Through simulations, ergonomists can include users in the design process, therefore profiting a number of benefits such as: focusing in users' priorities, improvement of solution acceptance and participants' knowledge (Wilson, 1995). The use of intermediary object concept is common for the accomplishment of those simulations to define tools, organize participatory structures and interfere in project decisions. These objects can be used for physical and virtual representations in participatory ergonomics, creating virtual environments (Wilson, 1996). Although we are not discussing here the use of virtual reality, we have similar purposes such as helping participant to analyze the interaction with objects and the relationship among objects (Wilson, 1995). Although several studies published the use of intermediary objects, we still observe that there are few representation supports available for use and that there is leeway for ergonomists to contribute to the design process by creating new intermediary objects.

The aim of this work is to present the use of intermediary objects created by an ergonomist and applied in a new biotechnology laboratory complex project in a French state-owned company. In this project, we used a scale model made of Lego bricks as support for a participatory structure, and to allow operators to express their views regarding the design of their own workspaces. This work will present a number of elements of a physical simulation planning such as work group formation, scale model preparation and information provided during simulations. Also, other objects created to spread the results between workers will be presented. We hope to collaborate with this paper through the planning of future simulations organized by ergonomists.

2. Intermediary objects

An intermediary object is a materialization which represents different stages of

development of something under design. This materialization can occur in different forms, such as with text documents (e.g. technical documentation), graphic representations (e.g. technical drawings) or even physical elements (e.g. prototypes) (Vinck, 2009). Different actors may find, through various intermediary objects, a representation to translate design requirements into solutions, represent their ideas and communicate them with different interlocutors (Jeantet, 1998).

In ergonomics, the concept of intermediary object has been recurrently used as an useful tool for ergonomists. Through the use of object like scale models and plants, ergonomists have been organizing participatory design reviews with operators and designers in order to promoting mutual learning, facilitating the construction of a common representation and offering support for mediations.

The use of intermediary objects is associated with three processes: representation, translation and mediation, and these processes help understand the usefulness of the concept in ergonomic action. Through an intermediary, participants can represent their ideas to facilitate their understanding among different interlocutors. It's also the translation process product of design requirements in form of solution. Finally, the intermediary object acts in mediation, materializing a common language and helping foster mutual understanding between different professionals (Jeantet, 1998). In this sense, the intermediary object becomes an exchange vector (Béguin, 2010) therefore making it a great concept tool for ergonomists to analyze and act in the design process.

3. Project Context

The project was originated by a demand with required involving representative users of future laboratories in the design process. The project manager aimed to involve user participation to help integrate requirements from the tasks to be performed in the future situation regarding the work to be carried out. The new laboratory complex encompasses the activities of four teams of researchers, each having their own principal laboratory and sharing another 13 common laboratories. The population is entails of researchers with master's and PhD degrees and certain work also in universities. Also present are technicians and scholars in various levels from graduation to post-doctorate. Among the spaces in the new complex, a number of laboratories was being expanded and new spaces were being created (mostly due to equipment mix currently scattered around various laboratories in the building, or mixed with other types of equipment due to lack of space). The new laboratory complex will consist of 22 laboratories, as well as office areas, meeting rooms and conviviality areas.

Before the ergonomist joined the project, a number of actions related to the project had already been ongoing. The project manager indicated that each one of the four teams had elected a "project-responsible individual" in charge of gathering information relating to their teams and interfacing with management. Based on information gathered by those responsible individuals, the project manager defined the size of each laboratory and secured from an external enterprise (engaged in other project for this department) an initial ground plan with the first organization of the new complex proposal. Based on this first plan, the four "project-responsible individuals" divided among themselves the laboratories so each one could work on their layout proposition. These constructions were made by those "project-responsible individuals" with little interaction with colleagues and no interaction between the teams.

For this project, the company already had aimed the holding of a physical simulation using a scale model made of Lego bricks due to an anterior experience that achieved good results published in Turchiarelli et al., (2012). However, simply gathering the operators

around the scale model is not sufficient to achieve the required objectives. It is necessary that the use of this resource be done in a coherently way as an element of ergonomic action larger than the use of the scale model itself.

4. Ergonomist action

The ergonomist participated in the project during four months. The two first months were dedicated to exploring the work situations and gathering information for scale model preparation. During this period, was held several guided visits with different researchers from all four teams to all laboratories to help learn the different uses of the spaces. In these visits, researches were requested to shown their main procedures, activities particularities, difficulties related to the performing of experimentations and also the good solutions found in the laboratories, which shouldn't be forgotten.

