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The Procedure Usability Game: A Participatory Game for the Development of Complex Medical Procedures & Products

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Abstract
When product designers develop advanced medical appliances, they have to deal with medical treatment procedures. If treatment procedures are ignored by designers, final products might conflicts with the hospital practice. Therefore, the development of procedures and product requirements should take place *before* or parallel with appliance design. However, the development can only be realized when access to the knowledge of users of the appliances is available. This paper discusses the application of a participatory design game to facilitate the participation of users in the development of a treatment procedure including appliances. The game has proven its usefulness in a case study.

Keywords:
Participatory Design, Usability, Design Game, Medical Appliance

1 INTRODUCTION: USE SITUATIONS OF MEDICAL APPLIANCES

Use situations of advanced medical appliances have a complexity that challenges product designers. Five aspects contribute to this complexity, and they are described below.

1. The medical appliances are technically complex products; therefore it is hard to design a simply usable interface that gives access to all functionality.
2. The appliances are integral parts of established treatment procedures that may be unfamiliar to designers.
3. Treatment procedures are complex; they usually include several people and often several appliances.
4. Medical appliances are often used by several different hospital departments [1], users with differing backgrounds must be able to work with the appliances equally well.
5. There are not only many users but also many stakeholders for medical appliances that must be considered. These stakeholders include the hospital managers, who are responsible for the purchase of an appliance and also the patient [1].

The design of a medical appliance, of its interface and of its compatibility always has an influence on treatment procedures that the appliance will be used in. This means that the designer is already –possibly unconsciously- shaping the future treatment procedure when he or she is designing a medical appliance.

In treatment procedures people and appliance use must be well-coordinated to prevent faults in the medical treatment. Since human wellbeing is at stake and doctors time is costly, anticipating the consequences of design decisions is essential when designing medical appliances.

Therefore, development of the treatment procedure that complements the appliance should take place before or parallel to the development of the appliance. Such a design process should prevent the development of appliances that entail complicated procedures.

However, product designers are often unfamiliar with treatment procedures. Therefore, the experience of actual users is crucial for the design of feasible procedures and including appliances.

2 CHALLENGES FOR PARTICIPATORY DESIGN

How can the experience and knowledge of specialist users be accessed?

Observing specialists during their work will evoke questions about reasoning or other invisible “know-how”. Interviews or focus group techniques (group discussions) rely on verbal communication without visual aids. Therefore, they are reliant on the accurate interpretation of each other’s words. Communication becomes complicated when discussing treatment procedures that include parallel actions and several actors.

Additionally, observations, interviews and focus group techniques usually only provide meaningful information about the current situation. A transformation of the information to a new treatment procedure still needs to be done. It is complicated to involve users as co-designers in the design process, especially at the concept generation stage when there is not yet a product design concept available to reflect on. Therefore, in practice specialists are brought into the design process at a point when the initial design choices have already been made, without considering the effects on the treatment procedure.

The authors believe that the participation of specialist users in medical appliance design must start in an earlier stage. Therefore application of a participatory design method that can deal with the challenges of the

development of complex medical appliances is proposed. The focus will be on the development of the treatment procedure instead of just the appliance itself.

To deal with the problems discussed above, a participatory design approach is needed that has six qualities. It should:

1. enable the users to invent and design a *usable new treatment* procedure for a product that has not yet been developed,
2. include *all users at the same time*, so that it can be discussed immediately what a change in one user's domain of responsibility means for the domains of others,
3. give a *clear overview* of a lengthy and complex treatment procedure and the consequences that changes to this procedure have,
4. *trigger the participants to empathise* the new treatment procedure situation.
5. include not only the appliance under consideration but also *other appliances* that are involved in the procedure,
6. be *time efficient* in view of the limited availability of time medical specialists have.

3 THE PARTICIPATORY DESIGN GAME APPROACH

What kind of participatory approach should be used to develop new treatment procedures and the including appliances?

The authors believe that a low-tech participatory game is fit for the task.

