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Employing UX Processes for More Focused Development in Research Projects

Ari KOLBEINSSON [a,1], Jessica LINDBLOM [b] and Peter THORVALD [a]
[a] *University of Skövde, School of Engineering Science, 541 28 Skövde, Sweden*
[b] *University of Skövde, School of Informatics, 541 28 Skövde, Sweden*

Abstract. The aim of this paper is to highlight some benefits of incorporating usability/user experience (UX) approaches in the software development process of research projects advancing digital human modeling (DHM), and how these processes, approaches, and methods can help keeping the development process more focused and efficient. Research projects that contain large software development components may receive funding only to complete the core tasks, and including additional persons in a project may seem like a waste of resources. This paper introduces user research that relied on a UX approach called *contextual inquiry* to ascertain user goals and how those might be translated into features for DHM named IMMA that has been developed as a part of numerous research projects in the last decade. The goal of the study is to support DHM development in general through highlighting methods and approaches that can be used, with specific results aimed to support the continued development of IMMA. Results clearly show that existing functions do not support the goals of the user group examined, and highlights the need of understanding user goals and creating functions to support achieving those goals, rather than assuming what functionalities might be needed. By understanding user goals, interpreting those into activities and functionalities time and resources can be used more effectively, which is important for small to medium research projects, where both time and budget may be limited.

Keywords. Contextual Inquiry, DHM Development, UX, Activity Theory

1. Introduction

Clear development processes exist for products as well as software [1]. These processes include lessons learned to avoid common pitfalls, as well as allowing for iterative approaches [1, 2], and including sub-processes for mechanical safety, software quality assurance, as well as for ensuring good usability/user experience within the product. From the users' point of view, a technical system that is suitable for its purpose, easy to use, and fits into its intended context are just basic. Users have also started to demand a positive experience when interacting with technological artifacts, beyond utility, usability, and acceptance [1, 2]. Broadly speaking, UX, in addition to ensuring usability, addresses the feelings created and shaped by the use of technology and how technology can be designed to create a positive user experience [1]. For this to be possible, UX processes posit that first the intended users have to be identified and described, and then focused upon during the whole UX design (UXD) lifecycle process (described as

[1] Corresponding Author, Email: ari.kolbeinsson@his.se.

the UX wheel). The process is iterative and consists of the four key elements of UX activities; analyze, design, implement, and evaluate [1, 2].

Research projects differ from commercial development projects in many ways, one of which is that standard development processes often do not align with other requirements of projects, such as educational requirements of graduate students or the scientific contribution requirements of most members. This can lead to common development processes not being followed, and specialists who are not critical to the academic and scientific contribution of the system being developed may not be involved in the process to the required degree from the beginning. One such specialization is the UX specialist or the usability designer, a role often left out of smaller development projects.

It is widely recognized that there is a substantial gap between UX research and practice, where UXD approaches are rarely applied. Although there is a large interest in UXD, organizational priority and competence is often lacking. Instead one relies heavily on questionable approaches such as designing systems for "trained professionals" to excuse the low effort towards UXD processes [3]. Not following development or design processes, and not including relevant (but peripheral to the academic side) specialists and project managers is a known hazard that can lead to problems down the line [4], and can have negative consequences for the quality of whatever is being developed, as well as the scientific validity of the research conducted along the way [4].

The focus in this paper is to highlight why and how the inclusion of UX specialists and UX processes throughout a project may be beneficial, not only to the finished product and the bottom line when selling a system developed in research projects but also to optimize the rest of the development process through a having a stronger focus on the intended end-users and a clearer idea of what is actually needed from the project, as opposed to researchers' assumptions based on their own needs.

This was explored through the study of one identified user group that would benefit from the use of DHM software to support their own analyses, namely ergonomists who use existing manual tools to evaluate work in multiple companies. These ergonomists evaluate various tasks, including office tasks and industrial tasks in both large and small factories, relying heavily on their own expertise in applying standards (by law) and tighter constraints (guidelines within companies) and evaluating work activities based on observation, interviews, and other manual and digital tools.

