Utilizing Experience Goals in Design of Industrial Systems

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ABSTRACT

The core idea of experience-driven design is to define the intended experience before functionality and technology. This is a radical idea for companies that have built their competences around specific technologies. Although many technology companies are willing to shift their focus towards experience-driven design, reports on real-life cases about the utilization of this design approach are rare. As part of an industry-led research program, we introduced experience-driven design to metal industry companies with experience goals as the key technique. Four design cases in three companies showed that the goals are useful in keeping the focus on user experience, but several challenges are still left for future research to tackle. This exploratory research lays ground for future research by providing initial criteria for assessing experience design tools. The results shed light on utilizing experience goals in industrial design projects and help practitioners in planning and managing the product design process with user experience in mind.

Author Keywords

Experience goal; Experience-driven design; Experience design tools; User experience; Industrial systems.

ACM Classification Keywords

Human-centered computing ~ Empirical studies in interaction design.

INTRODUCTION

In early 2000s, researchers introduced the experience-driven design approach, in which an intended user experience (UX) is the primary objective of a design process [10,30], in contrast to problem- or technology-driven design. Designers first define the experience they aim to enable in the users of the design, and only then decide what kind of product, service, or system would best enable the intended experience [4,5,6]. The design space is determined by the intended experience rather than by the technology at hand [18]. However, it seems difficult for technology-driven industry to adopt this kind of an experience-driven design approach, since technological skills in a company often dictate the design space. For example, an experience goal of social connectedness can be implemented in various ways, but a company developing mobile apps typically limits the design opportunities to social apps and does not start to market, say, cruises for singles. The core proposition in experience design, 'experience before product' [5, p.63], is thus rarely realized in industry.

While human-centred design (HCD) [11] and goal-directed design [3] have been widely studied in industry contexts, few works investigate the integration of experience-driven design into product development processes. Most studies about integrating UX design activities to industrial product development examine current practices, such as how the UX work in general has been integrated to the agile development process [28], or which tools the industry uses for experience design [25], rather than the integration of a new tool into a product development process. Rozendaal [25] shows that experience design processes in industry include largely similar properties as HCD, such as iterative development, a somewhat unpredictable process, user insights, prototyping, and empathy tools such as personas. Narratives were used as a tool to explain the intended experience, but how they were used in the different phases of the design process was not studied.

The aim of this research was to understand how experience design could be introduced to product development in companies. Although purely experience-*driven* design was not always possible, we wanted to advance the design process from traditional human-centered design towards an experience-centric approach, and from addressing utilitarian user needs to psychological needs [7]. We used experience goal (Xgoal) [12,32] as the central conceptual tool in transferring research knowledge to practice. An Xgoal is a

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design goal that states "the intended momentary emotion or the emotional relationship/bond that a person has towards the designed product or service" [18]. Thus, an Xgoal is more specific than a generic 'good' or 'pleasant' experience [4, p.11]. Table 1 provides examples of Xgoals defined in the design cases described in this paper. Earlier work has studied how to define what experience to design for, i.e., Xgoal setting [12], so this paper focuses more on the other challenge of experience-driven design: how to design something that could evoke that experience [4, p.11].

This research suggests that for experience design methods, the same applies as for usability testing methods: we should focus on ingredients (design techniques) rather than recipes (design methods) [33]. By focusing on Xgoals, we address the need stated by Woolrych et al. [33]: "HCI needs to focus more on what gets cooked, and how it gets cooked, and not just on how recipes suggest that it could be cooked." Thus, Xgoals focus on what gets cooked, and integrating them to industrial product development focuses on how it gets cooked. Companies have different design practices and the design projects are different. Rather than providing a full recipe by following the experience-driven design process by the book, we aimed to understand if Xgoals can be integrated to existing design processes to help product development teams focus on experiential aspects.

The objective of this research was to integrate Xgoals into design process and study their benefits and drawbacks. This paper specifically examines how Xgoals are used by multi-disciplinary development teams in as realistic product development contexts as possible. By examining four such case studies, this work sheds light on utilizing Xgoals in industrial design projects and proposes criteria for assessing experience design tools.

METHODOLOGY

Since studies on introducing Xgoals to industrial product development appear to be rare, and only one study has investigated the experience design process in industry [25], we only had a tentative idea on how Xgoals could work in industry; no quality criteria existed for experience design tools such as Xgoals. Therefore, exploratory research was chosen as the research approach.

In a research program with metals and engineering industry in Finland, we worked together with several companies to introduce experience-driven design into new product development. The company partners of the research program identified suitable topics for experience design, and a group of researchers worked with each company, following design approaches that suited the case and matched the team's expertise (Table 1). This setup resembled real life design projects in the sense that the project staff was not highly experienced in experience-driven design, and the projects were restricted by several practical limitations.

