Pre-conference proceedings of the IFIP TC 13.6 HWID working conference

Human Work Interaction Design – HWID2015

University of West London

25 and 26 June 2015

Edited by:

Arminda Lopes

Barbara Rita Barricelli

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Pedro Campos

Torkil Clemmensen

Venue: **The University of West London (UWL) is the site of HWID 2015**

Program

24th of June – pre Conference Meeting (British Computer Society – Southampton Street)

18:00 – 19:30 Meeting for networking and discussion of collaborative funding proposals under the HWID theme. All registered conference participants are invited to attend. Please confirm your attendance to this meeting to jose.abdelnour-nocera@uwl.ac.uk

Venue address:

London Office
BCS, First Floor, The Davidson Building
5 Southampton Street, London, WC2E 7HA

25th of June – Day 1 (University of West London – Paragon Site)

8:00 – 9:00 Registration – Coffee and biscuits available

9:00 – 9:30 Welcome – Pedro Campos and Jose Abdelnour-Nocera

9:30 – 11.00 Session A – Methodologies (Chair: Barbara Rita Barricelli)

- "Human Work Interaction Design: An Overview" - Frederica Gonçalves, Pedro Campos and Torkil Clemmensen
- "Reflections on Design-Based Research - In Online Educational and Competence Development Projects" - Rikke Ørngreen
- "Insights from UX Research in the Factory: What to Consider in Interaction Design" – Daniela Wurhofer, Verena Fuchsberger, Thomas Meneweger, Christiane Moser and Manfred Tscheligi
- "User-Created Personas – A Micro-Cultural Magnifier revealing Smart Workplaces in thriving Katutura – Daniel G. Cabrero, Heike Winschiers-Theophilus, Hedvig Mendoca

11:00 – 11.30 Coffee break

11:30 – 13.00 Session B – Environment (Chair: Torkil Clemmensen)

- "Pervasive Technologies for Smart Workplaces: A Workplace Efficiency Solution for Office Design and Building Manangement from an Occupier's Perspective" - Maria Ianeva, Stephanie Faure, Jennifer Theveniot, François Ribeyron, Gilles Cordon and Claude Gartisier

- "From Bottom-up Insights to Feature Ideas: A Case Study into the Office Environments of Older Computer Workers" - Valentin Gattol, Jan Bobeth, Kathrin Röderer, Sebastian Egger and Manfred Tscheligi
- "Characterizing Context of Use in Mobile Work" - Heli Väätäjä
- "From Transactions to Relationships: Making Sense of User-Centered Perspectives in Large Technology-Intensive Companies" - Petra Bjorndal, Elina Eriksson and Henrik Artman

13:00 – 14:00 Lunch

14:00 – 15:30 Session C – Specific context (part 1) (Chair: Pedro Campos)

- "Human Work Interaction Design of the Smart University" - Jose Abdelnour-Nocera, Samia Oussena and Catherine Burns
- "Providing a Holistic View and Bringing Life into the Conversation: Eliciting IT-based Administrative Work with Contextual Personas" - Åsa Cajander, Marta Larusdottir, Elina Eriksson and Gerolf Nauwerck
- "The Work and Workplace Analysis in Social Solidarity Institutions to address organization agility and innovation" - Arminda Lopes

15:30 – 16:00 Coffee break

16:30 – 17:30 Session D – Specific context (part 2) (Chair: Arminda Lopes)

- "A Grounded Theory Study of Perspectives on Automation Amongst Aviation Industry Stakeholders" - Samantha Quercioli and Paola Amaldi
- "Systems Design of a Virtual Learning Environment to Teach Space Syntax: Seeing from the User's Perspective" - Judith Molka-Danielsen, Mikhail Fominykh, David Swapp and Anthony Steed
- "Co-Design of a Cloud of Services for Archaeological Practice" - Stefano Valtolina, Barbara Rita Barricelli, Davide Gadia, Matilde Marzullo, Claudia Piazzi and Andrea Garzulino

19:30 – 22:00 Conference Dinner (Molana Restaurant in Ealing)

26 June - Day 2 (University of West London – Paragon Site)

This day will be focused on panel discussions based on papers presented on the previous day. Each panel will consist of papers presenters and appointed 'opponents' who will kick-start the panel discussion around each paper.

