Organizational Aspects of the Introduction of a User-Centered Design Process

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Abstract

The paper describes the introduction of a user-centered design (UCD) process into a large-scale software development organization and the effects it had on existing processes, roles and other organizational aspects. The case described here shows how a standard UCD process was incrementally implemented and adapted to the organization's overall product lifecycle. The paper also discusses how process effectiveness and efficiency can be assessed and what benefit assessment models can bring regarding process improvement.

1 Introduction

The benefits of the user-centered design (UCD) approach for the different stakeholders – ranging from end-users over customers to suppliers – are well known. The methods that are usually applied to achieve a user-centered design process are extensively described in publications by Mayhew (1992), Nielsen (1993), Preece (1994), Shneiderman (1998), Beyer and Holtzblatt (1998), Cooper and Reimann (2003) and many others. Additionally, process models have been specified that describe sub-processes, roles, tasks, and associated work products of user-centered design processes (for examples cf. Usability Engineering Lifecycle by Mayhew 1999, ISO 13407, ISO TR 18529, Usability Maturity Model by Earthy 1999). All these models are valuable and essential for researchers and practitioners in the HCI field. However, it is still a challenge to establish a user-centered design process in a large software development organization. The general process models have to be adapted to organizational conditions and vice versa. This includes the definition or re-definition of roles, tasks, ways of communication, artifacts, authority of decision-making, responsibilities, existing processes, etc. Concerning this topic only few case studies are available (e. g. Wiklund, 1994; Rudisill et al., 1996) and even less scientific publications. Although some authors address organizational issues (e. g. Mayhew, 1999; Quesenbery, 2001), they do not provide a systematic approach of how to implement a UCD process. Until now, it is not brought out how to assess an implemented UCD process quantitatively or qualitatively and what variables can be used for an evaluation. The authors will describe what aspects have to be considered while integrating a UCD process into a large software development organization. Especially the sub-processes of the UCD process, roles, tasks and associated work products will be discussed. This will be described using an example, where a UCD process was incrementally implemented in a large software development organization over a period of three years.

2 A generalized User-Centered Design Process

Before an organization can implement a UCD process it is necessary that the organization understands what a UCD process is and what sub-processes and tasks it consists of. One way to gain knowledge about UCD processes is to consult the existing literature on process models. The existing UCD process models do vary in terminology, number of phases, names of roles, and level of detail of description. If one takes a closer look at these models, it becomes obvious, that they are comparable on a higher level (Woletz & Zimmermann, 2004).

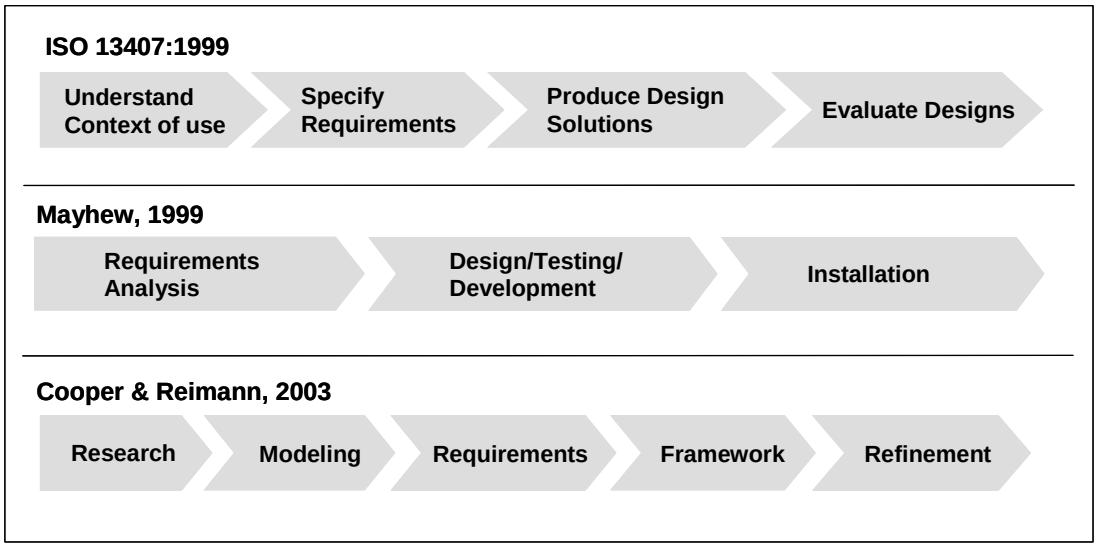

Fig. 1: Comparison of UCD process models

All models enclose the following four "core" tasks of usability engineering:

Gather requirements
During this phase information about the users, their tasks, the work environment, customers, markets and so on is gathered systematically. Also, general user interface design principles and guidelines are identified and reviewed and usability goals are set.