Our cases were active in different phases of the product development process, although all of them covered phases before the productization only. The cases followed different types of design processes, varying from scenario-based design to iterative agile development. This is why the cases were analyzed based on the different types of activities during the process, rather than distinct development phases. Following the structure of the traditional HCD process [11], we name the main activities as *Investigation* (ISO: Understand and specify of context of use), *Design* (Produce design solutions), and *Evaluation* (Evaluate).

The first activity category is Investigation. All activities aiming at improving team's understanding of the task at hand belong to this category, such as background research (interviewing users of current systems, literature review), defining and analyzing Xgoals or other types of design requirements. The second category, Design, includes the generative activities of ideation and prototyping the actual product concept. Evaluation, the third category, includes assessment of the concepts to identify whether they evoke the intended experiences, and evaluation of the feasibility of candidate Xgoals.

In earlier phases of the research program, we had developed methods for setting Xgoals, but the teams had little experience in using them in design projects. The viewpoints of different stakeholders were included in the Xgoal-setting, where insight and inspiration was sought from company brands, theoretical knowledge about users, stepping into the users' shoes with empathy, possibilities and challenges of new technologies, and vision of renewal [12].

The design cases were executed independently and in different points in time, but some researchers were involved in several cases. Although lessons learned from an earlier case informed and influenced subsequent cases, we are not analyzing the learning process or the design outcomes, but rather aim to understand how Xgoals were utilized in the different activities of design process. The Xgoal utilization analysis of each case was done retrospectively by the researchers who participated the case.

After the project was completed, the groups of researchers reported their Xgoal utilization in the main project activities. They were asked to report general information about the design case, i.e., the columns in Table 1, and how Xgoals were utilized in the three HCD activities. The utilization and impact of Xgoals was analyzed in several meetings with representatives from all project teams, and additional details were added as needed to make the descriptions easier to compare.

DESIGN CASES

This paper analyses four design cases from three companies: *Future Factory, SmartGUI, Remote Operation Station (ROS), and Remote Elevator Control* (Table 1). In the *Future Factory* case, the design project aimed at far reaching future concepts where envisioning the context of

Case	Design brief	Xgoals	Outcome	Approach	Team
Future Factory	An extensive vision of a factory process control room and work practices targeting 10-15 years ahead.	E.g., Trust in automation, Sense of freedom, Ownership of the process, Relatedness to the work community	A science fiction prototype in the form of scenario videos and interaction demonstrators	Future trends analysis and field visits as the basis to set Xgoals. Experience-driven science fiction prototype developed in a series of multidisciplinary co-design workshops [16]. Evaluation with user interviews and a web survey.	2 R&D staff members from the company; 5 researchers (systems usability, experience design); a video production professional
SmartGUI for crane operation	Analyze how the existing crane operation user interface supports Xgoals and what features are still missing, and investigate how the missing features could be implemented.	Supporting competence; Avoiding anxiety	A touch screen graphical user interface for crane operation (functional prototype)	Crane operator interviews and the framework of emotional UX [26,27] as the basis to set Xgoals. Scenarios guided design. 1-day concept design workshop with company staff. Qualitative evaluation of concepts.	1 engineer from the company; 2 researchers (psychology); 6 engineering staff members in concept design workshop
Remote Operator Station (ROS) for cranes	A novel remote operator station concept for container cranes in ports with 'hands-on experience for remote operation'.	Feeling of safe operation; Sense of control; Feeling of presence; Experience of fluent co-operation	Virtual reality based container crane remote operator station simulator (a functional prototype).	Core-Task Analysis [22,23] for work and domain analysis and the Systems Usability Framework [29] to set Xgoals and user requirements. From these, design implications and then design solutions were derived. Xgoals' fulfillment evaluated via user requirements in user tests.	1 usability expert and 1 designer from the company; 5 researchers (systems usability, psychology, interactive technologies)
Remote Elevator Control	A remote control solution for elevators in complex buildings as a mobile application.	E.g., Feeling of control of elevator action; Reduced feeling of waiting	A mobile application for controlling elevators (functional prototype)	The company and researchers jointly defined the Xgoals. Agile development of the mobile application until sufficient for user testing.	2 R&D staff members from the company; 4-6 researchers (computer science, interaction technology)

Table 1. An overview of the design cases.

future factory work was the key. The project started with future trend analysis and by collecting understanding of users and context of use from experts. Based on these, the initial Xgoals were defined in expert workshops and evaluated with potential users. In addition to Xgoals, an overall experience vision "Peace of mind" was set. The team could not have defined Xgoals without an idea of the future context of factory work, and therefore there was a need for a holistic future vision of the concept, i.e., a science fiction prototype that illustrated the Xgoals, which was used as a conversional tool in the evaluations [16]. In summary, a large part of the *Future Factory* case consisted of investigation activities, and a set of Xgoals was one of the main outcomes of the case.