It can stimulate users to do concept development by themselves and thereby bring in their specialist expertise. The open character of a game gives the game participants room for independent choices and they can visualize the consequences of their choices [2, 3]. A game helps to achieve commitment. It is simple, and is experienced as more exciting and appealing by participants than other techniques such as focus group discussions. It creates an informal atmosphere which is productive for creative work [4]. In addition, low-tech games can be developed with low effort and at low costs. They can show results within a short period of time.

In summary, a low tech game is cost-effective way to evoke, structure and discuss ideas.

Looking at the existing techniques, it was found that there is no low-tech participatory game approach available that has all six qualities. Therefore a new game was developed and called the Procedure Usability Game (PUG).

PUG is a novel combination of customized participatory techniques. Existing techniques were selected and adapted to complement one another and thereby meet the required qualities.

The viability of the PUG was tested by applying the game to an authentic design problem. The design problem is an actual design case within a medical appliance company. For reasons of intellectual property protection, details of the design case itself cannot be provided in this paper.

However to depicture the PUG clearly we will replace the real case by an illustration case of a design problem that has the same characteristics. This example will be presented in boxes.

The product under consideration has a complexity that can be compared to a computer tomography scanner or to a laryngoscope system. It exists in the state of a "next generation" product system idea: New technical solutions -and thereby new functions- should be added to an existing product to improve the patient treatment. The new treatment the product should deliver was defined. However, the product requirements that would result from implementing the product into a treatment procedure in daily practice were unknown.

Illustration case: Operation room radiotherapy appliance

Topic of the case is the design of a new generation high-tech operation room that includes an appliance for radiotherapy.

The operation room set up including the radiotherapy appliance can be used to perform radiotherapy treatment while there still is an opening in the body from a surgery and the target area can be reached easily, thereby minimizing damage to surrounding tissue.

Traditionally radiotherapy treatment is a separate procedure, given after surgery in a special treatment room.

A radiotherapy appliance is a complex device. A smooth implementation of a radiotherapy appliance into a surgical procedure most likely requires a re-design of the appliance itself, as it has been designed for a different use situation. It probably needs new functionality to be able to treat an area in an open body. In addition the treatment procedure and likely the operation room environment need to be adapted accordingly.

When starting the re-design project a first step should be to develop a feasible treatment procedure.

To develop a feasible treatment procedure that includes the product idea, develops this idea further and distils product requirements, potential users must be involved. Only they own the specialist knowledge about the medical procedures. The PUG was applied to stimulate the specialist users to design future treatment procedures, develop a clearer product concept by identifying the product requirements and possible bottlenecks that result from these procedures.

4 THE PROCEDURE USABILITY GAME

4.1 Game set up

The Procedure Usability Game (PUG) is a low-tech design game. It is a combination of a task flow analysis and a pivot game technique.

Task flow analysis is meant to organize the task flow of different people when doing a task chronologically. A pivot game on the other hand includes a scale model of an environment with persons and appliances that is used to play out tasks.

The two components not only complement each other, but also serve as mutual verification tools for the generated procedure. Both components have their own objective. The task flow analysis helps to capture the procedure in a structured and detailed way. It focuses on chronology, time management, staff deployment and information flow. The pivot game component provides a hands-on experience that clarifies logistical problems and helps participants to envisage the procedure in a realistic hospital setting. By acting out the defined task flow by means of pivots, the treatment developed can be assessed, optimized and verified.

Task flow analysis component

The task flow analysis within the PUG is inspired by the CUTA approach [5] and the CARD technique [6]. It helps the participants to sort out which tasks they wish to achieve using the new medical appliance and in what chronological order these tasks should be executed. A simple card layout was used that is based on the activity oriented CUTA cards that contain fields to fill in an activity, the person that performs the activity and a duration. However, there were added two fields; one regarding the information the user needs to fulfil the task described on the card and a second to indicate whether a task is performed alone or in cooperation with other actors. These additional fields enabled us to record the required information flow and cooperation between users. The developed task flow card scheme was expected to provide a good overview of the procedure and to be easy and efficient to use. It facilitates the recording of the developed procedure by making previous steps continuously visible for all participants. Additionally, it supports an iterative development process since rearrangement of the task flow is easily manageable.

