

ERTRAG – A Participatory Journey

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Abstract

The work-scientific project ERTRAG uses XR to make innovative medical devices tangible without in-person meetings with the goal of reducing psychological and physical stress factors and broadening the range of users' opportunities in their everyday work. To develop XR applications which are deemed usable and useful, different participatory methods were created which integrate all relevant stakeholder groups in every development phase. This paper briefly outlines these methods.

Keywords

XR technology, work design, HTO approach, participation, stress, health

1. Introduction

In the work-scientific project ERTRAG, we embark on a mission to use XR to make innovative medical devices tangible, reducing the need of in-person meetings in order to broaden the range of opportunities for sales and training initiatives in the challenging clinical environment. Two use cases from XR technology serve as technical 'vehicles' in this regard: First, a Remote Mixed Reality Show-Room for medical devices, to improve exchanges about such products between users – that is, healthcare professionals – and the manufacturers' staff; second, a „Hands-On Tangible Tracking“ approach, which links digital 3D models of the products, such as surgical instruments and implants, directly to physical objects which enables an interactive exploration and manipulation of the virtual objects near to realistic experience. In doing so, we, amongst other things, aim to minimize psychological and physical stress factors faced by different professionals, to strengthen their resources, and to contribute to ecological sustainability. Our starting point is the above-mentioned professionals, namely the engineers who develop medical devices such as Stryker's Gamma4 Hip Fracture Nailing System, the sales representatives who train surgeons and surgical technicians (STs) in the use of such devices, and the very same medical professionals - surgeons and STs - who rely on their training in the operating room. We invite all stakeholders on a participative journey in order to ensure that their needs are adequately considered, resulting in XR applications that are deemed usable and useful. In what follows, we retrace the methodological steps that have been taken in ERTRAG, from the initial formulation of ideas to the development of XR prototypes. We end this paper with an outlook on testing these prototypes as one of the last steps on our participatory journey.

2. ERTRAG Procedure Model: Mapping our Participation Journey

As with many good journeys, much of our work in ERTRAG consists of planning / mapping, adapting and journaling. This holds especially true for the development of the procedure model for the participatory design of XR-assisted work systems¹.

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¹"Work systems include the interaction of workers and work equipment to achieve a work result within a specific (possibly also virtual) space and a specific (possibly mobile and distributed over several work locations) environment, as well as the interaction of these components within a (possibly network-like) work organization" [1].

Phase of procedure model	Participation format	Objective	No. of sessions	Participants per stakeholder group	Total no. of participants
Phase 0	Participatory brainstorming	Initial idea generation for application scenarios	1	1	4
Phase 1	Resource & Workload workshops	Resources/Workloads Digital Skills; Application scenarios	13	32 surgeon technicians 6 surgeons 5 sales representatives 5 R&D engineers	48
Phase 1-2	MTO-Workshops	From the status quo to the new work process	4	2	8
Phase 2	Participatory Requirements Engineering	Specification of the requirements for technical prototypes	4	2	8
Phase 3-n	Work System Test	Technical prototype testing and work process	Expected 100	Expected 10-15	Exp. 100

Table 1
Steps of ERTRAG participative journey.

The HTO (Humans, Technology, Organization) principle [2, 3] is at the core of the procedure model and our work in general. This means that in all methods developed and utilized, all three elements of a work system are considered and jointly designed. As far as planning goes, the procedure model is based on previous developments [4] and laid out in terms of a phase structure. The phases currently comprise development / assessment of a use case (phase 0), analysis of status quo (phase 1), goal definition (phase 2), development of the work system (phase 3) and overall project evaluation (phase n, following any further iterations or phases that may be required). Similarly, the participatory methods, which are the units of implementation of the procedure model, are based on existing concepts as well as tailor-made approaches and adaptations. However, as illustrated by the yet undefined phases 4 to n-1, both the individual methods and the procedure model cannot be planned down to the last detail beforehand and have to be adapted to the concrete realities as described by the stakeholders. Methods must be adapted before and during usage, and new insights lead to an adaptation of the overall model. In short: We take both a deductive and inductive approach, and at the end of the participatory journey, we will have journaled a new way to develop XR-assisted work systems. Table 1 gives an overview of the concrete legs of the journey.