The *Elevator Control* case was quite different from the Future Factory case. Since the company already had a clear vision of the system to be designed, the Xgoals were agreed in the very beginning of the project. Xgoals were based on team members' knowledge of user needs gained from years of domain expertise. Thus, the investigation activities focused on defining how the Xgoals can be met in the given context. In this case, more specific design implications were defined as the outcome of the investigation activities.

In the *Remote Operator Station (ROS)* and *SmartGUI* cases, field studies with actual users were done before setting the Xgoals, and more focused studies followed to indicate the design implications of each Xgoal. In the *ROS* case, also an overall experience vision "Hands-on experience of remote operation" was set.

UTILIZING XGOALS IN PRODUCT DESIGN PROCESS

The following subchapters will expand the case descriptions to the different activities, i.e., Investigation, Design, and Evaluation. We will describe these activities in each case and identify similarities and differences in the utilization of Xgoals in each design process.

Xgoal utilization in Investigation activities

Through Investigation activities, the development team aims to gain an understanding of users, other stakeholders, context of use, future trends, competitors, and anything that helps to design a good interaction concept for the given purpose. The outcome of these activities can include not only Xgoals but also other user requirements, as well as understanding of the context. These outcomes can further be interpreted to concrete design implications. Compared to the ordinary requirements that define *what* to design, Xgoals define *how* the design outcome should feel like.

In our four cases, we could identify three different roles of Investigation activities as illustrated in Figure 1. When the investigation is done in order to understand what could be the best possible experiences, Xgoals can be the final outcome of the analysis (Figure 1, type 1). Xgoals can also be defined mid-way of the analysis, and they are further specified during additional investigation (Figure 1, type 2). If Xgoals are defined in the initial design brief, all analysis activities can focus on understanding how the Xgoals could be realized in the specified context (Figure 1, type 3). The general interplay between analysis and Xgoal identification could follow any of these paths – and Xgoals can be continuously defined and refined during design and evaluation activities.

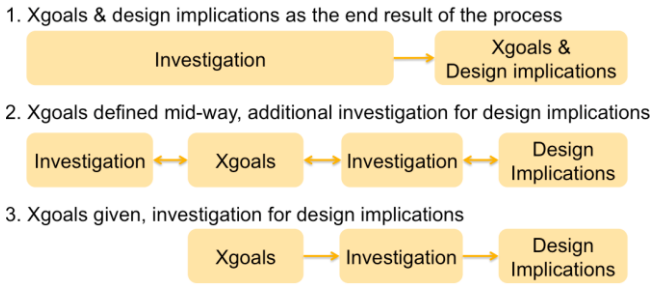

Figure 1. Interplay between investigation activities and Xgoals

Although Figure 1 is simplification of the actual, more iterative processes, it may clarify the overall differences between the cases in the way of Xgoal definition. The *Future Factory* case was of the first type, *ROS* and *SmartGUI* cases the second, and *Elevator Control* case the third type.

In the *Future Factory* case, a preliminary user study included studies of workers' current experiences of process control work and the positive experiences they expect to have in the future. Consequently, Xgoals were defined in a series of multidisciplinary co-design workshops that involved researchers and company partners [13].

In the Remote operator station (*ROS)* case and the SmartGUI cases first phase investigation activities produced an initial set of UX Goals, which was refined based on second phase investigation activities. In the ROS case, the defined Xgoals were used as the basis for some of the questions asked in the interviews of the crane operators in field studies (for details, see [14]). For example, regarding the sense of control Xgoal, the researchers asked the operators' opinion on which factors are important in crane operation to achieve a good sense of control. In this way, the team could also collect feedback on whether the proposed Xgoals were the correct ones. Based on the results of the interviews and field studies, the team defined detailed design implications for the chosen Xgoals (for details, see [15]). The design implications described the specific way to enable each Xgoal in the new product. The *ROS* case went through the following process: Investigation → Xgoals and user requirements → Design implications → Design solutions. Each of the defined user requirements was also connected to the appropriate Xgoal(s). In this way, all the created design solutions based on these requirements were traceable back to the originally defined Xgoals.

The *SmartGUI* team developed an initial set of Xgoals and design heuristics based on 31 crane operator interviews. The Xgoals were "competence support" and "anxiety

avoidance". The Design heuristics were defined to interpret the Xgoals for the design, similar to the Design implications in ROS case. For example, Xgoal Competence was connected to design heuristic "design for middle-level users, but offer shortcuts for experts". The connection between Xgoals and heuristics was established after a user study where, e.g., competence was found to be related to understanding the goals of the task, and not being constrained by the system for doing these tasks. The heuristics were general rules for any design solution while the design implications were more requirements of solutions to be included. For instance, "feeling of presence" Xgoal was interpreted to several design implications regarding operation view and auditory feedback.

In *Elevator Control* case, the teams had gained extensive user understanding from earlier user research, hence there were no specific background research studies. However, formulating the existing knowledge into Xgoals helped in crystallizing the goals of the project. Discussing those goals influenced the design team's general mindset and understanding of the requirements for the design.