Pivot game component

However, the task flow component of the game does not take care of logistics and might, due to its high level of abstractness, not stimulate the participants to consider all aspects of the treatment procedure. Therefore, the pivot game component has been added to the PUG. It helps participants to envisage the procedure in a realistic hospital setting and to clarify logistics in the new treatment procedure. A pivot is a "physical, symbolic representation that allows a person to move back and forth between a Figured (imagined) world and the real world" [7]. It has been stated in constructionism learning theory that learning can happen most effectively when people are actively creating things in the real world [8]. Designing a new procedure is a process of applying changes and learning what the effects are. Therefore, building the treatment procedure with pivot elements is most likely to support this process. A pivot game also has the capability to bring together people from different backgrounds. The game pieces work as "boundary objects" [4] because the physical game elements make it easy to exchange information [7] and oversee the situation. Many pivot techniques (for example [7]) include only a limited set of rules and are therefore very open. However, sometimes the principle of structured play is used in a pivot game to give it more direction. This means that the interaction the participants must play out is prescribed to some extent. The PUG employs structured play by providing a general treatment scenario consisting of a fictious patient record and treatment advice at the beginning of the game session.

Why low-tech?

For reasons of both effectiveness and efficiency, it was chosen to implement the PUG as a low tech game. The PUG could have been implemented digitally as a computer- or a virtual game, but this would have taken away the hands on experience. Furthermore, making adaptations to the procedure in a digital setting would have required a certain level of computer skills from the participants and therefore possibly a special training. This would have been time-consuming and might have distracted from work on the actual procedure problem.

4.2 Game participants

To develop a feasible treatment procedure, the PUG should ideally be played by the same team of specialists that currently handle the medical treatment procedures in their hospitals.

In the example case the participating team would consist of a surgeon, a surgical nurse and an anaesthetist from the former surgical procedure as well as a radiotherapist, a technician and a clinical physicist from the radiotherapy department. The patient would not be included as a participant since within the considered treatment he or she will be sedated most of the time.

The game is played by one hospital team at a time.

As Törpel [9] points out, the relations of power within the product usage field should be taken into account within the development of participatory design games. This means that in our game the higher ranking surgeon should probably not play together with his support staff, since there would be a chance that the doctor might enforce realization of his own ideas above those of other staff. On the other hand including participants from different backgrounds can be beneficial because they have to reflect on each other's views and thereby become inspired to think beyond their own boundaries [7]. Furthermore, the presence of a game moderator is meant to prevent such conflicts. It was chosen to invite all main users to one joint session to combine the different insights and benefit from the cross-fertilization effect.

Within the PUG, the moderator function is shared; the moderating team consists of a game facilitator, an expert support worker and an observer. The role of the expert support worker is to ensure that the company designers can obtain as much information as possible from the game by asking the participants to clarify or motivate their decisions. This is a task that requires detailed medical knowledge. In our case, the role was therefore fulfilled by an employee of the company with a relevant medical background.

4.3 Game elements

Game material for the PUG was specially designed.

The design case was analyzed in co-operation with the medical appliance company that had provided the case. Based on this, the game elements were chosen. For every game element, a degree of freedom [9] was determined. Degrees of freedom were for example whether the time frame of the introduction of the new product onto the market should be limited or how explicit the description of the problem case (patient data information) should be. Determination of the degree of freedom consists of a trade-off between the minimization of the risk of influencing game participants (and thereby the developed treatment procedure developed) and the "usability" of the game itself, since the game could be impaired by too open and complex a structure.

To prevent the participants from not taking the game seriously, an abstract design of the game pieces was selected. All game material was designed for simplicity while at the same time to making the game look well designed and appealing.

Game board

A central element in the game is the game board that forms the environment for the pivot playing. The layout of the game board is constructed by the users themselves. Since a new treatment procedure must be developed, the participants are given the assignment to "build" the ideal facilities for this procedure by placing "room cards" on a hospital layout game board and assign room characteristics to these cards. This technique helps the participants to go beyond their own hospital context.

In the example case the participants might build an operation room, a recovery room and additional rooms. A new characteristic of the operation room might be a wall shielding, since nuclear radiation will be released during the treatment.