2.1. Participatory Brainstorming: Choosing and getting to know the Vehicle

At the beginning of a journey, one might not exactly know where it should end and also the means of travel might not be entirely clear. In terms of our project, most of our stakeholders had little to no preexisting knowledge and experience concerning XR, and it was unclear what it should be used for. Therefore, the first step of our participative journey was to create an initial joint idea of what XR can achieve and how it could be employed. At the same time, we had to deal with a dilemma of participative technology development. On the one hand, we did not want to overly influence idea generation and create ideational path dependencies through pre-existing technologies. On the other hand, starting with a blank slate could have produced the anecdotal need for “faster horses”. Our solution was creating an online ideation workshop format called Participative Brainstorming (PB), based on the Walt Disney Method [5]. Using an online conference tool and an online whiteboard, representatives of the four above mentioned stakeholder groups developed a shared XR idea in three phases. After getting to know each other and watching a brief video on a specific XR application to gain a basic understanding of the concept, the first phase was to develop any kind of ideas of an XR application that would help the participants – without any regard for realism. 29 ideas were generated. In phase two, the participants were asked to select one of the ideas for further development. They decided to proceed thinking about possible applications in the operating room. In relation to this environment, they formulated specific functions and created a visual representation of the focused applications. The surgeon’s perspective



Figure 1: Surgeons' perceived workload and resources (NASA-TLX [8], modified).

combined with the challenging spatial conditions in the operating room implicated requirements for support by XR as well as interesting information for the product development engineers who addressed the question what this could mean for the design of medical instruments used to insert the nail into the bone. Another topic especially relevant to the surgeon assistant was the correct preparation of the implants and instruments and possible pitfalls.

In phase three, the XR developers joined the workshop. They were given a description of the idea developed in the previous phases and a space was opened for discussion on the feasibility of the ideas: Is it realistic to achieve these “destinations” of the journey with the available “vehicles”, might certain aspects need to be adjusted, and what resources and stages are required to travel there successfully? In ERTRAG, the developers assessed the plans as technologically feasible and compatible with the mentioned use cases as “vehicles”.

2.2. Resource and Load Analysis Workshop

Although all stakeholders jointly created a first idea of an XR application in the PB, it became obvious that each of them focused on a specific aspect – their journeys had similar courses, but different destinations. In the subsequent participative methods, we therefore focused on each stakeholder group individually.

Embarking on a journey requires to make clear which loads and resources are present and could hinder or enable to reach the destination: do we have travel provisions and petrol, which things should make their way into our suitcase and which should stay at home, are we in a good condition to face possible challenges of travelling? Therefore, the next step was to gain a clearer picture of these stakeholder groups in terms of the cognitive and physical loads they must bear in their everyday work and the resources they have at their disposal. In moderated Resource and Load Analysis Workshops in line with "Gemeinsame Deutsche Arbeitsschutzstrategie" [6], we therefore cruised with the participants through a broad range of aspects of their work situation, including work organization and collaboration with stakeholders, leadership and social relationships within the team, change processes and corporate culture, as well as technology design. Additional questionnaires on technical affinity and stress levels (TA-EG [7]; NASA-TLX [8]) rounded off the analysis. We conducted in total 13 workshops, eight sessions with in total 32 STs, three sessions with in total six surgeons and one session each for five RD engineers and five sales representatives. Since only four sales representatives completed the survey, we integrated the results of RD and sales into one group to prevent any conclusions being drawn about specific individuals. All stakeholder groups had – among other aspects – high mental and organizational loads, while the RD and sales persons had clearly less physical loads than surgeons and surgeon technicians. Fig. 1 shows, by way of example, the task load results for the surgeons (N=6). Their mean task load index is 11.56 (from maximum 20.00), while this index for STs is 10.09 (N=32) and for RD/sales it is 9.19 (N=9). Their most important resources result from self efficacy and from the social area: a supportive leadership and mutual support in their respective teams. Concerning affinity for electronical devices, the highest affinity was reported by RD/sales (2.78 from maximum 4.00; N=9), followed by STs (2.57; N=32) and surgeons (2.55; N=6).

2.3. HTO Workshop

After discussing the stakeholders' everyday work routines in more general terms, the HTO Workshop [9, 10] targeted a specific task which the respective stakeholder groups chose to be supported by XR. The goal was to explore how the participants perceive XR technologies and which changes they would like to effect regarding their work.

The first of four workshop parts consisted of collecting the positive expectancies and worst-case outcomes regarding the usage of XR. These were used as guiding aspects in the subsequent parts of the workshop. Part two consisted of selecting a concrete task and application scenario for the usage of XR. Here, the workshop participants could either choose from and expand on the application scenarios which were developed by the project team based on the Resource and Load Analysis Workshop, or they could develop a new scenario. In part three of the HTO Workshop, the participants were asked to give a detailed description of the selected work task in the current form, including the people, equipment, communication requirements and qualifications involved. The facilitation team used the input to simultaneously create a process model of the status quo in the software Draw.IO using the K3 process notation [9]. In the last part of the workshop, the status quo model was duplicated and used as a basis for discussing and designing what the new XR-assisted process should look like. The outcome of the HTO workshops was a clearer understanding of the current work processes and what the new processes should look like, specifically which concrete parts should be assisted with XR and which should not, and how activities should be allocated between people and technology.