Xgoal utilization in Design activities

The original purpose of setting Xgoals is to guide design. In practice, Xgoals are not used in vacuum, but various other guiding forces influence design solutions as well. In *ROS* and *SmartGUI* cases, investigation activities interpreted Xgoals to concrete design implications for design activities. In the *Elevator Control* case, Xgoals were used to create and maintain experience mindset in the design team. In *Future Factory* case, Xgoals were design outcomes similar to future scenarios. These different roles of Xgoals in making design decisions are described in the following.

In the *ROS* case, with the aid of the defined design implications, the team managed to produce design solutions that they considered to be in line with the defined Xgoals. The concept design activity included several co-design workshops in which all the project partners had a possibility to present their ideas. In order for the design team to focus on correct issues, insights from the fieldwork, the Xgoals, the user requirements, and the design implications were all gone through at the beginning of each design workshop. After these workshops, some of the most promising ideas were collaboratively materialized into a variety of low fidelity mock-ups and prototypes. During this process, many alternative design solutions and technological possibilities were considered and iterated. The iterative approach, which assessed the design outcomes, enabled the design team to quickly move towards one basic ROS concept within which different features were altered to fine-tune the concept. To support this activity, the team built a virtual reality based prototype, which was evaluated in two different stages. The user interface of this prototype was iteratively developed according to the defined Xgoals and requirements. However, Xgoals were not emphasized in the UI design phase as strongly as in the concept design phase.

The *SmartGUI* team organized a design workshop, with crane designers as participants, to conceptualize the new interface for operating automated Electric Overhead Traveling (EOT) crane features. In the beginning of the workshop, the Xgoals, their detailed descriptions, and the set of heuristics for evaluating how well the possible concepts supported the targets, were presented to the workshop participants. The participants were assigned into teams for specific design problems involved with the controller concept. The teams were asked to justify each solution using the Xgoals.

The result of the workshop was a number of solutions for the given design problems. However, at this point, the justification of the solutions based on the Xgoals was not visible in the concepts. In the next step, the individual solutions were brought together and made into a prototype controller concept for automated EOT crane features. At this point, the total solution was evaluated with the set of heuristics, determined in the analysis phase to be important regarding the Xgoals.

Although the workshop teams were asked to justify their solutions by reference to the Xgoals, the workshop participants were unsure how much the Xgoals affected their ideas when they were asked about this at the end of the workshop. It is probable that the introduction to the Xgoals at the beginning of the workshop gave some ideas and a common framework for the conceptualization, but that the Xgoals were not explicitly present. The reason for this may be that the Xgoals Competence and Avoiding Anxiety were too abstract to be understood as design guidance, whereas the heuristics perhaps were too concrete and detailed to give room for new ideas to serve the operationalization of concrete design solutions to the given problems. It was perhaps not possible to examine how the concepts would exactly affect or otherwise be connected to the Xgoals. Another possibility is that the Xgoals were not contextually rich enough, that is, their explicit application would have required more contextual narrative around them. However, when producing the final concept by combining the workshop results, more careful evaluation of how the concepts related to the Xgoals was conducted, and each concept was explicitly justified in connection to the goals.

In the *Elevator Control* case, the Xgoals were set quickly in the beginning of the project, after which they guided the initial ideation phase and provided a common context and understanding of the project goals. In this case, the overall design solution was decided before the project started (a mobile application). This is why Xgoals did not play as big role in design as technical feasibility or basic usability.

In the *Elevator Control* case, the use of the actual Xgoals in the design phase was limited to providing a common context and understanding of the project goals (a UX mindset of sorts). Although informed by the Xgoals and user feedback during evaluations, actual day-to-day design decisions within the iterative software development process

tended to be based more on the practical considerations of the case, such as available technological platforms and their features and defects. For example, the timed elevator call feature, which resonates with most of the stated Xgoals, had to be implemented to call the elevator after a specified time, instead of users being able to set the arrival time of the elevator in the lobby, because the desired functionality could not be technologically supported. While the Xgoals did not often directly influence the design activities, they were linked to the changes that were made as a result of design activities informed by the findings of user evaluations. For example, the addition of a rule-based predictive floor selection, improved feedback on the elevator call status and physical touch interface can be seen as attempts to reduce the feeling of waiting, fostering better the feeling of control over the elevator system, and providing better guidance. One of the challenges in applying the Xgoals was that it was not possible to accomplish them to the extent that would have been desirable. Many ideas motivated by the Xgoals were rejected for their complexity, unrealistic technological requirements or uncertain robustness.