Figure 1 shows the game board and some of the gaming material.

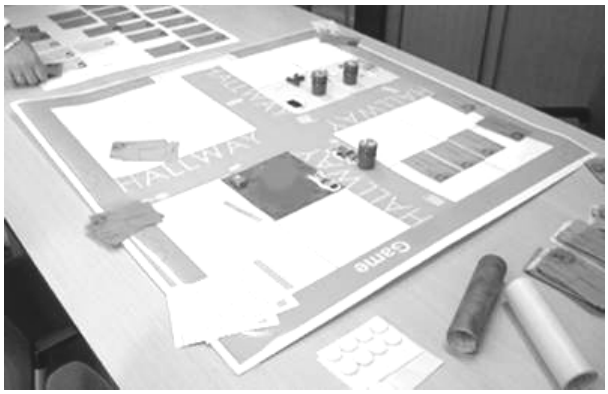

Figure 1: The game board.

Task cards

The lay-out of the cards the players need to fill in as a part of the task flow analysis is based on the activity oriented CUTA technique. They are complemented by a field about the required information and cooperation with other actors. An example of a task card is shown in Figure 2.

Cards were specified regarding the players. For the main players there are three types of personal cards with a representational picture of the player's character on it. By this means it was possible to hand over every participant his or her own set of cards to support the fact that every participant is an associated owner of the developed procedure.

There were also used wild cards, which could be used for additional personages the players possibly wanted to introduce, such as additional assistants.

The PUG cards are colour-coded to indicate categories of activities. A two-colour code indicates whether a task in the procedure represents an addition or change to the existing procedure. With the help of this code it is easy to see which part of the procedure has been redesigned. These new parts of the procedure are the most important to explore in the further product development.

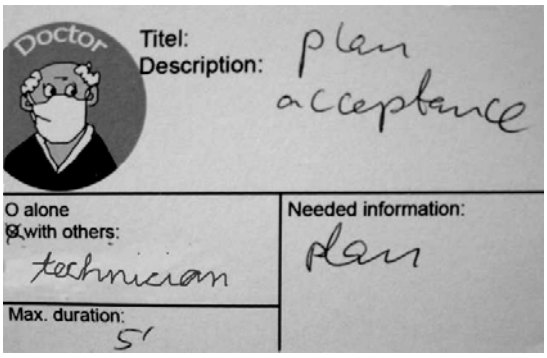

Figure 2: A task card.

Pivots

In between filling in the task cards the game participants play out the defined treatment procedure on the game board with pivots of their own personal representation. To get to know which (future) appliances users would like to use they are provided with game pieces representing appliances. There were pieces for existing appliances as well as unassigned game pieces to represent the new appliances that are needed to perform the new procedure.

In the case of the radiotherapy appliance in the operation room, the participants would be provided with small representations of radio therapy appliances, operation tables, anaesthesia trolleys, lights, computers wit planning systems and surgical instrument tables.

Product/tool cards

Within medical treatment procedures, appliances cannot be associated with single users since they are often used by several users simultaneously. Therefore, separate cards are needed to define the task flow of persons and objects. To give participants the opportunity to assign product characteristics to the appliances used and to document these, product/tool cards are included in the PUG. Game participants are asked to fill in product/tool-cards for every appliance or product they would like to use. On these cards preferred product characteristics can be listed.

On a product/tool card for the operation table might be filled in that it must be compatible with the radiation appliance. On the card for the radiation appliance some technical specifications might be given that are premises for radiation therapy inside a body.

At the end of the game, all product/tool cards are integrated within the task flow by placing them next to the task flow and by linking every product/tool card with the task cards of the tasks the product or tool is needed for. A completed task flow scheme is shown in Figure 3.

Event cards

After participants have developed a complete treatment procedure by the use of the task cards, product/tool cards and the pivots, “events cards” are introduced. Participants are confronted with five descriptions of events that might conflict with the procedure they have conceptualized.