The first steps of a user study will be examined where a projected primary user group of digital human modeling (DHM) software for ergonomics simulation is interviewed, and user goals (i.e. what users want to achieve) are mapped. These user goals are then translated into possible features, and these were compared to available features in the IMMA DHM software [5] through interviews with specialists in the software. The final section discusses the impact of any identified discrepancies between features that exist and features that would support achieving the goals required by this user group.

2. Method

This study relies on an approach used in the analyze activity of the UXD process, called *contextual inquiry*, which uses a master-apprentice approach to exploring the domain [1, 2]. Contextual inquiry is based on a 'quick and dirty' ethnographic

approach, and is useful in many parts of a development process, but can give particularly good insights into the domain being explored early in the analyze activity. Contextual inquiry allows UX specialists to learn what the relevant questions actually are through interviews, discussions, and observation of domain experts to [1, 2, 6, 7]. Applying the contextual inquiry approach requires first identifying some user groups, although these may be redefined during the process.

User groups were identified through discussions with stakeholders within the research project. One groups was identified as being important and interesting to study in more detail, and had in fact been discussed by stakeholders working on the IMMA DHM system during previous projects: practical ergonomists working in the field. This group was identified as being important as they constitute an envisioned target user group of the IMMA system, and interesting because this group has a very different background and skillset when compared to ergonomists working in research who may work more with DHM simulation software and CAD systems.

Identifying potential users in this way through discussions with stakeholders is commonly used method in the discovery and analyze activity of a development process [1, 2, 6], with more details emerging through interviews with these users that allow further defining primary, secondary, and tertiary (or supplemental) user groups.

This can be used later in the UXD process to identify candidates for creating personas for other approaches such as *scenario-based design* where identified user goals are first consolidated, and data is used to create personas (pretend users that are essentially aggregated from the data that has been gathered) and can be used for various methods of usability and UX evaluations [1, 2].

2.1. IMMA at a glance

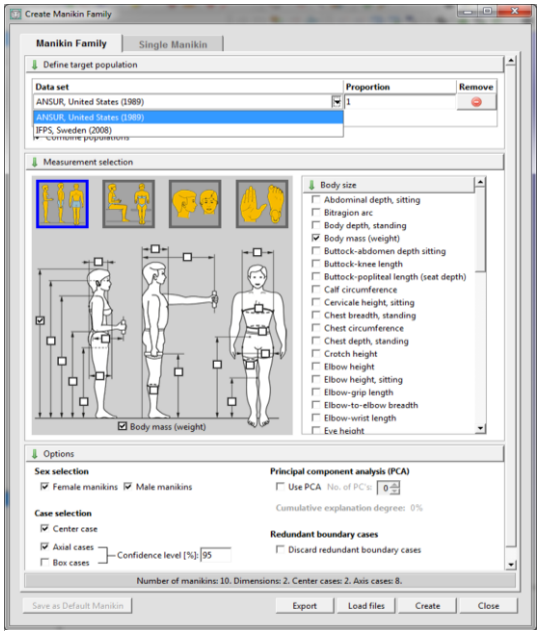

Figure 1. IMMA manikin family creation dialog. Here the user can create multiple manikins for testing based on anthropometric databases. Measurements can be selected as appropriate.

IMMA is a DHM tool created to allow the evaluation of ergonomic factors in assembly stations in manufacturing, even before the assembly station is created. As such, IMMA simulates a manikin or group of manikins (referred to as a manikin family, see Figures 1 and 2) in an environment, performing tasks such as assembly or climbing into the cab of a truck, and forces for each joint are calculated. This works with complex geometries, using path simulation software to generate paths which object will need to take to avoid collisions. IMMA can perform these calculations with families of manikins that are created from ergonomics databases, thus highlighting the ergonomic attributes of a task for different people.

