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LEARNING PARTICIPATORY WORKSPACE DESIGN IN AN ENGINEERING DESIGN CURRICULUM

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1. Introduction

September 2002 the Technical University of Denmark (in the following referred to as DTU) greeted 60 enthusiastic students to a completely new *design & innovation* educational programme leading to a engineering masters degree based on five years of study.

Before this happened a group of 10 devoted and experienced teachers of engineering design and social science subjects based in the departments of 'Mechanics, Energy and Construction' and 'Manufacturing Engineering and Management' at DTU had worked throughout more than one year to construct this new curriculum. Though the education was constructed at an already existing and old engineering university, the basic idea was to re-design the complete curriculum including the core engineering and natural science curriculum to create a coherent new education.

The new engineering education is planned to meet the demands from industry and society following the dynamic changes of technology and society. New structures of cooperation in product development and innovation following these changes also demands new competences from engineers whose traditional training in the natural sciences and technical disciplines have been prone to supplements from social sciences including ethical, social, economic and management issues.

The *design & innovation* programme is therefore also a contribution to the renewal of the educational profile of DTU even though there is no general and overall consensus among faculty and management at the university about the specific character and extend of the changes needed. An important motivation for the new education has from the university management side been the interest in attracting more and new types of students having good grades from their high school graduation but not being attracted by the traditional engineering education curricula. The new educational profile has proven valuable for this purpose as it has recruited almost 50% of the students, who explicitly would not have sough admittance to the engineering programs and also has been able to attract almost as many female as male students.

The *design & innovation* education emphasises competences in carrying out engineering work in practice which in the specific case with focus on design engineering include a number of competence not paid so much attention to in the standard engineering curricula. Our graduate's professional profile includes the technical- and social sciences and a heterogeneous engineering competence covering three important dimensions:

- Reflective technological engineering competences, which refer to the reform of teaching and integration of the core engineering curriculum that has been an important part of the design engineering education.

- Creative, synthesis oriented competences aimed at integrating technical and social components during the development of products, systems, processes and services. The education emphasise the development of the students personal, creative potential, engagement and enthusiasm, professional insight and the mastery of methods.
- Innovative, socio-technical competencies to be utilized in the creation and renewal systems and situations where technical organizing and humans interact, and where complex, political decisions confronts the engineering field's way of modelling and optimization. The education aims to give competencies to work with a spectrum of considerations and values.

These significant issues will be supported through a number of courses and projects covering a broad spectrum of professional disciplines reflecting aspects of design processes on individual, organizational, commercial and societal levels.

The project on the fourth semester is "Workspace Design" which is supported by a course "Design of work processes". The objective of this paper is to discuss how participatory design processes can be introduced to the students and to discuss some of the didactic considerations in that sort of engineering design education based on our experiences from the very first class.

2. Workspace design

Workspace design is about designing workplaces and work processes. Workspace is perceived as a heterogeneous entity consisting of individual human work practice, work organization, competencies and artefacts in the work environment. It is strongly related to the ideas of workplace-making which is seeing a workplace as consisting of four interdependent dimensions: space, organization, technology and finance [1]. Workspace design cut across a number of established disciplines such as human factors, man-machine interface, usability, ergonomics, socio-technical analysis and production planning.

Workplace-making in industry and other businesses are often a partly haphazardly and non-managed process leading to workplaces, which need redesign to be optimal. Workspace design practice is about a deliberate staging of collaborative processes in an organization resulting in effective and healthy workplaces and work processes. Workspace design research is about conceptualizing workspace design processes and understanding options and constraints in organizations for staging such processes.

We consider workspace design as an important competence necessary in a modern engineering design curriculum. Some design engineers will end up in jobs in which they are designing machines or production systems and hence directly or indirectly workspaces for other people. Such engineers need to know how to design effective and healthy workspaces. Other design engineers may end up in positions directly concerned with strategic workspace design in organizations. One may anticipate that such positions will become increasingly more important as workplace-making is seen as a strategic tool for transforming organizations, which are able to respond quickly to changing environments.