Create Concepts
The collected information is analyzed and used to build the structure of the user interface. In larger projects it is also used to structure the product portfolio and to organize and plan the project steps. The main output of this task is usually user and workflow models, use cases, and/or persona descriptions.

Produce Designs
During this step the concepts are translated into designs and evaluated with users. In the early stages the design is visualized through sketches, wire frames, mock-ups and prototypes. Later, these work products become more and more detailed and final screens describing the UI are created and UI specifications are defined.

Evaluate
The evaluation of concepts and designs is done using methods ranging from peer reviews, normative tests, focus groups to performance and usability tests. The results are fed back into the concept and design activities.

The first three tasks are usually done more or less sequentially. The analysis of requirements should be completed before the concepts are created. Translation of concepts into designs can start as soon as concepts are available, but it is essential for the designer to understand the overall rational of the user interface. The fourth task, the evaluation, needs to be done in parallel to the concept and design activities. Some of the UCD process models contain an additional fifth task, the so-called support or installation task which takes place after the new product is released. Users are supported in using the new product and user feedback can be gathered as input for further development.

To achieve a generalized model of a UCD process, each task can be assigned to a phase of the process (see figure 2).

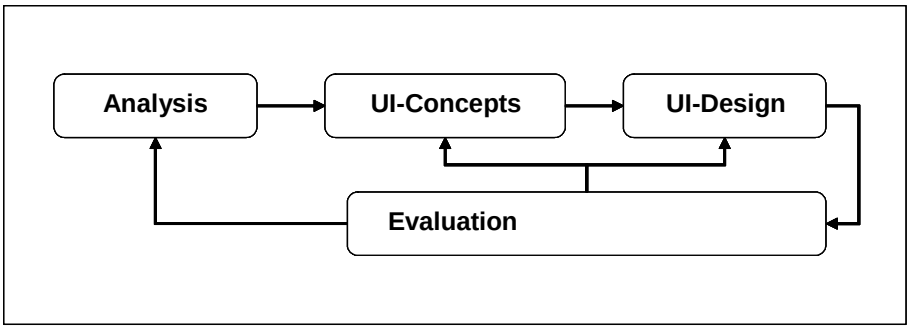

Fig. 2: A generalized UCD process

The following chapter will describe how these four usability engineering process phases have been incrementally implemented into a software developing organization.

3 Introducing UCD Processes into an Organization – A Case Study

The introduction of a user centered design process in a software development organization usually has to be based on existing business processes and practices. In most cases different groups already perform a certain amount of usability related tasks. In such an organizational environment the implementation of a new, complete usability process means to re-arrange the way things are done, to change the range of individual responsibilities, and to set new priorities. Also the area of accountability and the authority to make decisions has to be revisited.
This paper describes the introduction of a user-centered design process at Siemens Medical Solutions (SMS). The product developed is a healthcare information system providing support for clinicians in all areas of a healthcare enterprise. The situation prior to the product analysis and design process reengineering was sub-optimal. Even though some product teams added a phase for usability testing prior to the product's beta test, they did not incorporate analysis and design practices up front in the development process. In a lot of cases the clinical product analysts included mock-ups, wire frames or sketches, example screens from other systems to illustrate the concept of the desired functionality – with the expectation that the technical designers and developers translate these into screens. On the development side, however, the sketches were usually taken verbatim and coded exactly as shown by the product analysts' artifact, resulting in inconsistent and less usable solutions. There was a clear gap in the development process - both sides expected the other party to develop the actual UI design, a situation that is not uncommon in a lot of traditional development models.