In the *Future Factory* case the Xgoals were expected to guide the design towards positive experiences and help in communicating important objectives [5]. The Xgoals gained quite an important role in the project as they formed the backbone for the future concepts and the science fiction prototype. In the design phase both future scenarios and Xgoals for them were developed. The drivers for the Future Factory concept were increasingly intelligent automation, new technical possibilities for remote control, remote presence of workers, and new collaboration practices. The design outcome was an extensive set of scenarios that formed a coherent future vision, a science fiction prototype, and complementary interaction demos. The Xgoals were prioritized based on user feedback, and product development company's perspectives about future technology, societal and business trends. After the prioritization, a brainstorming session was organized to group the most interesting Xgoals, user needs and future trends and to develop the initial concept candidates. The Xgoals were then used to further develop the concepts and especially to describe the usage scenarios. It should be noted that the initial Xgoals were refined in parallel to co-designing the future scenarios. In practice, it was difficult to use Xgoals to narrow down design options, as Xgoals seemed to always produce new design possibilities and opportunities. As the variety of scenarios represented multiple work situations, also the Xgoals varied in different scenarios. Still, in the end of the process, eight main Xgoals were agreed on, and they were used as the UX evaluation framework. The final Xgoals reflect well how user experiences in process control work focus on work activities instead of mere tools or user interfaces (as predicted in [21]).

Based on the experiences of the four cases, we can conclude that keeping the focus on experience is challenging even if the Xgoals would have been interpreted to concrete design implications as in the ROS and SmartGUI cases. Xgoals may be too abstract for designers to take as an input, whereas too concrete interpretations such as heuristics may not leave room for ideation. However, even if there is no concrete evidence on how Xgoals guide design, they can be beneficial in maintaining experience mindset in the design team. This happened in the Elevator control case and also in the Smart GUI case. In an ideal case, Xgoals form the backbone for whole design as happened in the Future Factory case. Then designing Xgoals gets as important as designing the actual concepts, and Xgoals do not just reflect user interaction but work experience in general.

Xgoal utilization in Evaluation activities

The Evaluation activities cover testing of the generated idea, sketches, prototypes, or the actual product. As a part of the human-centred design process, Xgoals in evaluation can be used to study whether the design evokes the desired experiences and whether the targeted experiences were what the users wanted. All our cases studied the former but the latter was present only in the Future Factory case. where it was studied whether the Xgoals were desired and valuable. A challenge in each case was that experience was not the only aspect to be studied, so experience evaluation methods had to be combined with other methods. As identified in the ROS case, experience evaluation would require a realistic setup of an actual work environment. Operating a prototype of the user interface does not raise work related experiences such as competence or feeling of presence.

Elevator Control

The first prototype of the *Elevator Control* was subjected to an initial user experience evaluation and a subsequent long-term evaluation with four participants. Based on the results of these studies, improvements and new features were implemented to the prototype. After this, a larger scale long-term evaluation was organized.

Questionnaires probing expectations and user experiences were used both in the initial user evaluation and in the larger-scale evaluation. Both times, the SUXES method [31] was utilized. Some aspects of the Xgoals where thus covered already by the existing items in the method. For example, the feeling of being in control over the elevator system will supposedly increase if the user experiences using the application to be fast, pleasant, clear and so on. Hence, the Xgoals were indirectly assessed with these statements, although not explicitly used as measures.

However, in the latter evaluation items to explicitly correspond to the Xgoals were added. The background information questionnaire asked how the participants feel about waiting for the elevator, and do they feel they have to wait for too long. For the expectations and experiences

questionnaires, three additional statements were constructed to directly assess the design against the set Xgoals:

- I am able to control the elevator better when using the application.
- Using the application shortens the time I need to spend waiting for the elevator.
- Using the application expedites my daily movement.

As a result of the user studies, additional design requirements were identified that contributed to the realization of the Xgoals: offer real value to users, keep the user informed of system status, and ensure reliability of control. The latter are fairly practical and it is reasonably easy to provide examples of how to operationalize them in effective designs, whereas the first one is analogous with the Xgoal provided in the design brief.

SmartGUI

The *SmartGUI* team evaluated the initial design concepts using the heuristics for the Xgoals, and the final concept was evaluated with a prototype in a field experiment. The data from the field experiments consisted of think aloud protocols collected during the testing of the prototype controller, and of interviews conducted after the experiment. The participants of the field experiment were given tasks, which they had to complete with the prototype controller. The tasks were designed so that each aspect of the prototype would be tested. While the tasks were not designed to directly evaluate either competence support or anxiety avoidance, it was expected that the operators would be able to reflect on their emotional states during the tasks.

Both Xgoals were utilized in creating the interview questions. Themes such as being determined, having clear task goals, understanding each step in the interface use, not having to perform seemingly unnecessary actions, being able to operate the crane freely, being free from doubt and confusion, and not feeling anxious about the automated features, were connected to the competence support and anxiety avoidance Xgoals.

The think aloud protocols were analyzed using protocol analysis, in which focus was placed on thinking errors made by the participants. These errors were primarily connected to the usability of the prototype user interface. The reason for not utilizing the Xgoals in the protocol analysis was that the protocols did not relate to the goals. The protocols were detailed and task-oriented, and the goals were more descriptive of the general emotional states of the users throughout their working days. The interviews following the actual test were more suited for evaluating how the concepts related to the Xgoals. The evaluation tasks were short, of course, and contextually reduced, so much of the feedback concerning the Xgoals was hypothetical; the real results would have required more realistic setting and a longer time period.