9:00 – 9:45 Panel Session A – Methodologies (Chair: Ganesh Bhutkar)

Panelists	Opponents
Frederica Gonçalves	Judith Molka-Danielsen
Rikke Orngreen	Samia Oussena
Daniela Wurhofer	Heli Vaataja
Daniel G. Cabrero	Jan Bobeth

9:45 – 10:30 Panel Session B – Methodologies (Chair: Frederica Gonçalves)

Panelists	Opponents
Maria Ianeva	Assa Cajander
Jan Bobeth	Torkil Clemmensen
Heli Vaataja	Ali Gheitasy
Petra Bjordal	Barbara Rita Barricelli

10:30 - 11:00 Coffee break

11:00 – 11:45 Panel Session C – Specific context (Chair: Paola Amaldi)

Panelists	Opponents
Jose Abdelnour-Nocera	Arminda Lopes
Asa Cajander	Rikke Orngreen
Arminda Lopes	Samantha Quercioli

11:45 – 12:30 Panel Session D – Specific context (Chair: Jan Bobeth)

Panelists	Opponents
Samantha Quercioli	Jose Abdelnour-Nocera
Judith Molka-Danielsen	Daniela Wurhofer
Barbara Rita Barricelli	Petra Bjorndal

12:30 – 13:30 Lunch

13:30 – 15:00 Workshop: wrapping up main take aways in four groups (posters)

15:00 – 15:30 Coffee Break

15:30 – 16:30 Closing Plenary: towards a new HWID framework

17:00 – 18:00 TC 13.6 Business meeting (for TC 13.6 members and optional for conference delegates

Preface

We are particularly satisfied to present the pre-conference proceedings of HWID2015. The conference is a working conference held under the auspices of IFIP TC 13 on Human-Computer Interaction.

1 Technical Committee TC13 on Human–Computer Interaction

The committees under IFIP include the Technical Committee TC13 on Human – Computer Interaction within which the work of this volume has been con- ducted. TC 13 on Human-Computer Interaction has as its aim to encourage theoretical and empirical human science research to promote the design and evaluation of human-oriented ICT. Within TC 13 there are different Working Groups concerned with different aspects of Human-Computer Interaction.

The flagship event of TC13 is the bi-annual international conference called INTERACT at which both invited and contributed papers are presented. Contributed papers are rigorously refereed and the rejection rate is high. Publications arising from these TC13 events are published as conference proceedings such as the INTERACT proceedings or as collections of selected and edited papers from working conferences and workshops. See http://www.ifip.org/ for aims and scopes of TC13 and its associated Working Groups.

2. Working Group 13.6 on Human-Work Interaction Design

This working group was established in September 2005 as the sixth Working Group under the TC13 on Human - Computer Interaction. It focuses on Hu- man-Work Interaction Design (HWID) and it is called WG13.6. A main objective of the Working Group is the analysis of and design for a variety of complex work and life contexts found in different business and application do- mains. For this purpose it is important to establish relationships between extensive empirical work-domain studies and HCI design. The scope of the Working Group is to provide the basis for an improved cross-disciplinary co- operation and mutual inspiration among researchers from the many disciplines

that by nature are involved in a deep analysis of a work domain. Com plexity is hence a key notion in the activities of this working group, but it is not a priori defined or limited to any particular domains. The aim of this Working Group on Human-Work Interaction Design (HWID) is to initiate new research initiatives and developments, as well as an increased awareness of HWID in existing and future HCI educations.

Welcome to the HWID2015 working conference on "Work Analysis and HCI"

Theme, Scope and Focus:

The Human Work Interaction Design 2015 (HWID 2015) working conference focuses on the integration of work analysis and interaction design methods for pervasive and smart workplaces.

Pervasive and smart technologies have pushed work-place configuration beyond linear logic and physical boundaries. As a result, workers' experience of and access to technology is increasingly pervasive, and their agency constantly reconfigured. While this in certain areas of work is not new (e.g., technology mediation and decision support in air traffic control), more recent developments in other domains such as healthcare (e.g., Augmented Reality in Computer Aided Surgery) have raised challenging issues for HCI researchers and practitioners. The question now is: how to improve the quality of workers' experience and outputs?

This working conference focuses on answering this question to support professionals, academia, national labs, and industry engaged in human work analysis and interaction design for the workplace. Conversely, tools, procedures, and professional competencies for designing human-centred technologies for pervasive and smart workplaces will be discussed.

Conference Chairs:

José Abdelnour Nocera, Associate Professor, University of West London, United Kingdom

Pedro Campos, Assistant Professor, University of Madeira, Portugal.