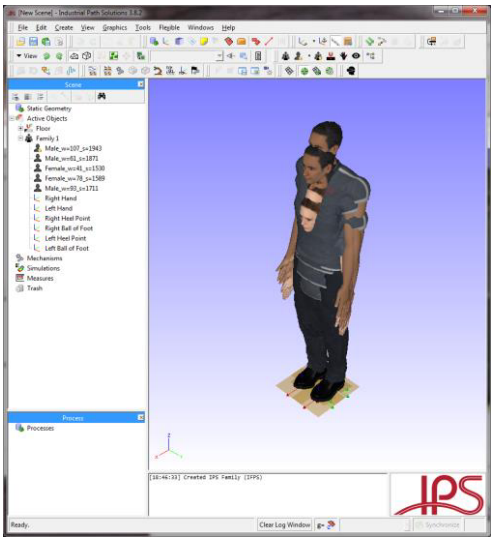

Figure 2. A family of manikins has be created and can now be used for ergonomic analysis of an activity for a range of "people".

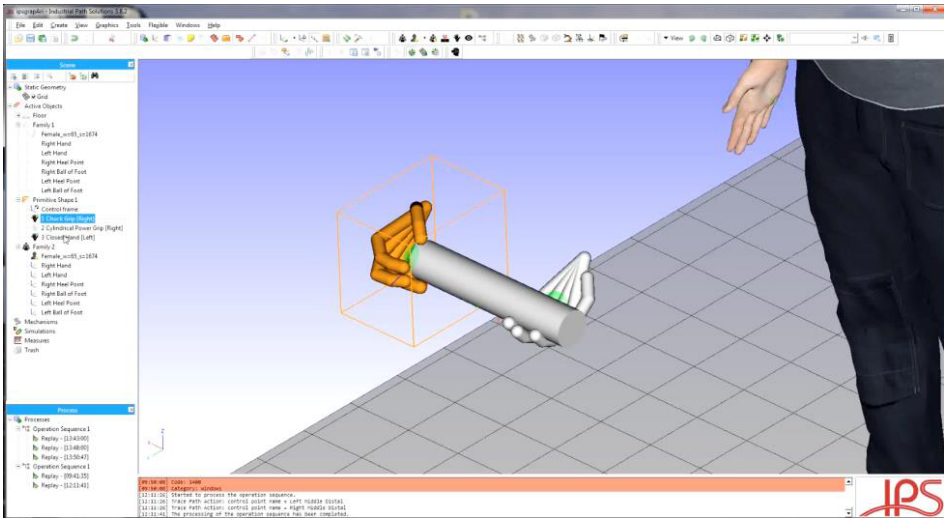

Figure 3. IMMA grip control interface. Here the user can select how the manikin(s) will hold onto the object that will be moved in the activity being analysed.

2.2. Identifying users

User groups require further verification as the project progresses, as current limitations on visits have led to a pragmatic approach being used. This is particularly important when it comes to UX work, as discussions with stakeholders are important for identifying user groups within the industrial use cases.

The IMMA program has been used by project partners for a number of years, with these partners including large industrial production companies as well as research institutions. This means that some user groups may be well established, but this can

complicate identifying prospective users [2]. That said, one partner in the SVE project is new to the system, and has specialist knowledge long been discussed as an important potential user group, in the form of practicing ergonomics evaluators who contract to companies. This user group was seen as both an important potential user group, but the actual project partners were also new to IMMA, as well as not having used any DHM software for ergonomic evaluations. Users without heavy exposure to the system are less likely to get stuck on existing functionality, making it easier to evaluate what functionalities might support their goals. Other user groups, such as engineers working with workstation development and ergonomics researchers, have been identified, and will be explored later in the project.

2.3. Interviews

The interviews were conducted using the *contextual inquiry* approach, which is an ethnographically inspired approach commonly used within UX research [1, 2]. Contextual inquiry is an approach widely used (and recommended) for exploratory user research [2, 6] and can be used to combine multiple field-study approaches and activities [7]. Contextual inquiry employs a master-apprentice model of learning, assuming that the interviewee is a master of their craft and the researchers are novices trying to learn [2]. Contextual inquiry further relies on four basic principles: *context*, *partnership*, *interpretation,* and *focus* [2].