As the result of the evaluation, five concrete design changes and five discussion points were presented. While most of the points related to the details of the concept, all could be indirectly connected with the Xgoals. However, no explicit reference to either Xgoals was made in these concluding points of the evaluation.

Remote Operator Station

The first-phase evaluation with 20 university students investigated how, and whether, the user experiences about the ROS simulator interface could be enhanced with either force feedback or visual augmentations. Here, the team emphasized the Xgoals especially in the design of the questionnaires. Since the global number of target users is very small and even domain experts are available only in few select locations, the first phase evaluation was done with 20 university students. The target at this point was to evaluate how, and whether, the user experiences of the ROS simulator could be enhanced. Based on the results received from the first-phase evaluation, for example, the amount of events triggering the force feedback was decreased. Overall, the results affected the improvement of user interface solutions supporting the Xgoals and the selections between the implemented options.

After further development efforts, another evaluation study of the prototype system was conducted with six work-domain experts. The objectives of this study were both to compare the UX of two different user interface concepts and to receive feedback on how well the Xgoals of experience of safe operation, sense of control, and feeling of presence are fulfilled with the developed ROS prototype.

This second evaluation was conducted with a simulator version of the ROS system, which was operated with two industrial joysticks and a tablet computer (see Fig. 2). A 32-inch display placed on the operator's desk provided the main operating view, which included virtual reality camera views and simulated, but realistic operational data.

To evaluate how the originally defined Xgoals and user requirements are fulfilled with the evaluated prototype, the team used a combination of different methods: interviews, questionnaires, thinking-aloud, and task performance

Figure 2. Concept illustration of the ROS system with the four-view setup in the main display

indicators (for details, see [13]). To assess whether the chosen Xgoals were fulfilled with the system, a Usability Case (UC) method [17] was utilized. In line with the UC method, the data gathered from the user studies was carefully analyzed regarding each defined user requirement (i.e., a subclaim in UC) on whether positive or negative cumulative evidence was found about the fulfillment of each requirement. This fulfillment was based on the arguments derived from the evidence. On the basis of the fulfillment of different user requirements, it was possible to determine whether a certain Xgoal (i.e., a claim in the UC) was fulfilled or not. If most of the user requirements connected to a certain goal were met, then also the Xgoal could be said to have been fulfilled. In addition to this kind of evidence-based reasoning, the UC method also provided data on the usability and UX of the concepts under evaluation. These results supported the design work by providing feedback for future development.

The evaluation results indicate that the evaluated concepts had both positive and negative aspects. The design of the final concept solution should be based on the positive aspects taken from both of the evaluated concepts. According to the results, the experience of safe operation and feeling of presence were not supported with the current version of the system. However, it was difficult to assess the fulfillment of these goals with the developed prototype as the operations were conducted in a virtual world where no human lives were at danger and the presented camera views were not real ones. Despite this fact, there was, however, clear support for the fulfillment of the sense of control Xgoal in the results, for example, because the used joysticks were felt to be robust enough and to control the crane with an appropriate feel of operation. In addition, the possibility to freely decide when to start and stop operating and to easily adjust the speed of operation with the joysticks were felt to be positive features supporting sense of control.

In general, it can also be said that the originally defined main experience vision of 'hands-on remote operation experience' was not yet fulfilled with the current prototype system. In the future development, the requirements that were not met should be taken under careful investigation and answered with sufficient solutions. In this way, also the defined Xgoals could be met better with the final ROS system.

Future Factory

For the future factory case two complementary user research setups with expert control room operators and process control workers were established. In the first evaluation setup, the participants were introduced to the Science Fiction Prototype (SFP) via YouTube videos embedded in a Web questionnaire. The questionnaire included a discussion space that was active for a two-month period. In all, 58 experts participated in the Web survey; 16 of whom were active commentators. The participants were selected from among the customer companies of the project's participating company and they had work experience of process control work up to 41 years. The second evaluation setup included interviews conducted in situ in a municipal power. In addition to seeing the SFP via YouTube videos, the participants were also able to try out speech and gesture control demos. The evaluations included six operators (all male) aged 27–34.

The Web survey consisted of both closed and open-ended questions; the interview setup consisted of a video interview with user analysis and a semi-structured interview. In both groups, the participants assessed six video scenes, one at a time; the main difference between the evaluation setups was that in the Web survey the participants could choose which of the six scenes they wanted to see and comment first. The eight Xgoals were used as the evaluation framework in the quantitative part of the user evaluation. The users were requested to assess if they could identify with the Xgoals, after seeing each video scene, by answering a UX significance questionnaire with a 5-point Likert scale. The users in both research setups answered the same open-ended questions related to the SFP; in addition, they were requested to analyze the new interaction methods and deliver new ideas. As a final part, the participants were allowed to give overall feedback on the presented future control room environment.