Organising Committee

Torkil Clemmensen, Associate Professor, Department of IT Management, CBS Denmark, Denmark

Dinesh Katre, Associate Director & HOD, Human-Centred Design & Computing, Centre for Development of Advanced Computing (C-DAC), Pune, India

Arminda Lopes, Instituto Politécnico de Castelo Branco, Portugal

Effie Law, Reader, University of Leicester, United Kingdom

Barbara Rita Barricelli, Research fellow, Università degli Studi di Milano, Italy.

Program committee

Catherine Burns, Professor, Director, Centre for Bioengineering and Biotechnology, University of Waterloo, Canada

Paola Amaldi, University of Hertfordshire, United Kingdom

Sergio España, Full researcher, Universidad Politécnica de Valencia, Spain

William Wong, Professor of Human-Computer Interaction and Head, Interaction Design Centre, Middlesex University, London

Anirudha Joshi, Associate Professor, Industrial Design Centre, Indian Institute of Technology, Mumbai, India

Anant Bhaskar Garg, Director, HaritaDhara Research Development and Education Foundation, Dehradun

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Ebba Þóra Hvannberg, Professor, Computer Science, University of Iceland

Ignacio Panach, Universidad de Valencia, Spain

Frederica Gonçalves, University of Madeira, Portugal

Ali Gheitasi, University of West London, United Kingdom

Nathalie Aquino, Universidad Católica de Asunción, Paraguay.

About the Conference

The Human Work Interaction Design (HWID) working conference is organised by IFIP TC 13.6 working group.

The first HWID conference was organised at Madeira, Portugal in 2006 (Clemmensen, Campos, Orngreen, Pejtersen, & Wong, 2006).

The second HWID conference took place at Pune, India in 2009 (Katre, Orngreen, Yammiyavar, & Clemmensen, 2010).

The third HWID conference was held at Copenhagen, Denmark in 2012 (Clemmensen, Abdelnour-Nocera, Campos, Katre, Lopes, Pejtersen, & Orngreen 2012).

In continuation with this series of the IFIP WG 13.6 on Human Work Interaction Design, the fourth HWID conference will take place in London, England on 25 and 26 June 2015.

Human Work Interaction Design: An Overview

Frederica Gonçalves[1], Pedro Campos[1] and Torkil Clemmensen[2]

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Abstract. In this paper, we review research in the emerging practice and research field of Human Work Interaction Design (HWID). We present a HWID framework, and a sample of 54 papers from workshops, conferences and journals from the period 2009-2014. We group the papers into six topical groups, and then attempt to map these groups to the framework to find research gaps for future research. We find that the groups of papers cover all areas of the framework well for a variety of work and leisure domains. The area in strongest need for more research papers is the development of the holistic framework itself. Furthermore, much focus has been on studying design sketching or implemented systems-in-use, while little attention has been paid to mature design (prototypes) or early implementation (content templates). In conclusion, we recommend an update to the framework so that it can be also useful for research in prototyping and early organizational implementation.

Keywords: Human Work Interaction Design, User Experience, Literature review.

1 Introduction

The boundaries and work processes for how people work and interact are suffering changes due to the very fast emergence of new information technologies. To address this comprehensive problem, the Human Work Interaction Design Working Group (HWID) was established in September 2005 under the auspices of IFIP, the International Federation for Information Processing (Campos, Clemmensen, Abdelnour-Nocera, Katre, Lopes, Ørngreen, 2012). In this paper, we provide an overview of recent research related to HWID. Our focus is on identifying research gaps for future research.

HWID is a comprehensive framework that aims at establishing relationships between extensive empirical work-domain studies and HCI design. It builds on the tradition of cognitive work analysis (Ørngreen, Mark-Pejtersen, Clemmensen, 2008). In order to provide an easy understandable version of the framework that is applicable across domains, Clemmensen (2011) developed a revised HWID framework (Figure 1).

The characteristics of humans and work domain contents and the interaction during their tasks and decision activities, individually or in collaboration, are the base of this framework. The top box illustrates the theories used, the left is the analysis of users' work and life, in the middle column the artefacts, and to the right the design of interactive information technologies. The box at the bottom indicates that environmental contexts, such as national, cultural, social and organizational factors, impact the way in

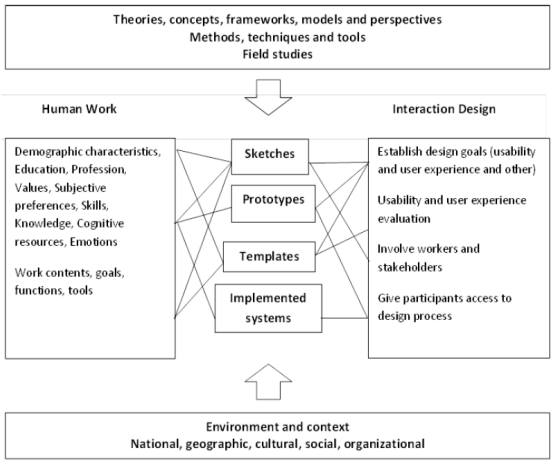

Figure 1 Human Work Interaction Design framework (Clemmensen, 2011).

which users interact with computers in their work and life. The lines connecting the left-right boxes illustrate the various relations between empirical work analysis and interaction design activities and products, which are the focus of HWID research.