2.4. Requirements Engineering Workshop

After the HTO Workshop made clear which work task and application scenario was to be designed and which changes stakeholders wish for, it was time to derive concrete socio-technical requirements which can be used by the technical teams to develop XR software. For this reason, we created the Requirements Engineering Workshop. Based on the Domain-Driven Design (DDD) Workshop [11], this method was about integrating the stakeholders, who often do not have programming or software development knowledge, into the development of the XR application by creating a shared language (ubiquitous language in DDD terms) and aligning the software with the real world. To do so, we used the DDD method of Event Storming to take another look at the new XR assisted work process developed in the HTO Workshop. The participants were asked to break down this process into highly detailed activities (DDD: events) and to assign actors (humans, technology, and organization) to them. Furthermore, system dependencies, pitfalls and other significant aspects were noted. This resulted in a shared understanding of how the XR application should work and a flow chart that could be used for prototype development.

2.5. Bridging the Gap: From Workshops to XR

For space constraints we will limit ourselves to the stakeholder group of the surgeons. So how did their ideas and requirements identified through the participatory process shape the development of the XR application? First of all, they decided to be XR-supported by a training scenario for exercising incision steps, which stems directly from the resources and workload workshop. Additional exercise reduces stress and the duration of training, which lowers the burdens of the whole team. The Requirements Engineering Workshop helped identify several key components that have to be incorporated into the XR app. For example, it was specified that the app should have haptic elements, especially regarding surgical tools. In particular, surgeons must learn through motor skills how firmly the incision must – or may – be made within a particular layer so as not to damage surrounding structures. Therefore, the development focuses on Meta's HMDs since these support the Logitech MX Ink stylus, which can be used to simulate different surgical tools and give feedback concerning haptic parameters. Further, surgeons voted for a multi-user app to enable a senior colleague who can advise and give feedback. Upcoming work system tests will show if human-technology-interaction by XR controllers is helpful for the surgeons or if they prefer hand gesture control.

3. Lessons Learned and Outlook

This paper outlines the participative journey ERTRAG undertook with its stakeholder groups aiming at developing XR applications which are deemed usable and useful.

XR software development proceeds in iterative loops in which future users apply and evaluate the technical system in a mostly realistic task context. According to the HTO concept, these tests consider the holistic work task, including personal and organizational criteria, and are therefore called work system tests [12]. The duration of iterations as well as the whole process depends on the resources of application and technical partners, but also on the results of work system tests and resulting to dos. This may be an issue for time-critical environments. Therefore, companies which want to implement participative structures should establish time reserves. While the differentiation of issues of criticality in XR supported environments could fill a separate paper, the participative journey itself is basically suitable for a broad range of environments. Examples of required adaptations could range from a more intensive preparation of participants concerning their knowledge of technology as well as the goals of the participative process dependent on organizational culture, to the case of compliance requirements which hinder external guidance.

The fields of application of XR technology in the ERTRAG project are challenging in different ways. First of all, the participatory process takes up relatively manageable time resources overall; approx. 3 hours per workshop and approx. 1.5 – 2 hours per test run in the work system test (i.e. per person or team testing the application in a task). However, in the clinical environment, especially in the groups of physicians and sales staff who also provide care in the operating room, time resources for organizational development and participation are not provided for and the simultaneous presence of several people from these groups in a workshop is hardly possible.

Additionally, the operating room environment itself presents its challenges. Integrating test tasks for work system tests into the process of a real OR, including the associated data recordings, observation presence, risks to sterility and disruptions to the process that cannot be ruled out, will in the best case be possible with prototypes that have already been tested and matured several times in advance. This poses methodological tasks of test scenario development and validity testing for user-centric XR development, which are usually not relevant in this form in more robust industrial environments.

Nevertheless, it's worth it for everyone involved. Measured against often necessary rectifications, acceptance problems, functional and economic undesirable developments as well as (especially mental) health hazards resulting from inadequately designed technology that is integrated into the work system, the effort of the participatory approach is a worthwhile investment. The involvement of employees in this journey prevents unpleasant surprises upon arrival at the (supposed) destination, improves the framework conditions for healthy and attractive work, creates commitment to successful activities at the "destination", increases the functionality and usefulness of the work system and is also accompanied by the acquisition of new skills, e.g. in technical and communicative areas.

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Declaration on Generative AI

During the preparation of this work, the authors used Qwen 3.8-27b in order to: check grammar and spelling and to: improve writing style. Further, the authors used Mistral Small 4 119B in order to: draft abstract. After using these tools/services, the authors reviewed and edited the content as needed and take full responsibility for the publication's content.

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