3.1 Goal and Expected Outcome of the Process Redesign

For new projects, products, or releases, an organization usually investigates ways to enhance their performance in meeting the company's business goals (e.g. decrease time-to-market, increase usability, decrease requirement volatility). Business processes are scrutinized as well as organizational structures or quality and document management. Especially if there are deficiencies in the current process, the question of "evolution vs. revolution" is likely to be raised. In the authors' experience, the deciding factor is the degree of innovation or independence from existing solutions. For example for a new release of an existing product, it is usually not recommended to completely change the process model, so an evolution in smaller steps is more appropriate. On the other hand, for the next generation of a product, revolutionizing the process is appropriate in order to set it up correctly from the beginning.
The new analysis and design process described here was expected to support different goals. From a UCD point of view, the first one was to ensure proper user and task analysis and sufficient stakeholder and user validation to complement and confirm the analysis work. The second one was to define a consistent UI design framework as a basis for all up-coming members of the new product-family.

3.2 Introducing and integrating new processes

The new UCD process had to be integrated into and aligned with the overall SMS product lifecycle process. Thus, the general UCD model described above had to be adapted to the existing processes, procedures and milestones. The

SMS product lifecycle is subdivided into five phases (see figure 3). As the concept and elaboration phase activities usually range from gathering requirements, creating concepts and designs to validation with domain experts or end users, the choice was to integrate the majority of UCD activities into these phases. The process encompasses activities carried out by two different roles: product analysts and UI analysts.

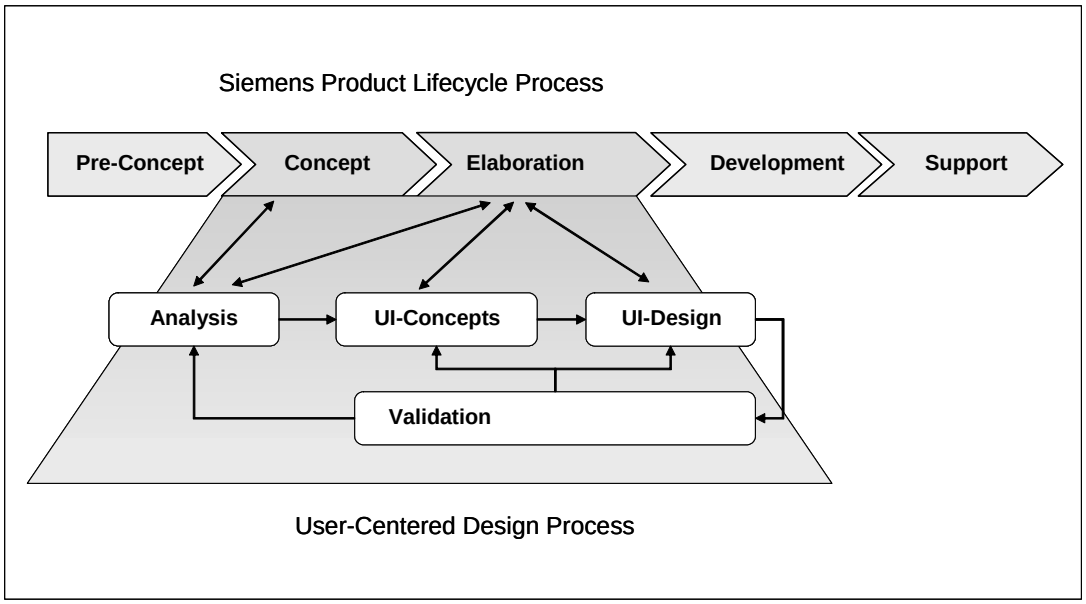

Fig. 3: Integration of UCD process

The introduction of the UCD process had several priorities. The first one was to optimize the requirements analysis process to revolve around use cases. The designated role for this task was the product analyst, but since a good part of the use case audience was the UI designer, there was a lot of initial collaboration to focus the artifact on the right elements and levels of detail. The benefit of this use case based analysis was not only continued conformance with the UML based analysis process in place, but also much wider availability of domain knowledge than conveyed through a list of requirements. The use case format enabled the subject matter experts to share their knowledge and experience specifically pertaining to clinical workflows and tasks with the downstream organization in a structured and effective way.

In addition to the introduction of use cases, a new artifact called User Interface Specification was introduced. The aim was to separate workflow analysis and system conceptualization, allowing the product analysts to concentrate on workflow and non-functional requirements, while the UI analyst focused on the system concept, information architecture, interaction model and Screen design. Knowing that this change redistributed parts of their previous tasks and responsibilities, a lot of emphasis was put on shared ownership of a complete analysis package. Thus the initial work was rather educational and focused on obtaining buy-in than looking at the mere analysis work.