For the early years of HWID research (2005-2008), Ørngreen et al. (2008) reviewed the theory and empirical evidence behind attempts to combine empirical work studies and interaction design. Since then, the research in this area has grown significantly, and an updated review is timely. We have reviewed and selected 54 research papers about HWID from workshops, conferences and journals from 2009 until 2014. This analysis has resulted in the identification of six groups of papers (see the Appendix for a list of the papers), which reflect diverse topics relating problems that the researchers perceive to be the major concerns and challenges in HWID.

2 Exploring UX and Designs for Smart Places in Work Environments

The first group of research papers takes as the starting point the empirical analysis of human work and its relation to IT artefacts (the left side to center column of figure 1).

Understanding UX of Smart Workplaces. To design successful human-centered technologies for smart workplaces, Meerbeek et al. (2014) did a case study of automatic window blinds to acquire a better understanding of the current behavior of office occupants with respect to the control of daylight entrance. They used mixed methods to investigate the effect of user-controlled and system-controlled (automatic) changes of exterior venetian blinds on occupants' experience of the blinds' system and their satisfaction with the indoor climate, including lighting, noise, and temperature. They found that people's work habits tended to overrule artefact settings.

Smart and Pervasive Technologies. There are very few reports on how pervasive and smart characters of information and communication technologies shape the quality

of the life, working and user experience of telecommuters. Law and Abdelnour-Nocera (2014) discussed, from different design and cultural perspectives, including emerging economies like India, the nature of sociotechnical gaps in telecommuting and the implications of these for the quality of work and quality of life teleworkers.

Identifying user experience goals. Clemmensen and Barlow (2013) used an interpretive phenomenological approach to find user experience goals in complex work systems such us an interactive climate management with growers and crop consultants. They presented a model of the essence of the emotional user experience with examples of how to capture the user experience in work contexts and with a qualitative methodology. In order to measure the identified emotions in other contexts than climate management or other climate management situation than greenhouses they suggested that futures research aim to develop work context sensitive user experience scales.

Ergonomic and Motivating Workplaces. Designing a platform for ergonomic and motivating workplaces, especially targeted at older employees, was the vision of Bobeth et al. (2014). The authors designed a smart and flexible work environment to support a prolonged, productive and satisfactory involvement of older employees in working life. Offering a range of assistive tools and services, both for the office and the home environment, was a goal driven by bottom-up insights into the work realities and contexts for this type of users.

Viz Reporter *in vivo*. Studying mobile journalism in the context of the professional news organization TV2 in Norway, Guribye et al. (2014) show in this paper through ethnographic inquires into the work practice of these journalists, how the adoption of a mobile application called Viz Reporter can be accomplished in practice. The authors identify design implications not only for the usability of the product but also for the ways in which journalists themselves can take part in configuring their digital habitats.

UX in a work context. To capture the user experience of the smart workplace, Yadav and Clemmensen (2014) present an approach discussing a pilot experiment where they integrate multiple data-streams of user experience, such us physiological, behavioral, and environmental and IT processes, in a work setting to give us a holistic view in user experiences due to Internet of Things. Their experiment provides one basic framework to new experiences in the future.

ICT Design and evaluation for trans-mediated workplaces. Traditionally human work analysis is focused on user goals, user requirements, tasks and procedures, human factors, cognitive and physical processes and contexts. Abdelnour-Nocera et al. (2013) show a formal initiative at a European level to harmonize HWID as a substantive discipline supporting the interaction of workers through technology, at a time in which concepts of workers and workplace are changing significantly.

Evaluate the work environment of future work. Sandblad (2013) developed a checklist for analysis into aspects such us physical, psychosocial and cognitive work in order to prevent possible negative work environment consequences. It is not enough to simply introduce information technologies systems that support the organization's current work practice but also is important to use the full potential of the new technology to improve the organization, work practices and work environment. Developing this checklist based on the Demand-Control-Support model, Sandblad present a research approach with a focus on the work environment aspects.