3. Setting up the framework for learning participatory workspace design

In the planning phase we decided to set up a script for the learning goals, central course contents, and learning principles. The learning goals were formulated:

- The students have to learn how to analyze existing work processes and workplaces as starting point for designing and testing changes, which will contribute to improvements.
- This type of design process has to take place in dialogue with users and to some extent involve the users.

The central course elements were listed in four groups:

- Work processes, work systems and work organization
- Occupational health and safety
- Contextual design: (re-)designing workplaces based on user data
- Workspace design: Designing new work practices embedded in space, organization, finance and technology

The learning principles included:

- A unified learning platform due to a very close and almost seamless relation between the course and the project activities.
- In relation to lectures the students are trained to use different methods.
- The students are working in teams, organizing the design process themselves based on course lectures and textbooks. The teachers determine milestones during the process. The form and content of the milestones are planned by the student teams.
- Students are engaged in:
  - Information gathering and analysis of real workplaces
  - Conceptualization and modelling of new or changed workspaces
  - Testing new concepts and models with users

Given this script we anticipated the following challenges:

- How to get the students to understand that workspaces cannot be designed normatively?
- How to get the students to understand the relationship between problem framing, information gathering, and search for solutions?
- How to give the students skills in user dialogue, user experiments, and user communication?

4. The structure and content of the learning process

The approach taken to learn participatory workspace design was reflected by three fundamentals.

Firstly, the textbooks which were “Excellence by Design” by Turid H. Horgen et al. [1], and “Contextual Design” by Hugh Beyer and Karen Holtzblatt [2]. In different ways they both emphasize how users and user dialogue can be part of the design process. Horgen et al. primarily point to the design of new workplaces as a result of the dialogue and interaction between designers, users and other stakeholders. The design of workplaces is seen as complex organizational processes which must be staged and facilitated by ‘process architects’. In doing so they might use design games and other methods aimed at facilitating the process,

especially enabling users to transcend the daily perception of work and workplace in order to articulate visions and ideas of improved work processes.

Beyer & Holtzblatt set up a methodological approach in which the design solution is to be found 'out there' among the users by the help of methods and tools. Understanding the current work practice of users is a prerequisite to design new and improved workspaces. Different work models are used to reveal aspects of current work practice.

The two textbooks were supplemented with texts on ergonomics introducing some fundamentals and examples on ergonomically sound workplace design.

Secondly, in the project work the teams were assigned a workplace in a company or institution in which they had to identify and attack situations, which neither the company nor the teachers on beforehand had pointed out as problematic. A framework was set up, which to a great extent allowed for independence in the team work. The teachers suggested the teams to appoint a project manager which could be a role shifting between team members. Throughout the project work there was an exchange between the reality at the workplace and a series of activities in the student team. This included work process analysis by help of work models, a design process, and a progressively construction of a physical artefact resulting in a prototype, mock-up or scaled model. The transformation from the workplace reality to a series of design activities was mediated through data collection, user dialogues, and user involvement based on design games. It was for the teams to stage this transformation process.

Thirdly, the evaluation of the *projects* was twofold. First, the teams had to elaborate a PowerPoint presentation of their designs setting up the background, problematic situations, and design solutions. This presentation was targeted to the users and other stakeholders in the workplace, thereby being a sort of sales promotion. Second, the teams were asked to present the design process in a poster. The teams were asked to reflect upon how they had been working as 'process architects' [1], staging the design process, including critical reviews of the methods and tools which they have applied. These two results formed the basis for the examination of the teams. Further, in order to pass the *course*, the students had individually to deliver two essays on workspace design and user-centred design. Based on the theoretical framework in the textbooks they were supposed to reflect critically on their own design process and/or examples given in the books or guest lectures.

The students were working in teams of 5-6 members and assigned a workplace. Table 1 shows the workplaces and the subject of the workspace design task.