- Context involves meeting users in their own work environments, rather than in a lab of some sorts
- Partnership means that the domain expert and the UX specialist are working together to create improvements.
- Interpretation is important because users, even experts, tend to focus on the tasks as they are performed today, not what the actual goal of the task is. This means that the UX specialist needs to "read between the lines" to identify goals in a holistic manner.
- Focus refers to how interviews and discussions are conducted. Although the interviews may feel open or free form they should be carefully guided by the UX specialists to capture information relevant to the design questions being explored.

The approach used was enhanced by employing recommendations for effectivising contextual inquiry. Examples of these effectivisation approaches are e.g.:

- Shortening the interviews, avoiding full day interviews and instead using interviews as short as an hour, so long as the approach is used in a targeted manner.
- Using smaller design teams. Older and more formal approaches assume a large team for interviews, observations, and analyses, but UX specialists have found that smaller teams can lead to all the UX specialists gaining direct interaction with all the domain experts, and have found that this can make analyses more effective [2].
- Using interviews and other contextual inquiry methods for identifying goals. This allows other parts of the development process to be more task focused.

Furthermore, contextual inquiry rewards "storytelling", i.e. allowing the experts being interviewed to explain through anecdotes (even going into seemingly unrelated details

to shine a light on goals that might otherwise be missed [2]. Analyses should then be performed by the interviewers discussing and comparing notes, highlighting patterns and *coding* the interviews [1, 2]. The participants were two ergonomists, one highly experienced with additional training and experience as a physical therapist, and the other with a few years of experience and a background in health care. Two interviews were conducted. The first interview was conducted online by two researchers and one ergonomist. The second interview was conducted some weeks later after a preliminary analysis of findings from the first interview, and involved the same two researchers, the ergonomist interviewed in the first interview, and a second ergonomist. This interview was conducted face-to-face, and was relatively short (under two hours).

2.3.1. Interview 1

The first interview was conducted in an exploratory manner with few assumptions being made, relaxed and questions were directed to explore mostly the current work practices of the ergonomist. This interview led to some points that needed further exploration. Differences in work practices, experience, and techniques also suggested that interviewing both main ergonomists would be beneficial.

2.3.2. Interview 2

The second interview was more focused on user goals when conducting ergonomics evaluations. The partnership model of contextual inquiry was employed, and the interview was less than 2 hours long. This interview was conducted in the ergonomists' workplace. Questions and discussions were guided by the understanding that had been gained from the first interview.

2.4. User Goals

One central principle of the UXD lifecycle process (see Figure 4) is the need to identify and characterize the user goals, with these goals being connected to the business goals, and subsequently the business goals connected to the user behaviors [9]. An important activity for the whole UX wheel is to extract, identify, and characterize user goals [1]. User goals are high-level objectives, which should be driven by the representative use of an envisioned interactive artifact or system. The user goals should identify what is important to the users, stated in terms of anticipated UX of an interaction design. User goals are important because they help and support the designers and developers to continuously focus on the intended experience when interacting with the envisioned interactive artifact. For that reason, they are referred to as "goals", instead of "requirements", since user goal fulfillment cannot be guaranteed for all intended end-users [1].

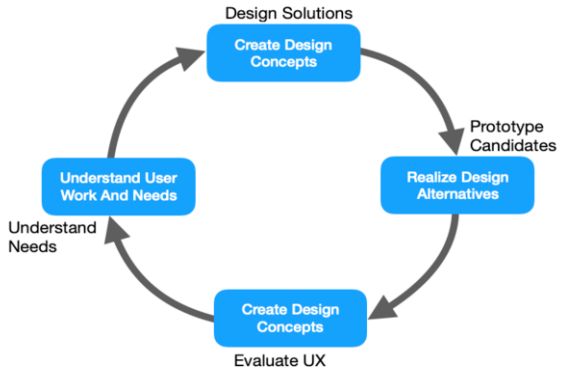

Figure 4. The UX design lifecycle (adapted from [1]).

User goals differ from features, actions or activities. In general, users do not want to use a feature or function, and do not want to perform an action. What the user wants to do is to fulfill a goal [1, 2, 8]. This distinction is important, as it allows us (the system designers) to focus on what the user wants to achieve rather than what actions are performed to achieve this goal [1, 2]. User goals can be simply defined as desired real-world end states, and can be split into many or few sub-goals [2].