Studying Contextual Interaction. In order to derive inspirations for designing future interactions Murer et al. (2014) provides an approach using industrial companies'

habit to showcase their products as well as production facilities. Their strategy approaching extensive tours "behind the scenes" that are augmented with ad-hoc staging of contextual interactions, allows to study human work interaction in domains and facilities usually hard to access in research.

Workplaces for Creative Writers. Gonçalves and Campos (2014) describe an analysis based on HWID framework to make a simple analysis for a complex domain such as creative writing. The authors describe an analysis of connections between human work and interaction design from a creative writing support perspective.

Mind the Gap. Arguing there is a gap between the technological artifact produced and the social requirements that govern how well the system will fit in the organization, Lind et al. (2013) in this work in progress paper, present a framework – SOT (Social, Organizational and Technical) – to analyze the deployment of information systems (IT) from a sociotechnical perspective. The authors propose the concept of inertia to reflect the relative and varying ability of either of SOT aspects to adjust with respect to the other two. They believe that the sociotechnical gap is a result of the collective inability of these aspects to reach a middle ground within an organization.

Cognitive Work Analysis. Burns (2012) highlights the importance of cognitive work analysis (CWA) and their recent work focused on adapting CWA to face the new challenges and provides a solution that fits a truly social technical system in this paper.

Usage of Different Work Analysis Methods. Campos and Noronha (2012) describe and elaborate around the usage of different work analysis methods in a complex, real world work domain: collaborative review of large-scale 3D engineering models. They concluded that hierarchical task analysis was not effective in obtaining a clear, common vision about the work domain.

3 Improved Qualities in Health and Support in Work Design

The second group of papers are strong on work analysis in particular organizational contexts (right to bottom of figure 1).

How to Improve the Interaction Quality of Psychologists and Patients. Serra et al. (2014) look at the gap in the research about "computerized psychology". They present a work in progress project that consist on the development of an application that will support and facilitate the interaction among psychologists and patients. By interviewing several psychologists after and during the prototype evaluation phases, they showed that with the use of therapeutic writing could bring results for the clinical heath of patients.

Using Well-being Data. The advent of new technologies is changing the way people work. Valtonen et al (2014), describe a new way to think about how we work. They propose the study of well-being from employees that are feeling overwhelmed and exhausted to design new ways of work and work environment to support productivity and well-being.

Designing a Health-care Worker-Centred System. Silvestre et al. (2013) report prototypes around personal schedules, games and personal digital artifact management that investigates different ways of looking at long-term health care based on multiple user-centred design iterations with the chronic mental care hospital staff. They established this approach as promising for improving overall care for the residents in long-term care.

Challenges in Applying a Participatory Approach. Scandurra et al. (2013) recommend increasing the use of "health informaticians" with usability and human work interaction design expertise within national and local eHealth development. In this paper, they present the experiences of applying a participatory approach in a nation-wide project. They considered that eHealth development is a challenging and complex activity, and best-practice methods from HCI related with HWID can support the business development within health and social care.

Usability Heuristics and Quality Indicators. Medical errors and cost the life of a patient can be caused by complexity in the user interface, features and functionalities of ventilator systems. Katre et al. (2009) presents a study about heuristic evaluation of three touch screen based ventilator systems manufactured by three different companies. Evolving a specialized set of heuristics combined with objectively defined usability indicators for the usability evaluation of touch screen based ventilator systems was performed by four different usability evaluators to ensure the reliability of heuristics proposed. Findings on several observations in ventilators systems shows that the interface design of touch screen ventilator needs significant design enhancements.

The influence of mood feedback. Sonderegger et al. (2013) offer experiences that examine the influence of mood feedback on different outcomes of teamwork in two different collaborative work environments. The authors present a new collaborative communication environment, using an avatar, which provides visual feedback of each team member's emotional state to support teamwork.

Do Usability Professionals Think about User Experience? Clemmensen et al. (2013) investigates how usability professional's thinking about system use is different from other stakeholder groups with different nationalities, in particular system developers and end users. The paper shows results that indicate usability professional focus on emotion-related aspects of system use, while users focus more on context in terms of utility and degree of usage.

Work and Speech Interactions among Staff. Care services are often provided by the devoted efforts of care staff at long-term care facilities. Chino et al., (2012) observed bathing assistance, night shift operations, and handover tasks at a private elderly care home for eight days. The authors found that staff members are always speaking during the task, remote communication is rare, about 75% of staff utterances are spoken residents, utterance targets are frequently switch, and about 17% of utterances contain at least one personal name.