The UX significance questionnaire worked very well in assessing the strengths and weaknesses of the future scenarios, as by using it there was a possibility to gain an understanding of how the nominated Xgoals were received by the expert process control workers. The interviews and the free comments in the Web survey complemented the results by reasoning the expected experiences. In addition, the interviews gave feedback to whether the presented concepts were feasible, needed, and valuable; whether the future work environment was conceivable and desired; and whether the Xgoals were desired and valuable.

DISCUSSION

We reported four cases where Xgoals were utilized during the three HCD activities: Investigation, Design, and Evaluation. While user experience was important in each case, only the *Future Factory* case was able to define the Xgoals before the product. In other cases, the product was defined in the design brief (Table 1), although the exact functionality was still open for discussion.

Our projects invested very different amount of resources into the Investigation activities: when the team was familiar with the context and users, they could agree on the Xgoals quickly, as in the *Elevator Control* case. The other extreme was the *Future Factory* case that studied the possible futures and developed Xgoals similarly to future scenarios: both Xgoals and scenarios were evaluated, refined or redefined along the process. The process from Xgoals to the final science fiction prototype was not straightforward, since the Xgoals were changed as the future vision was changed. While Xgoals are meant to help focusing on the

key experiences, in *Future Factory* case they actually broadened the focus. It seems that the further ahead the project targets are and the more open the end result is, the more time it seems to take to define the Xgoals. Most cases had either a single high-level experience vision (*ROS* and *Future Factory*) or two main Xgoals (*SmartGUI*). These may be easier to share and to keep in the design team's mind than a long list of Xgoals. If there are several Xgoals, defining a unifying experience vision may help in sharing and memorizing the overall goal.

Once Xgoals are defined, they need to be operationalized in generative design activities. In design, we identified three distinct challenges: 1) finding the appropriate abstraction level of Xgoals, 2) translating Xgoals into appropriate guidance for design, and 3) directing and keeping focus on experience. First, our experiences show that Xgoals work well in creating and maintaining an experience mindset within the design team but it is challenging to find the right abstraction level for Xgoals. High-level Xgoals are not tangible enough to guide design but too specific experience based heuristics, as in the *SmartGUI* case, may hinder ideation. Second, the *Elevator Control* case highlights the difficulty in translating Xgoals, and more generally insights generated from user requirements, into actionable design solutions. In the small development team, the original Xgoals were not formally processed into a specific set of design implications although the means to turn Xgoals into design solutions were discussed within the team during development. Hence, the Xgoals provided only generic guidance for design (e.g., providing remote control opportunities and reducing the feeling of waiting) while leaving a lot of freedom for the designers to realize the concept as practical design solutions. In the *ROS* case, on the other hand, an elaborated process was used to get from Xgoals to the design solutions. The benefit of such a process is that it is possible to trace the design solutions back to the Xgoals for validation purposes. However, the potential downside is that the use of a new process that the designers and developers may be unfamiliar with could add overhead to the design process. More research is needed to study in which conditions Xgoals can be translated to design implications, and how complex the relations can be. Third, the *Future Factory* case showed how Xgoals can form the experiential backbone for the developed product concepts. While the use of Xgoals managed to turn the design focus to how the work will feel instead of how the interaction will feel, it will be interesting to see whether this focus can be maintained through the subsequent product development process.

Regarding evaluation activities, Xgoals were successfully used in planning the evaluation. For example, the interview questions in *SmartGUI* case and additional survey questions in *Elevator Control* case were based on the Xgoals, and the UX significance questionnaire used in the *Future Factory* case helped to evaluate whether the intended experience was realized and how the experience was valued. However, evaluating design outcomes against Xgoals was not as straightforward. Xgoals are only a part of a longer list of design requirements; they are not always in the focus of evaluation. For example, some teams were used to using certain questionnaires that provided only indirect feedback of the Xgoals. Also, testing preliminary prototypes against the Xgoals proved to be difficult. Functional, contextual and aesthetic shortcomings directed the attention to pragmatic rather than emotional aspects of experience.

Originally, we expected Xgoals to act as evaluation criteria for meeting experiential goals, but evaluations of the design concepts sometimes revealed the need to reconsider the Xgoals themselves. This validation of the Xgoals turned out to be a more important and challenging activity than expected when planning this research, and ultimately it proved to be useful to ensure the Xgoals are focused on appropriate aspects of experience.

Exploratory research such as the one reported in this paper can help develop frameworks for future studies. Based on our findings, we have developed initial criteria for assessing the usefulness of experience design tools (such as Xgoals) in real life design (Table 2).