Due to the number of laboratories and researchers, it was not possible to hold an in-depth study of all work situations. So, the ergonomist have dedicated some time to analyze some of the shared laboratories which were more used among the teams, at which the problems of coactivity were more present. During these visits to laboratories, the ergonomist profited by presenting the ground plan proposed for the laboratory complex to put forth questions concerning the relationship between the laboratories. This was an important issue to be explored, because the researchers' activities were not developed exclusively in a laboratory all day, but rather distributed among many work spaces to use various pieces of equipment, seek for chemical products or available work stations (e.g. chapels) so that they could carry out their experimentations. Some labs have a more intense relationship with other spaces and the issue of how organizing the spaces was important to be addressed so as to foster the coherent organization of the new complex with the activity performed by the teams.

5. Planning and preparing a simulation

Performing a simulation involves much preparation that goes from the choice of materials to the formation of the working group. In this section, some elements of this planning will be presented.

5.1 Preparing the scale model: the use of Lego Digital Designer

The "Lego Digital Designer" (LDD), free software produced by Lego that allows users to create their own models using virtual Lego bricks, was used for the ergonomist to reproduce the equipment with Lego. It was possible, with LDD, to reproduce all equipment and obtain a list of the bricks required to assemble all the materials for the scale model construction. For their reproduction, all the material to be represented in the scale model had to be photographed and measured as reference. Based on this repertoire, the bricks were commanded by a service named "pick a brick", with allows customers to acquire customized Lego bricks requests. The modeling purpose was not to reproduce the equipment realistically, but to secure figurative reproductions allowing researchers to recognize their own tools (Figure 1). The scale used was 1:25 and as Legos bricks bear standardized measures, we couldn't reproduce the measurements accurately. Nevertheless, the goal of working with a scale model is to open a space for discussion of the project related to work activities and not to measure proposition accurately.

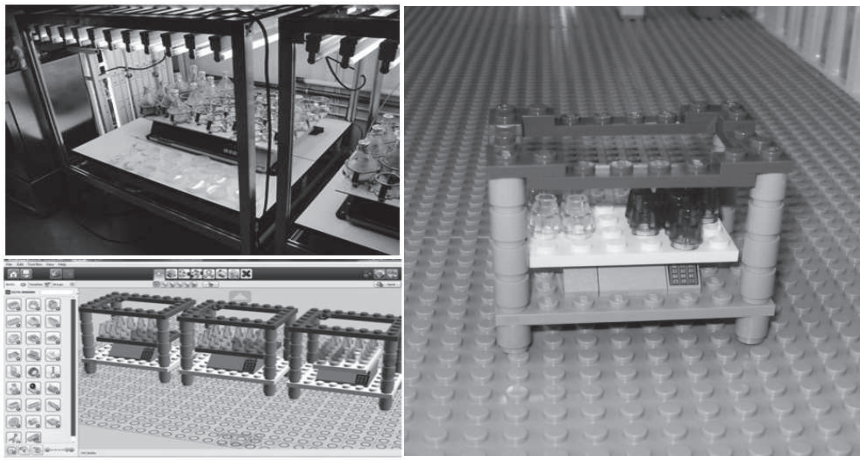

Figure 1 – example of an equipment reproduced in Lego

5.2 Cycles of simulation and work groups

The work with the scale model was divided into three physical simulation cycles. In the first round of cycles, each team was gathered individually to discuss only their main laboratories using a section of the scale model. This cycle consisted of four sessions of approximately three hours which were conducted, whenever possible, within the same laboratory represented. The goal of this cycle was to practice the scale model handling in a situation of reduced complexity.

Then, two more meetings called "complete cycles" at which the scale model representing the entire laboratory complex was used. For these meetings, each team was represented by two or three researchers, so every team had their views represented during the cycles. These two cycles had the same 3-hours duration of and were performed on consecutive weeks.

5.3 Characteristics of the Lego scale model

The Lego as material for the scale model components presents some interesting advantages: (1) Lego assemblies are resistant to handling, and even when some element disassembles they are easily reassembled, (2) the Lego base provides an excellent support for the scale model elements, which can be well fixed and will not tumble, and yet, can be easily removed, (3) the variety of colors and shapes of the bricks allows distinguishing the elements (e.g. all furniture was beige while structural elements like walls are white), (4) Lego modularity allows changing the size of elements or building new ones that were not unanticipated, (5) as it is a famous toy, people know how to handle parts.