Usability Model for Medical User Interface. Bhutkar et al. (2012), in this paper used a usability model for medical user interfaces, especially for ventilator in Intensive Care Unit (ICU). They proposed this based on Norman's action-oriented seven-step model to capture a related medical context. This comprehensive model brings related medical context into human work analysis in terms of vital medical elements such us medical user, user interface, ICU environment and time required. The authors suggested that usability professionals for improved results could use this model as a template with medical user interfaces effectively.

4 Supporting Human Collaborative Work and Cognitive Strategies in a Global World

The third group of papers is strong on the environment and context, as they focus on the global world (bottom of figure 1).

Transnational Teams' Impacts. Global organizations can choose to configure and structure their teams in a wide variety of ways. Haines et al. (2013) found important to understand the implications of various transnational team configurations. The authors conducted a research in a large multinational technology company and they found that the development of social capital is impacted by whether a person is in their home context or transplanted and their expectations based on that context. They highlight factors in the creation of social capital as well as some mechanisms that may mitigate cultural difference.

Supporting Human Collaborative Works. Chino et al., (2013) proposed in their paper an application model to support human collaborative works. The model is designed based in a real field study at an elderly care facility in Japan and a virtual field experiment on the collaborative words utilizing a voice communication systems for human workers of what they called "action oriented intellectual services" that works in distributed work fields. To improve the interaction design among the system and the human workers, the authors suggest to use the data accumulated in the system itself to support the human work analysis.

Collegial Collaboration for Safety. Jansson et al. (2013) present a model for verbal probing procedures that is used to assess situation awareness in dynamic decision contexts – colleagues explore each other's cognitive strategies. In this paper the authors shows the results from a cognitive field studies using a method developed for knowledge elicitation in applied contexts and reviewed from previous studies – *collegial verbalization*. They purposed to evaluate whether the knowledge elicitation procedure can be used as a basis for exploring how colleagues can learn from each other, using studies that will take place at an intensive care unit.

Distributed Scientific Group Collaboration. Li et al. (2012) explored in this paper the collaborative practices, particularly information sharing, in scientific collaboration between different groups and over the distance of physical containment barriers in a biosecurity laboratory. Their findings contribute to the design of collaboration platform for this type of environment that can resolve common communications issues over distance.

An Integrated Communication and Collaboration Platform. In this paper, Müller-Tomfelde et al. (2011) present the design process, the technical solution and the early user experience of a collaboration platform, which integrates life-size video conferencing, and group interactions on a large shared workspace to support distributed scientific collaborations. This platform was developed to support the diagnostics and research scientists in an animal health laboratory to work collaboratively across a physical containment barrier.

Usability Testing in Three Countries. Triangulating how companies perform usability tests, Clemmensen (2009) in this paper reported and compared three ethnographic interviews studies in Mumbay, Beijing and Copenhagen. This study, using structural

and contrast questions do a taxonomic and paradigm analysis, indicates that a typical or standard usability test across countries had some clear similarities.

5 HCI and Usability Research in Educational, Cultural and Public

The fourth group of papers focus on the global context's relation to usability and interaction design (bottom to right side of the figure 1).

Usability in a Cultural Context. The aspect of culture in design of user interfaces and interactive products is an issue important that Clemmensen et al. (2009) tries to underline in this paper. To understand the differences in how people with different backgrounds respond to directions and test methodologies, they focused on presenting and discussed the aim context, challenges, results, and impact of the Cultural usability named as CultUsab. This was a project with four-year international research effort from 2006 to 2009, supported by a grant from the Danish Research Councils for Independent Research in Culture and Communication.

Usability Research in Indian Educational Institutions. In this paper Yammiyavar (2009) traces briefly the evolution of human work interaction in educational institutions in India. The author highlights through samples of research work done the urgency for training more researchers in the field of emerging area such us HCI and the great potential in this country.

Usability Evaluation of State Government Portals. Katre and Gupta (2011) present in this paper a usability evaluation of 28 state government web portals of India. This evaluation was based on 79 parameters grouped under 7 broad categories such as accessibility, navigation, visual design, information content, interactivity, ownership and branding. The expert usability evaluation presented in this paper highlights the lack of human work analysis in the design of the state web portals.

A rapid ethnographical study. Righi et al. (2011) conducted a rapid ethnographical study aimed at understanding attitudes of older people towards e-government related activities and Information and Communication Technologies. The authors presented initial results derived from their study and discussed a potential scenario for supporting information sharing and promoting a more active and dynamic participation of older people in their neighborhood. Their findings suggested that a variety of inclusive aspects, such as socialization, face-to-face contact, or mutual support impact the use and adoption of e-services by older people.