Table 1. Workplaces and workspace design tasks

Type of workplace	Workspace design subject
Pharmaceutical company	Layout of new assembly line Design of new work station
Governmental railway agency	Knowledge management in a work group Layout of new office
Super market	Handling of returnable bottles and cans
National railways	Ticket office Combined newsstands and ticket offices
Technical university	Design of flexible classrooms

5. Experiences from the first class

The experiences from the first class going through the course and project are very good. Based on the students' course evaluation, reporting in essays and project presentations, it seems that working with a real workplace was very motivating and giving a feeling of responsibility, e.g. the design solutions had to be feasible and the users had to be involved in a serious way. Different sort of design games with the users turned out to be very strong tools in identifying current work practice and wishes to future workspace design. Figures 1 – 4 illustrates some aspects of the students' project work.

Figure 1. In their own workspace a student team is working with designing layout of a new assembly line in a pharmaceutical company. A new inter-operator communication system based on headsets and displays is also designed due to physical isolation of the operator at each work station. The student team considered this isolation as an unavoidable constraint because the design of work stations already was locked in by the company. To enable operator communication after all, they designed the computerized communication system.

The way we tried to meet the anticipated learning challenges can be summed up in the following points:

- We believe that the students experienced the real-life difficulties in (re-)designing workspaces. Working with real workplaces they became acquainted with organizational dynamics and social processes revealing disagreements and some times even conflicts between managers and workers and workers in-between on how the daily work should be understood and how the workplace could be redesigned. They experienced in small scale the situation of a design consultant meeting his customer and finding out that the customer does not speak with one tongue. Hence, there were no obvious one-way of designing an improved workspace.

  In a postal service the student team was met by their contact person who anticipated and pressed for a specific approach in the design process. He would not let the student

see the actual workplace for a while because he was afraid of ‘contaminating’ their creative thoughts not being able to go beyond the current design concept. Instead he wanted to tell the team about the technical specifications in the process of handling irregular packets at a sorting line. He then imagined the team to search the market for suppliers of technical equipment which could meet the demands of the process. In this situation the team succeeded in acting as a process architect. They negotiated with the contact person and explained him the approach they had planned. This was a tough process including a treat of stopping the cooperation with the student team. Finally, the team succeeded in reframing his predetermined design approach and they started working with exploring the actual work practice involving the users. It turned out that the users contributed new dimensions in the problem setting than the ones he had explained to the team. The team was then able to open a larger design space for solving the current problem of handling irregular packets. The contact person admitted this was a good approach. We believe the settling of this dispute also contributed to initiate a learning process in the technical department of the postal service on how to implement technical design projects.

Figure 2. The student team is testing two dummies (display and headset) of the computerized communication system with operators at the pharmaceutical company.

- The students realized that the problematic situation at the workplace could be framed in different ways and hence pointing to different design solutions. Typically, the student team after the first visit to the company had their own picture of problematic situations which could be subject for design solutions. However, when doing a more thorough analysis based on interviews with users and observations the students were often able to reframe the problematic situations pointing to quite other design solutions because of shift in ownership or origin of the problematic situation.

As an example, one of the student teams was looking at the ticket office at a railway station thinking they should redesign the desk layout. After a period of interviewing and observing from inside the ticket office, they found out that the best way they could improve the ticketing work process was by focussing on the information displays at the station. Ticket office personal was constantly burdened with customers asking how to find sightseeing's in the neighbourhood, busses in a nearby bus terminal and other things not related to railway tickets. Hence, the student team changed the design object to the precincts of the railway station trying to improve the displaying of relevant information.

- We believe that students during the ongoing contact to a real workplace learned a lot of how to bring about dialogue and communication with workspace users. The students had to introduce themselves and arrange the events in which they gathered information on work practice and the users' ideas and comments to redesign. The idea in a contextual inquiry gradually became clear for the students, and they learned to see different aspects of work practice through the lenses of work models. Setting up and playing design games with users forced the students to think of appropriate ways to communicate and engage the users.

  In a pharmaceutical company the student team developed and played a design game with operators of polymer moulding machines. The objective was to gain a detailed knowledge of problematic situations in the daily work practice and the operators' ideas on how these situations could be improved. It was a board game with four different cards: problem cards, favourite cards (benefits in current workplace), solution cards, and inspiration cards. Initially the cards were blank and the operators' had to fill in subjects. In playing the game there was a limited number of card spaces at the board game so the operators had to agree upon how to prioritize problems and solutions. The student team recorded the discussions that aroused during the game and by that they gained detailed knowledge of the nature of problematic situations perceived by the operators and additionally they identified the design ideas of the operators. Playing the design game was an important step in the team's design process informing their further design work.