In order to extend the knowledge gained in this new process to the downstream organization (e.g. the development or testing teams), the work mode of collaboration was introduced at the handover point between the elaboration and design phases. In these sessions, analysts, developers, and testers walked through the complete body of analysis for a given project or module in order to ensure unambiguous and complete understanding.

3.3 Organizational Aspects

The second priority of process rollout was to establish ownership and decision authority. In a large enterprise, this is a crucial element of process introduction. ISO 9001 requires the complete analysis and design work to be traceable in documents or requirement repositories. Therefore the organization relies on the various stakeholders to document their results and relate them to existing requirements. Usually a review and release process is applied to prevent errors from being identified too late. Considering these factors, the UI Specification (owned by the UI design team)

was introduced as a new mandatory artifact in the company's Quality Management System (QMS). The QMS group understood its benefit for ensuring traceability of workflow and UI requirements through the process and provided support for ensuring compliance in the organization. In a second iteration, review and approval authority was established. As analysis and design documents were reviewed and approved by various stakeholders, the UI designers were included as reviewers for those documents that govern their work (both project and product related). Over time, this was extended to approval or rejection authority for the key documents utilized as baseline for the UI work (e.g. use cases, project plan, etc.). The UI analysts thus gained a considerable influence on the direction of the project and the respective product, transitioning from document contributors to reviewers to approvers. This ensured a UI and usability focus on many levels of product and project planning.

The two strongest supporters in this process have been upper management and quality management. Upper management had to be convinced that the change is actually going to improve product quality as they had the authority to establish the organizational framework and to mandate the changes to the affected teams. Quality management's main goal was to establish and support repeatable and manageable processes throughout the organization. Thus, a more comprehensive analysis process instead of a mere feature based approach easily found their support, which facilitated the implementation into the organization's standard process model.

3.4 UCD at Siemens Med HS CS today

The current UCD process at Siemens Medical Solutions is shown in figure 4 and explained in the following section. It starts with the concept phase where the initial **requirement analysis** happens. The product analysts elicit business needs, stakeholder requests, feature and non-functional requirements. These high level requirements are documented and serve as the basis for product scope and effort planning. The requirement analysis is continued during the elaboration phase, where more detailed workflow descriptions are gathered.

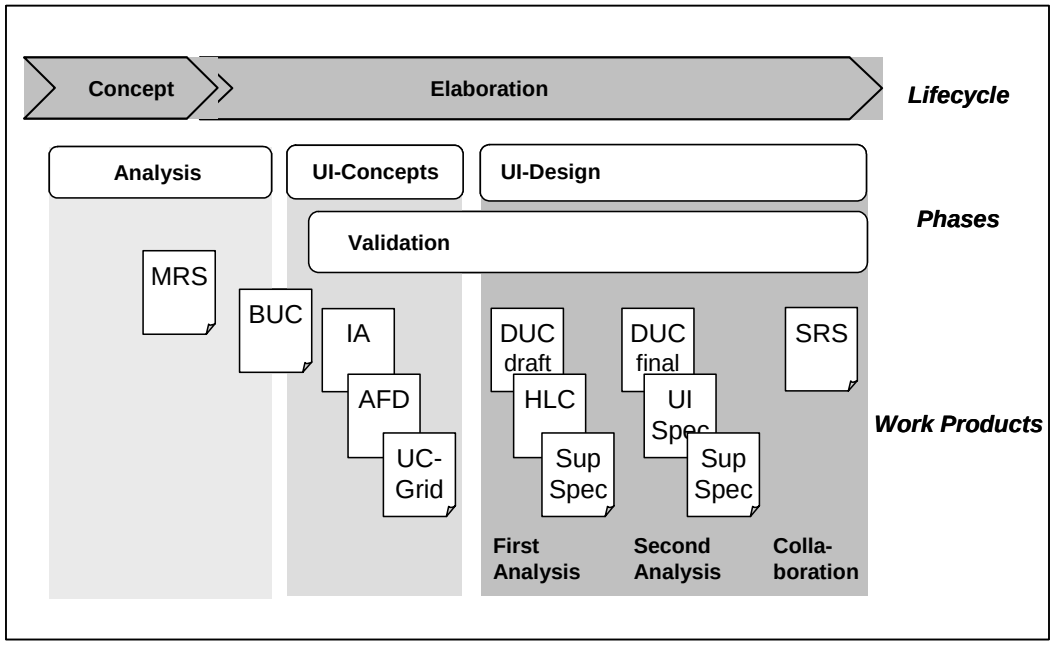

Fig. 4: Adapting of UCD process model to Siemens processes

With the creation of the business use cases (BUC), the **UI concepts phase** gets started. The BUCs describe users' roles and their main tasks and goals. They serve as input to the planning process, where scope and number of detailed use cases and supplemental specification documents are defined. The documents are grouped into analysis packages containing the relevant documents for a certain task context.