Narrative Interaction. Authors such as Schreder et al. (2011) suggested that narrative interaction could be used as a design possibility for human-machine interfaces in public information systems. They considered that using storytelling and narration for the graphical presentation of information in self-service technologies enables customers to draw on their everyday experiences. This paper presents a case study of a train ticket purchase process with a story structure that demonstrates the concept of narrative interaction.

Designing Accessible Public Information Systems. Campos (2011) presents in this paper a design approach towards the development of a fully interactive tourism information office. The author considered that public information was facing unique design challenges arising from the need to a diverse range of users, such as tourists, senior users, passers-by, children and teenagers. He concluded arguing that human work interaction design can be a solid, useful approach to better support the diversity of public

information systems' users.

Success within user centred design. Hamilton et al. (2011) considered that E-Government websites and other online channels had the potential to empower citizens by making Government services more accessible and convenient to use. They examined three recurring challenges to applying User Centred Design (UCD) in the public sector and then described a successful service design project that overcame these challenges. Their experience in relation to UCD practitioners, was developed in the United Kingdom Government domain, and usability techniques were not being been sufficiently embedded in e-Government projects.

E-Government and Public Information Systems. Clemmensen (2011) outlines a revised version of the general HWID framework with a focus on what connects empirical work analysis and interaction design. Presenting a case study of the Danish government one-for-all authentication system NemID that has been briefly analyzed using ethnomethodology, work domain/task analysis, and the HWID approach for comparison. The author concluded that there were benefits in studying how human work analysis and interaction design in concrete cases are related and connected.

Cultural Elicitation in HCI. In Information and Communication Technologies (ICT) design many different approaches for techniques and frameworks are offered to eliciting culture and context in this field. Camara et al. (2009) in this paper argue that designers need to locally identify context and culture aspects and further explain their implications through the design process and at the global level.

Usability and Culture. Kurosu (2009) in this paper outlined the conceptual framework of the Artifact Development Analysis (ADA) and its relationship to the usability engineering. The author proposed to focus on the extent where the usability can provide the core satisfaction and also summarized the guideline on how the artifact should be designed.

Culture and Human-Computer Interaction. The interest in the correlation between culture aspects and Human-Computer-Interaction had grown significantly during the years. Clemmensen and Roese (2009), propose in this paper a review of current practice in how cultural HCI issues were studied, and analyzed problems with the measures and interpretation of their study. They found that Hofstede's cultural dimensions had been the dominating model of culture, participants had been picked because they could speak English, and most studies had been large scale quantitative studies.

'Adaptation' in Children. Deshpande et al. (2012) in this paper describe an exploration of how children adapt their interactions with different graphical user interfaces (GUIs) in carried task situations. They could observe that a GUI is rich in features facilities user adaptations in coping with differences in task complexities.

Library Usability in Higher Education. Based in UK university libraries, Wiles et al. (2012) in this study aims to find out how and to what extent user experience forms parts of university library policy, and how it can effectively be incorporated into it. The authors show that the creation of a library user experience policy begins with the identification of the social-technical gap between experiences and expectations.

6 Exploring Scenarios to Create Design Ideas

The fifth group of papers focus the relations between interaction design and artefacts (left side to center column of figure 1)

Using Storytelling to Create Design Ideas. Madsen and Nielsen (2009) in this paper explore the persona-scenarios method by investigating how the method can support project participants in generating shared understandings and design ideas. They contributed with guidelines that delineate a) what a design-oriented persona-scenario should consist of product and b) how to produce in order to generate and validate as many, new, and shared understandings and design ideas as possible.

Personas in Cross-Cultural Projects. To communicate data about users and to create a shared perception of them, Nielsen (2009) considered the method Personas in this experience using 16 participants in 9 different countries. The author asked participants to return a photo that resembled the persona and for them to explained their choice. Results in this analysis shows that there is a difference between the participants with professional experiences and those without.

A Game-Like Interactive Questionnaire. Dai and Paasch (2012) describe in this paper the use of a questionnaire to facilitate a photovoltaic (PV) application research, which led by University of Southern Denmark and with collaboration between local companies to popularize PV technology in both residential and the industrial markets.

Using Lego Mindstorms for Sensor-Intensive Prototype. In this paper, Pedersen and Clemmensen (2012) describe a design science framework for the use of interactive, sensor-intensive prototypes to develop interactive greenhouse climate management systems. This study provides a reference platform for combining micro information systems and human-computer interaction in design science research into environmental sustainability research.