6. Perspectives

Setting up the workspace design classes in the *design & innovation* programme relates to the current debate of engineering education. In the words of Bucciarelli*: "… engineering education had over-invested in analytical technique and scientific understanding at the expense of the practical, 'hands-on', the creative, the reflective, the social, the constructive, the ethical, the economic – all those dimensions spanning engineering design space"* [3, page 295]. The workspace design project tries to meet some of his suggestions. The students are working in teams (however not cross-disciplinary) with open-ended problems requiring internal negotiations and compromises regarding setting up 'problematic situations' and developing design options.

The workspace design project also relates to the ideas of Donald Schön [4] putting emphasis on problem-setting before problem solving. Observing the work process in the teams, the teachers could identify a collective reflection-in-action and see the students listen to the

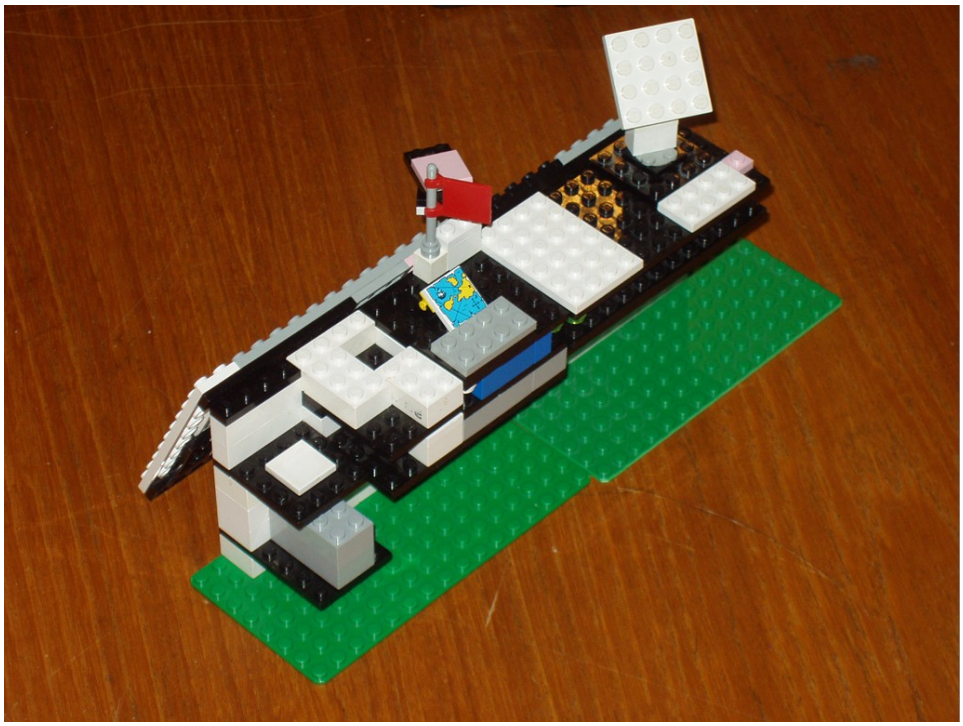

Figure 3. A student team was working with redesign of a counter for combined newsstands and ticket offices at railway stations. They represented their redesign ideas by this LEGO construction, which they presented for the users as the starting point for

Figure 4. The student team is building a game board, which they used as part of a design game aimed at facilitating the knowledge management in a work group at the governmental railway agency. This is an example of workspace design focussing on work organization, competencies and communication rather than physical artefacts in the work environment.

'back-talk' of the situation. This back-talk was more than a cognitive process because of the users. The interaction between the students and the users created a very concrete back-talk which influenced the design process.

The overall approach to teach participatory workspace design seems to be satisfactorily. However, some improvements can be made. We have a thought of letting a senior design student have the role of project manager in the teams.

7. References

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