The next step is to create the information architecture (IA) for the system. The UI analyst derives the main information and interaction areas from the business use cases, and documents the resulting structure. Based on this

structure, the UI specification documents are identified. Together with the planned detail use cases, the identified UI specifications are consolidated and cross-referenced in an analysis artifact grid.

The next phase, the **UI design phase** is carried out in three iterations and starts with the **first analysis phase** where the first drafts of the detailed use cases (DUC) are written. They typically contain the „happy paths“ through the workflows, pre- and post-conditions, and the business rules and serve as input to the UI analysts, who create the concepts that specify the UI on a high level, usually captured in wire frames, sketches or flows. Validation of the high level concepts is done as needed, using either prototypes or mock-ups.
At the end of the first analysis phase the analysis outcomes are reviewed. The purpose of this review is that the UI analysts understand and interpret the requirements correctly and the initial concepts fulfill them.

In the **second analysis phase** the product analysts complete the analysis documents. At this stage the detailed use cases contain all the alternate workflows and all data definitions. These documents provide input to the UI analysts to refine and complete the concepts and designs.
The UI analysts create the UI Specification containing the final screen designs and interaction descriptions for all features and workflows. At the end of this process step all analysis documents are synchronized to ensure that all requirements are covered by the solutions.

Validation, both with internal stakeholders and external users, occurs alongside all analysis phases. Starting with the validation of workflows and feature requirements, through review of concepts, wire frames and mockups, to evaluation of prototypes and final screens, stakeholders are involved in all iterations of the conceptualization.

The last step in the UI design process is the **collaboration phase**. Collaboration sessions between product analysts, UI analysts and system designers are conducted to make sure the downstream organizations understand the requirements, the specified solutions and also to resolve open issues. After this handover point the technical design, coding, testing and documentation processes follow, which turn the system concept into the actual solution.

In summary, the UCD process at Siemens Medical Solutions matured over the years and today is in many aspects close to an ideal process model as described in section three. Nevertheless, there are areas that can be further optimized, e.g. through integration of UCD activities with the downstream processes, especially testing and the user documentation as well as through enhancement of the UCD process into the product support phase. In order to get continued support for these activities, there is a need to demonstrate overall gains in business objective achievement. Thus, it is necessary to measure efficiency and effectiveness of the implemented processes.

4 Evaluating Effectiveness and Efficiency

During and after the implementation or optimization of a UCD process an organization usually wants to understand how effective and efficient the process is carried out. One possibility to measure this is to look at the process outputs and to draw conclusions about the quality of the process. This is problematic for two reasons: First, a less usable product might indicate an ineffective UCD process but a product with high usability does not necessarily mean the process was effective. After all, the output can be of high quality by pure coincidence. Second, even though process characteristics that influence the product quality can usually be identified and operationalized as independent variable, a development project is also characterized by changes due to organizational adjustments, e.g. to changing markets or environments. Hence, it is not possible to keep the independent variables stable and conclusions about causal or correlative relations between process and product are not reliable. Therefore an evaluation needs to cover both effectiveness and efficiency. In the following sections the authors describe approaches to assess the process effectiveness and efficiency for the four core phases of a UCD process.

Requirement Analysis Phase
The key objective of the requirement analysis phase is to achieve a complete set of requirements that accurately and consistently describe the task, workflow and contextual needs of target users. In order to evaluate these effectiveness criteria, several indicators can be used. Completeness could be assessed through counting the number of requirements that have been discovered after the analysis has been concluded. For the evaluation of requirement accuracy, their durability and degree of confirmation through user validation can be used. The stability/volatility of requirements throughout the product lifecycle is indicative of the analysis consistency.

In order to assess the process efficiency, i.e. the relative effort required to meet the effectiveness goals, the number of iterations needed to solidify a requirement, the number of requirements that are deprecated before the finalization of analysis and the overall length and effort put into the analysis phase can be used as indicators.