Moreover (and in many ways even more importantly) users generally cannot put this into words. Users often explain the actions involved in currently fulfilling the goal, never explicitly explaining the goal, or what effect they want to achieve. This means that goals must be interpreted from interaction with users [1, 2].

Unfortunately, the extraction of user goals is an activity that is often overlooked, either because of lack of time or lack of knowledge [1], which may result in negative consequences for the final design of the system. Proper and relevant user goals that are extracted and characterized early on can simplify and strengthen the UX evaluation performed later on through pointing out exactly what should be investigated in order to enhance the positive UX of IMMA.

Identifying user goals from user interviews is a well documented approach [e.g. 1, 2]. Cooper et al. [2] also recommend observing users and their activities in their normal context, as that will result in the most accurate understanding of the work practice.

3. Results

The interviews led to a new understanding of user goals in ergonomic evaluations, as well as other general information that can be of importance to the development of the IMMA DHM software. These will be listed here, starting with general points that may be of interest, and then details that are clearly linked to initial user goals. Each point will be introduced and analyzed, identifying user goals.

3.1. Interview findings and interpreted user goals

The ergonomists explained that multiple people are involved in risk assessments of workstation design or work tasks, especially in manufacturing, and these risk

assessments require collaboration between various specialists. Visualizations support this communication early in the project.

> Identified User Goal: An ergonomic evaluation using knowledge and skills from all who can contribute to the ergonomics evaluation and risk assessment. Requires communication between stakeholders from beginning to end.

The ergonomists work with "persona-like" approaches. Personas are an accepted tool in UXD processes [10]. The ergonomists call their version MIP ("montör i projekt" or "assembly worker in project") and are similar to personas in many respects. Personas are seen as central to understanding the user, empathizing with the user, and communicating to stakeholders, including decision-makers.

> Identified User Goal: Ergonomic evaluation that supports empathizing with users and communicating user attributes in empathetic ways.

The ergonomists note that they are being taken onboard in projects earlier now than they used to, which is positive, especially by companies who have experience with involving specialists.

> Identified User Goal: Applying ergonomic evaluations throughout the process, as opposed to "painting on some ergonomics" at the end of the process.

The ergonomists focus a lot on *frequency*, i.e. how often a task is performed. This comes up repeatedly. Repetitive strain is clearly a central factor to take into account, and should be represented in any tool used (including DHM software). This is explained as being central to a holistic approach to ergonomic evaluations. In a case where physical load is within the (legal) standard, but outside of tighter company constraints then the frequency of the task becomes central. A once-per-day task that exceeds company constraints but is well within legal standards might be deemed as being acceptable if other factors are acceptable.

> Identified User Goal: Holistic evaluation of ergonomics, taking into account all major factors (e.g. frequency).

Tools and functions that visualize analyses and visualize ergonomic stresses in general and limits were described as being extremely helpful. A manikin that just performs the action is seen as possibly useful up to a point, but seeing forces in action while performing actions is considered central. This was further discussed as being beneficial to comparing standards and also for comparing observed work to simulated work.

> Identified User Need: Ergonomic evaluation where forces, standards, and observations have been taken into account.

Rules/standards and company guidelines (which must be tighter than the laws) were discussed. The possibility of visualizing constraints (laws or company-set guidelines) is seen as potentially extremely helpful in holistically evaluating the ergonomics of a workplace.

> Identified User Goal: Holistic evaluation of workplace, taking into account standards and company imposed constraints (Standards)

An important part of regular (non-DHM) analysis of tasks when performing risk assessments in practice involves observing natural body positions, including grip (which may be shifted during a task) which is seen as supporting the holistic approach to ergonomics evaluations mentioned previously.