> *An event would be: “The local database crashes… all prepared patient data is lost.”*

The participants are asked to discuss the impact of the events on their procedure, pick out the one event with the greatest impact and adapt the procedure to deal with it. The introduction of events forces the participants to reflect once more on the developed procedure and the identified product requirements and to verify their robustness under all circumstances.

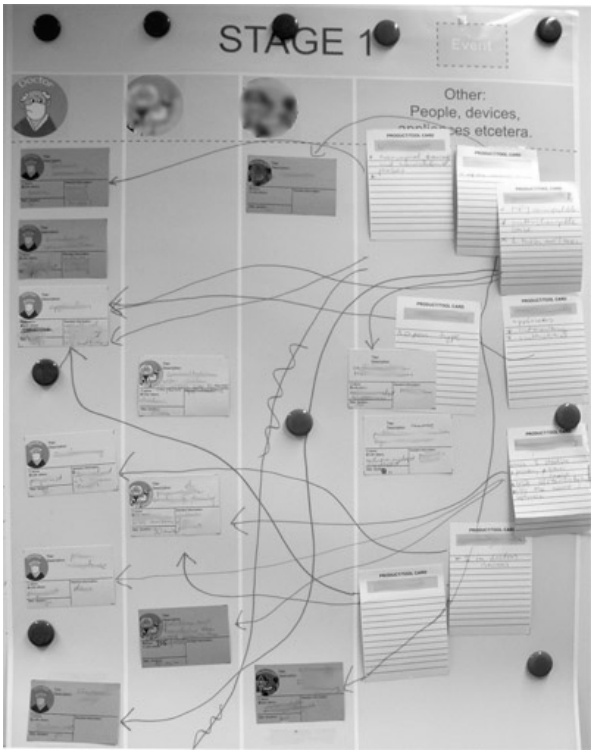

Figure 3: A task flow scheme with product/tool cards (white)

4.4 Over-all game session set up

To give the participants an idea of what awaits them, they received a preparation letter in advance of the game session. In this letter, the general idea for the product improvement was introduced. There was also described a fictitious patient case that would be the basis of the game. The participants were also given an overview of the game**,** its goals and several questions about the treatment procedure the participants were asked to reflect upon in advance.

The game session itself started with a short interview and a discussion with all participants. The purpose was to stimulate team-building among the participants and to obtain some general knowledge about the mindset of the participants. Next, the facilitator gave a short overview of the game structure. The detailed explanation of the game was divided into small pieces so the players could start to engage with the game and would receive the next bit of information just at the moment they were ready for it. The general game structure consisted of alternating the task flow analysis and the pivot game. When the participants reached the point that they were satisfied with the basic procedure and corresponding product requirements they had developed, events were introduced and, if required, changes to the procedure were made accordingly. After the procedure development, a discussion about the feasibility of the results was initiated. The session ended with a debriefing and a “thank you” to the participants. Several weeks after the session the participants received the session report for confirmation of the procedure.

5 RESULTS

To date, two PUG sessions have been run.

The application of the PUG proved to be efficient. A redesign of the procedure could be made and required information could be fully obtained through a three hour gaming session. Both sessions resulted in a complete overview of a new procedure set-up, the required appliance characteristics, the information flow and actor and appliance movements within the hospital. Before the game, participants were critical about the game since they were not familiar with “serious gaming” techniques. Afterwards, participants were surprised at how much coherent information they had been able to generate within the time frame of just three hours.

Players were all engaged during the game. Participants worked well together. Doctors, technicians and supporting staff – all players decided what would be written on his or her own task cards and took part in the discussions.

The task flow set-up was not straightforward but revised several times. This was due to discussions or as a result of the pivot game playing component that revealed that the initially proposed task flow did not work well. The level of detail of the task flow analysis was limited to higher level tasks such as “accepting the treatment plan”. Lower level tasks such as “pushing the button” were not described. The level of detail was automatically applied by the participants. It resulted in enough information for the participants to develop a new treatment procedure and identify appliance requirements. Product tool cards were filled in during pivot playing with several product requirements.

During the discussion at the end of the game, participants stated that the game set up had been really useful, without being asked for a comment on it. They said that the game had helped them address all elements of the procedure and included appliances and prevented them from overlooking the consequences of choices they had made.