However, the use of the Lego scale model displays some disadvantages: (1) it is necessary to learn how to use the LDD software, (2) preparation takes time: modeling with the software, material delivery and elements assembly, (4) Lego use is undoubtedly more expensive compared to other materials like paper and cardboards.

5.4 Scale model presentation

The scale model was presented to the work group only with the structural elements (e.g. windows and walls) and all equipment and furniture to be placed by the work group. An introduction was made at the beginning of the cycle to establish a number of ideas and rules. The ideas presented were as follows: (1) the aim of the cycles is reflecting the space organization in a coherent manner with the activity carried out in laboratories and not attempting to reach the precision of representations of inches. (2) Reflecting on the relationship of using the elements and the possible negative or positive aspects related to

the activity carried out with them. (3) Although not all problems are soluble in with the scale model, it is important to phrase these problems so we are able to find other solutions. (4) The use of the scale model allows testing new possibilities easily, without additional costs. (5) Be careful not to reproduce existing problematic situations, not to eliminate existing positive solutions and not to create new restrictions to work activity.

The following rules for use the scale model have also been proposed: (a) only one hand at a time to handle the elements in a "room", (b) the motivation for positing the elements should be explained to the group, (c) before someone change the proposition made by colleagues, one should explains the problem to be solved and how the new arrangement is better. The purpose of the rules was attempted to focus the group on the same point of discussion, encourage them to verbalize their views and avoid propositions that were made mechanically or without due reflections.

5.5 What was used during the simulation besides the scale model

Other elements were added to complement and facilitate the scale model use. These objects were as follows: (1) a "scaled ruler" to measure distances without the need to calculate proportions printed on paper and glued onto cardboard to gain stiffness. (2) A common tape ruler to measure real distances. (3) The "cubic brick" was a Lego-made piece with all sides representing 1m, to help people visualize distance immediately. (4) Another Lego brick with edges corresponding to 0.8 m ("door distance" as minimal distance agreed within the group for a circulation area) and 1.40 m (distance agreed within the group to be complied with between two work benches to reduce interruption problems when colleagues move between the benches). (5) "Photographic subtitles" printed on A3 sheets distributed by laboratories with photos of actual equipment to facilitate identification of representations in Lego. (6) "Documentary Repertoire" of material to be transferred, generated by the project management. (7) Initial proposals made by the "project-responsible individuals". (8) The laboratory complex ground plan with identification of spaces to facilitate people locates laboratories (subtitles were not placed on the scale model because this might suggest that spaces could not be altered). (9) Camera for photographing intermediary proposals before they were undone, to try a new idea. (10) A set of extra Lego bricks for assembling additional elements not anticipated by the ergonomist.

5.6 The ergonomist's role during the simulation

Two ergonomists participated in the simulation cycles, acting as facilitators (Broberg et al, 2011). They helped in scale model use and fostered discussions on the basis of field information. For this, the work situations visiting phase was essential, as it allowed the ergonomist to know a little of point of view of all teams. They also contributed with general project information (e.g. building restrictions) obtained with the project manager.

5.7 How results were distributed

Two news intermediary objects were formulated to disseminate simulations results: propositions and photo compilations. The propositions compilation comprised a file presenting all laboratories' proposals and their different stages of construction: preparedby the "project-responsible individuals" and the different constructions made in cycles. For this compilation, the language created by the "project-responsible individuals" in the initial propositions was used, so it would make its use during the project continuation easer. The difference between the compilation file and the initial proposition file was that the compilation was sent in editable format for all researchers of the department in a single file, allowing everyone to access to what had been done. A photo compilation was made

as a photographic record aiming to facilitate the proposals reading. As understanding a ground plan (even a simplified version) requires practice, the photos would help identifying what had been represented in ground plan.

6. Discussion and conclusion

This paper presented planning elements for preparing and performing a physical simulation in ergonomics with the support of an intermediary object. An important aspect to note reside in the fact that simply placing an intermediary object is not enough to integrate work activity dimension into workspace design. Ergonomists have to use these objects and perform simulation dynamics as elements of a larger action in ergonomics, so that the use these tools and methodologies becomes meaningful to all actors involved.

It is important to note that the context of this project has exhibited a very favorable degree of freedom. The ergonomist's joining in occurred at a project stage where few decisions were taken and there was great possibility for change: not only the equipment and furniture could change positions, but also the organization of the laboratories and internal walls placement were open for discussion. However, regardless of the degree of freedom that ergonomists may find in a project, several questions regarding organizing a simulation remains the same. This paper presents a number of solutions given by an ergonomist in order to help others to organize and plan future simulation dynamics in workspace projects.

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