> Identified User Goal: Naturalistic, holistic evaluation of workplace, taking into account body positions, stance, and grip (Body position and grip)

Rules/standards that need to be considered when performing a risk assessment:

- Formal standards (Arbetsmiljöverkets) rules should be included, possibly selectable for different regions.
- A major manufacturing company's own standards should be includable.
- Tasks may go beyond a company's guidelines, but an expert holistic evaluation takes into account frequency and additional aspects (including cost of changes) when assessing whether it is acceptable to go over guideline limits.

This resulted in the need to include different "limits", and visualize these in the tool in the form of constraints (Spärrgränsar), which is the term used by the ergonomists.

> Identified User Goal(s): An ergonomic evaluation where standards, rules, and constraints are linked to the rest of the evaluation; understanding forces holistically even while focusing on one aspect of the evaluation (i.e. keeping an overview while focusing on a detail).

The core goals that have been identified are primarily that the evaluation should be holistic, and that collaboration between specialists will be required throughout the whole process.

The overarching UX goal *to holistically evaluate ergonomic factors in a work context* is hard to interpret into features; this is where the detail level offered in the interviews is helpful. Note that the overarching goal is not always to reduce ergonomic strain, but rather ensure that strains are sustainable and balance that with the needs of the company. Multiple factors should be taken into account during these ergonomic evaluations, which involves high levels of expertise and expert judgment.

3.2. Further results

Although the interviews focused on how the ergonomists approach their analyses and how their current tools are used, the discussion also highlights the ergonomists' experience with IMMA and other technical tools they have either worked with or observed specialists working with.

When discussing the IMMA DHM software as it is today the ergonomists discuss how complex the software seems, and how importing geometry seems to require trained specialists in CAD/IMMA. This highlights their view that interacting with the IMMA software as being for experts in the software (see Figures 1, 2 and 3), not necessarily for specialists in ergonomics such as themselves. Further interviews and observations were planned, but have been delayed due to constraints imposed by the COVID-19 pandemic. Observations, in particular, proved impossible to organise at this time. Further interviews, as well as observations, will be conducted later this year.

3.3. Interview: IMMA experts

An interview with specialists familiar with the IMMA software was conducted by one of the researchers to compare the identified goals to existing functionality. This interview revealed that only some of the identified goals are currently supported by the IMMA software. In particular, the current visualization has certain limitations in visualizing real-time ergonomic information, and getting out information in the form of

reports was explained as being limited or missing. While it is possible to select a measure (e.g. a joint) for monitoring, it is not easy to view the action being performed and get data about forces and constraints (e.g. standards or guidelines) at the same time.

More importantly, comparing multiple versions of the same task (e.g. after iteration of the workstation) or observing differences between different manikins is not directly supported. The concept of seeing multiple levels of standards, such as legal, standards (e.g. RULA), and company specific guidelines/standards visualized was novel to the specialists, but immediately seen as being potentially useful, as were many of the visualization needs lifted by the user goals.

A functionality that was pointed out as being potentially useful, especially if comparison functions are implemented, is IMMA's support for motion capture (mocap) which allows the IMMA tool to record and evaluate a real user performing the task. This would fit in directly with the user goals if comparisons can easily be made between the mocap manikin and the data-generated manikin.

The specialists also pointed to the anthropometric module for IMMA as potentially being of interest to implement some features that would support user goals, especially surrounding persona concepts (communicating an empathetic version of the manikin) and for further analyses and evaluations.

4. Discussion

A comparison of the findings from the ergonomists and the findings from the IMMA DHM specialists makes it clear that opportunities have been missed by not engaging with one of the user groups expected to have much to gain from the use of the IMMA software. This does not suggest that the software lacks power or other qualities; rather that resources might have been more effectively used to support multiple user groups during the product development process. Indeed, the potential power and flexibility of the software is apparent, and the modularity of the software may prove to be a great asset.

All interviews turned out to be extremely rewarding, with the IMMA experts stating that the found the identified needs and goals interesting and expressed an interest in further incorporating this kind of UXD approach into the development process. An acceptance of unfamiliar development processes and an openness to including user perspectives have been shown to have a positive effects on product usability [1, 2] which means that this introduction of UX approaches into DHM software development should be seen as an opportunity, which is how the specialists considered the discussion.

Acknowledgement

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