Concept & Design Phases
As user interface concepts and designs tend to be different elaboration levels or iterations for a given solution, the evaluation criteria are very comparable and differ mostly in the scope of the assessment methods.
The expected outcome of the concept phase is a set of conceptual models (e.g. information architecture, interaction model, storyboard, and wireframes) that support the requirements in the most usable way. The design phase is expected to yield the actual solution specification (e.g. screen layouts, activity/sequence models, detailed interaction description). Both concepts and designs need to be understandable, complete and consistent.
Validation feedback from users or other stakeholders can be used to assess the comprehensibility, e.g. by the number of clarifications needed or usage errors in prototype walkthroughs or system usability tests. The completeness can be evaluated by calculating the percentage of functional and non-functional requirements that a concept or design addresses and the number of conceptual or design clarifications needed after analysis. Consistency is best assessed through user and expert feedback, i.e. the number of issues brought up through the different levels of validation.
In order to investigate the efficiency of these processes, the number of iterations needed to complete both concept and design and the percentage of revised/added/removed elements can serve as proxies.

Validation Phase
The validation phase is a special area, as on the one side it generates different evaluation data for the assessment of the other UCD phases, but on the other side also deserves to be optimized and monitored based on effectiveness and efficiency criteria.
Standard quality measures for validation results are representativeness (i.e. to which degree did the validation cover the complete breadth and depth of the system as well as the variability in user and usage types), objectiveness (i.e. how independent of observer, observation setting and other uncontrolled influences was the validation), and reliability (i.e. how stable are the findings, either over time or in terms of internal consistency). Together with the degree of feedback-absorption in the UCD process (i.e. how much feedback is turned into concept or design changes) they can be applied to estimate the prognostic/ecological validity of the findings and thus the effectiveness of the validation.
For the evaluation of validation efficiency, the overall effort for conducting the validation and the appropriate choice of validation methods (i.e. how suitable a method is for generating the intended result type) can be used as approximations.

Both from scientific and from organizational point of view efficiency and effectiveness are fundamental dimensions to assess process quality. If an organization does not just want to assess, but also improve process quality, knowledge about effectiveness and efficiency is generally not sufficient because it lacks specific and tangible measures for future improvement. One way to obtain these measures is to compare the existing organizational process with a reference model, and to use the results as basis for improvement actions. Appropriate reference models for UCD processes are contained in the Usability Maturity Model (Earthy, 1999), the Human-System life cycle process model (ISO/IEC, 2001) and the KESSU Usability Design Process Model (Jokela, 2004). All these models allow both identifying the current status of process maturity, and deriving appropriate measures of improvement. But, those assessment results are only applicable and beneficial if the process maturity measurement is reliable and valid. To examine this is a crucial topic in the HCI field that up to now has been addressed in only a few studies (Bevan & Earthy 2001, Jokela 2001, Woletz, in prep.).

5 Discussion of Results

A variety of organizational factors need to be considered when a large-scale software development company implements a user-centered design process. Based on the experiences gained in the implementation of UCD processes at Siemens Medical Solutions, the main factors for a successful implementation of a user-centered design process are:

- Support by upper management and quality management
- Establishing a new team, that is responsible for the usability of the product

- Organizational integration of the UI team into the Product Management division, fostering a close collaboration between UI Designers and Product Managers
- Re-definition of responsibilities and decision making authority (here: giving the UI Team authority of approval about key documents)
- Adjustment of operations including re-assignment of responsibilities between different roles, definition of dependencies between specific tasks and process steps and introduction of new artifacts as mandatory deliverables for all projects

The authors have identified approaches to apply these interventions and their advantages and disadvantages as well as qualitative and quantitative criteria to evaluate the implementation success and the overall process efficiency.

The case study showed that the implementation of a usability engineering process aims at multiple goals. The authors believe that it is necessary but not sufficient to deal with aspects on a mere operational level, e.g. regarding what methods should be conducted or what tools should be used. The main focus has to be on the organizational level. Thus, the implementation of a usability engineering process is a significant intervention and needs to be conducted systematically and with knowledge about organizational conditions and constraints.

Only few research studies have been conducted concerning the introduction of a usability engineering process into a software-producing organization. In future research the influencing factors, dependent and independent variables should be further described and analyzed and a systematic evaluation should be conducted. The authors see this as an important emerging area requiring further research.
Furthermore, criteria and indicators should be developed that allow valid and reliable UCD process assessments in a given organizational scenario. Finally, the authors see a research need in systematically analyzing UCD process assessment methods regarding their viability for process evaluation and optimization.

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