Activity	**Assessment criteria: Does the tool help in…**
Investi-gation	1. Stepping into the users' shoes with empathy 2. Sharing experiential design goals to different stakeholders
Design	3. Creating meaningful experiential concepts 4. Tracing design choices back to the intended experiences
Evalua-tion	5. Defining criteria for evaluation of experiential aspects of the design 6. Evaluating whether a design is moving towards the intended experience(s)
Overall	7. Integrating experience aspects with other design aspects (technology, safety, etc.) 8. Making experience design more systematic and enabling continuous improvement 9. Improving user experience of the design outcome

Table 2. Criteria for assessing the usefulness of experience design tools

Limitations

The studied cases had many external limitations affecting the utilization of Xgoals, and thus the cases are not meant to be model examples. However, we deliberately wanted to study Xgoals in realistic contexts and understand how the context influences Xgoal utilization. As such, the real limitations for this study do not lie in the circumstances but rather in the research setup that did not employ a full separation of concerns: rather than assigning the design tasks entirely to the company staff, researchers were doing

more than half of the work. In some cases, this was close to subcontracting, which is an increasingly common context of industrial product development. A highly intriguing future research line would be to study Xgoal utilization in companies where experience-driven design is routine.

CONCLUSIONS

The variety of the design projects and real-life constraints in the industry make it challenging for companies to adopt any given experience-driven design method as a rigorous process. Our research suggests that when introducing experience design methods to industrial product development, the same applies as for usability evaluation methods: we should focus on ingredients and meals rather than recipes [33]. We took Xgoals as an ingredient to be added to the design projects and followed how this affected the process. Unfortunately, we cannot analyze if Xgoals made the outcome better, since it is practically impossible to run a controlled experiment comparing industrial design processes with and without Xgoals. Instead, we reported utilization of the Xgoals during the design process by analyzing four design cases against three activities: Investigation, Design, and Evaluation. We address knowledge transfer from design discipline to design practice and therefore our findings have both scientific and practical implications. Below, we summarize the main benefits and challenges in each typical activity and the related research topics for the future.

Although Xgoals were originally meant to aid focusing the design activities on experience, this research found that Xgoals can also serve Investigation activities by providing a framework for user studies or by crystallizing emphatic understanding about users. The main challenge in the investigation activities was related to Xgoal definition. Recent work, which was not available at the time of this research, has identified possible sources for setting Xgoals [12] and defined the Xgoal Elicitation Process [32]. Examples of possible Xgoals may help designers get inspiration, and indeed, there exist many experience/emotion card sets designed for this purpose [1,19,34, see also[1]]. Future research is still needed for investigating the different formats, level of abstraction, and hierarchy of representing experience visions, Xgoals, and design implications.

Regarding the Design activities, high-level Xgoals helped to create and maintain an experience mindset within the design team. The main challenge was the jump from high-level Xgoals to practical design solutions. For seasoned interaction designers or design researchers this may not be a problem, but for developers who are used to solving specific technical challenges, high-level Xgoals need to be processed into more specific design guidelines. In the *ROS* case, a specific process to get from Xgoals to design solutions was successfully trialed [15], and *SmartGUI* concretized Xgoals as scenarios. Other known solutions include experience patterns [8] and design strategies for commonly used Xgoals [19]. Future research on analyzing the role of Xgoals in design should pay attention to fostering an empathic mindset of the development team, the means of deriving design requirements from Xgoals, and tracing the Xgoals throughout the design process.

Finally, Xgoals were successfully utilized in planning Evaluation activities and there is potential in utilizing Xgoals evaluation criteria. However, our evaluation activities faced several of challenges (see Discussion). The main challenge to be addressed in future research is to find means to evaluate the designs against the Xgoals, and do it as early as possible during the design process.

This research addressed the lack of studies on integrating results of methodology research with real-life product development projects. We created project teams consisting of both researchers and industry professionals, and let the project work follow the structure typical for the team. The main intervention was the introduction of Xgoals to the design process. Documenting this research process will hopefully help others conduct similar studies in the future. Based on this exploratory study, we derived criteria for assessing tools aiming to improve experience design processes in the industry. These criteria will help experience design tool developers and provide a basis for researchers to conduct similar studies in the future.

Our design cases were the initial attempt at introducing Xgoals in companies and thus the results are far from optimal. Nevertheless, the research contributed to two products that have been successfully launched on the market[2,3]. The company stakeholders saw Xgoals as a highly promising technique that helped the teams to focus on user experience, and they are motivated to utilize Xgoals in other projects as well. One reason is that focusing on the experience offers remarkable possibilities for organizations to renew and differentiate [9]. However, if future research is planned on introducing the 'experience before product' idea [5, p.63] to the industry, studying product development projects might not be the right focus area. Companies plan their product portfolios, technology roadmaps, and market strategies well before the product development starts, which means experience goals should be introduced to the strategic operations. Company-wide experience goals [24] might be one way to get there.

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[1] https://hassenzahl.wordpress.com/experience-design-tools

[2] http://www.konecranes.com/remote-operating-station-ros

[3] https://play.google.com/store/apps/details?id=com.kone.mop

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