The procedure design and requirement information was directly accessible after the game, as it was recorded within the task flow scheme and the product/tool cards. The complete sessions were documented by means of observational reports and video recordings to capture discussion between the participants.

The appliance company was satisfied with the quality of the results and the efficiency with which they were obtained.

The resulting task flow and utilized appliances were similar in the two sessions. Furthermore, important information about bottlenecks in the procedure has been discovered. The most relevant criteria in decision making proved to be the best possible treatment for the patient, the time that the doctor needed for the treatment and practical logistics.

Having product users participate in the product development by playing the PUG resulted in an effective and efficient design process: The results gave designers detailed insight in the ideal treatment procedure and corresponding product requirements – all developed in consensus between the expert users.

6 DISCUSSION

6.1 Working of the game

The PUG's complementary set-up worked as intended. It proved to have the six identified qualities that are needed to develop a new treatment procedure.

1. The PUG makes possible the development of a new complex treatment procedure. It facilitates and structures discussions and makes the involved elements "visible and touchable".
2. All specialist users that work with the appliance were included in one game session and their participation was good. Therefore, it can be stated that the voice of every relevant specialist user of the hospital was heard and reflected in the developed procedure and identified product requirements.
3. The task cards and product tool cards supported the systematic development of the procedure. The task flow card scheme provided a good overview of the procedure. It made manageable adjustments to tasks that had been set up in an earlier stage. The pivots and the game board supported the imagination process. The alternative techniques worked as control mechanisms for each other. The game helped the participants to consider all elements of the procedure and prevented them from overlooking the possible consequences of choices they had made.
4. The game set up worked well in triggering the participants to emphasize the new treatment procedure and product requirements.
5. The set-up included all users, all necessary medical appliances (some of which new concepts that didn't yet exist), pieces of equipment and required rooms.
6. Participants were able to set up a complete - yet new - treatment procedure and identify product requirements within three hours.

The results from two game sessions cannot be seen as a scientific proof of the working of the game or the use of gaming for the development of sophisticated medical appliances. However, scientific proof is hard to realize in this field. Every game session evolves differently and nobody likes to pay for large numbers of sessions that do not deliver relevant new information for the business case. Therefore, the value of a design game can only be related to the amount of worthwhile design information that has been achieved by playing it, the effort that was needed to achieve this, the satisfaction of the company with the results and the economic success and performance of the product that is developed.

As for the amount of information gained, the realised efficiency and the company satisfaction, the PUG has achieved a satisfactorily score: a large amount of information has been gained, a complete new treatment procedure has been designed by the users, an overview of main product requirements has been made and there have been some new insights into bottlenecks within both the new procedure and product requirements.

With respect to the economic success and performance of the product, there cannot be given any indication yet, as the new product is still under development. However, the company is very satisfied with the results of the first gaming sessions. They are planning to continue using gaming techniques.

Overall, the application of the PUG has shown its valve in triggering participants to empathize with a new treatment procedure situation and to provide a clear overview of a lengthy and complex treatment procedure - and the consequences that changes to this procedure have to the product requirements. Merely "talking" about the treatment procedure would most likely have required an enormous memorizing performance on the part of the participants.

6.2 Possible game improvements

In optimizing the PUG, improvements could be made to the game set-up or the organizational setup of the sessions.

Regarding the session setup, it is sometimes advisable to let people work out something individually first (as done within LEGO® Serious Play™; see [10]) and have them afterwards discuss and combine their ideas in shared sessions in order to prevent the situation in which one leader dominates the whole session while the other participants are passive. In the PUG, this has indirectly been realised by means of the questions in the preparation letter. Although there was not perceive any passive behaviour or "overruling" of participants, starting with individual development sessions might be worth a trial to see whether this would deliver a broader spectrum of results. However, this adaptation might have consequences for the time-frame of the game session and thereby its efficiency, which is one of the PUG's strengths.

Every participant will possibly develop the optimum solution with a different priority list of goals in mind. These goals could be, for example: efficiency of the treatment, best treatment for the patient, costs or maintenance of existing structures. The bottlenecks discovered in the procedure can only give some indirect information about this. Although this might be interesting to investigate further, from a commercial perspective it is far more important to know where the boundaries of feasibility are located for the whole team of specialists.

7 CONCLUSION

The concept of using a low-tech participatory design game to develop a new treatment procedure including a innovative new medical appliance was presented. Due to the difficulty of over viewing a medical procedure with all those involved persons, additional appliances and the consequences that changing this procedure might have, a complementary game of combined participatory techniques has been developed. Intended future users of the appliance were asked to participate in this game to provide insight into their roles in the treatment and to benefit from their specialist knowledge and experience.

The Procedure Usability Game (PUG) comprises a custom-made combination of a task-flow analysis and a pivot game. Within this complementary set-up, the task-flow analysis supports a structured development of the procedure whereas the pivot game stimulates envisioning the whole procedure and all the elements within.

The PUG was tested in a commercial medical design case for a medical appliance company. In the organized game sessions the specialist users were able to design a complete new treatment procedure within a time-frame of only three hours. They managed to do this despite the fact that they were not skilled designers. The players showed commitment to solving the problems and enjoyed taking part in the game. Playing the PUG resulted in a large amount of useful information, the design of a complete treatment procedure and insights into possible

bottlenecks in both the new procedure and product requirements. The results obtained - as well as the efficiency of the application of the PUG - were appreciated by the company. It is therefore concluded that the Procedure Usability Game can successfully support the development of a new treatment procedure including an innovative new medical appliance.

As the first applications of the Procedure Usability Game have been a success, there are plans to organize more such gaming sessions for further research on both the procedure and the game. Furthermore, a “follow-up” game will be developed that uses the procedure that has been developed in the first game as a starting point scenario. It is intended to work out the treatment procedure in more detail and enable users to find and validate corresponding product requirements.

The complementary game set-up is also likely to work for non-medical, similarly structured design problems as well. Not only the designers of medical products are confronted with an early phase in the design process where a new product function is defined in general, but the effects of its implementation to a use situation still need to be discovered. We believe that the PUG could be beneficial in the early development phases of every product that is used within lengthy procedures, complex use situations or with various specialised users.

8 ACKNOWLEDGEMENTS

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9 REFERENCES

[1] Martin, J.L., Norris, B.J., Murphy, E. & Crowe, J.A., 2008, Medical device development: The challenge for ergonomics. Applied ergonomics, Vol. 39, pp. 271-283

[2] Brandt, E. and Messeter, J., 2004, Facilitating collaboration through design games. In: Proceedings of Participatory Design Conference 2004.

[3] Johansson, M. and P. Linde, 2005, Playful Collaborative Exploration: New Research Practice in Participatory Design. Journal of Research Practice, 2005. 1(1): p. Article M5.

[4] Brandt, E., 2006, Designing exploratory design games: A framework for participation in participatory design? In: Proceedings of Participatory Design Conference, pp. 57-66. Trento, Italy

[5] Lafrenière, D., 1996, CUTA: A simple, practical low-cost approach to task analysis. Interactions, vol. 3, Issue 5, pp. 35-39

[6] Tudor, L.G., Muller, M.J., Dayton, T. and Root, R.W., 1993, A participatory design technique for high-level task analysis, critique and redesign: The CARD method. In: Proceedings of HFES’93, pp. 295-299(5). Seattle WA, US

[7] Engbakk, S., Rafn, J.K., Urnes, T., Weltzien, Å. & Zanussi, A., 2002, Pivots and structured play: Stimulating creative user input in concept development. In: Proceedings of NordiCHI 10, pp. 187-195. Århus, Denmark

[8] Harel, I. and Papert, S. (eds.), 1991, Constructionism. Noorwood, USA: Ablex Publishing Corporation.

[9] Törpel, B., 2006, The design game in participatory design and design education – Chances, risks and side effects. In: Proceedings participatory Design Conference, pp. 77-86. Trento, Italy

[10] Rasmussen and associates. The science of Lego serious play. Available at www.rasmussen-and-associates.com, accessed march 2008