UCD Guerrilla Tactics. Ericksson and Swartling (2012) in this paper present a case study within Sweden's military defense organizations, concerning the introduction of user-centred design (UCD). This paper describes the guerrilla tactics, how it was applied in this case study and factors that should be considered when using it.

Feedback in a Training Simulator. This paper aims to understand the importance of early work analysis in a real context during the design of such a simulator. Druzhinina and Hvannberg (2012) showed results that there were several significant differences.

7 Applications and Evaluations

The sixth group of papers focus on the IT artefacts as part of a holistic HWID context (center column and whole figure 1).

A Materiality-Centered Approach. To assess materiality from a user and artifact perspective, Fuchsberger et al. (2014) described an approach that puts the user and the artifact equally in the center of attention using a materiality-centered data analysis. Their approach allows identifying material attributes of actors that are less obvious.

Empirical Evaluation of Complex System Interfaces. Garg and Govil (2012) in this paper starts discussing two cognitive science paradigms and then present third approach related to interaction with the world as known as embodied cognition. They focused their analyze in work settings with the help of cognitive work analysis and human work interaction design approaches.

Natural Interactions. Proença and Guerra (2012) in this paper present a system for the development of new human-machine interfaces focused on static gestures recogni-

tion of human hands. Results shows that it is possible to interact with a machine naturally and intuitively through hand gestures without requiring support material such as gloves or markers.

Focus on Computing Practices. Franssila and Okkonen (2012) present a work in progress paper to considered the utility of current theoretical and methodological human computer interaction and work analysis in understating and supporting knowledge workers. They focused in the design efforts, instead of technical artifacts, into the observation, understanding and development of computing practices.

Mobile Probing and Probes. Duvaa et al. (2012) highlight in this paper the mobile probing as a method developed for learning about digital work situation and as an approach to discover new grounds.

Support of Multimodal. Velhinho and Lopes (2012) present a work in progress to evaluate frameworks used by business enterprises and to state the advantages and disadvantages in their use.

Safety Critical Social-technical System. This paper, authored by Amaldi and Smoker, (2012), used the UK service organization for Air Traffic Management Domain called NATS (National Air Traffic Service) as a case study to illustrate an example of an organization currently undertaking critical self-reflection about automation policy or lack of such.

8 Discussion and Conclusion

Figure 2 shows a mapping of the different groups (I, II, …, VI) of paper topics on top of the HWID framework. These are the groups that correspond to the previous sections. For instance, Group I (Exploring UX and Designs for Smart Places in Work Environments) is depicted on the middle left side of the Fig.2 since this is where the HWID framework depicts the empirical analysis of human work and its relation to IT artifacts. The same applies to all of the other groups.

It is obvious, from the analysis of missing bubble in the top of the framework's figure that one research gap is the need for better theories, concepts, frameworks, models and perspectives on HWID.

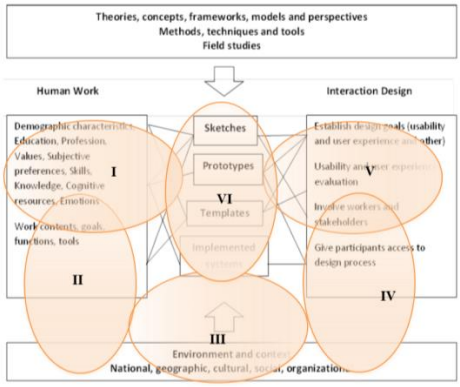

Figure 2 - Mapping groups of HWID papers to the HWID framework

We do have theoretical work for different aspects of HWID, e.g. Burn's (2012) paper on social aspect of work analysis, but we need more papers that account for HWID as a holistic phenomenon that covers both work analysis and interaction design.

Second, we need more research on methods, techniques and tools, including field studies, for doing HWID research. Clemmensen (2011) suggested a specific way to use a combination of the HWID framework and grounded theory with digital qualitative analysis software (such as atlas.ti), and we need more HWID-specific methods.

Third, Figure 2 also indicates that we need more work explicitly dedicated to the relations (the lines in the framework figure), though we have the research papers represented by bobble I and V, and also earlier work on sketching for human work (Campos et al., 2006).

Fourth, when distributing the papers into the HWID framework, see Figure 3, we can see that most of the papers are about human work and less about interaction design, and also, that there has been more studies of very early phases in system development (sketches) or, at the other end, late phases (studying implemented systems). There has been few studies of late prototypes or early stages of implementation (content templates for use).

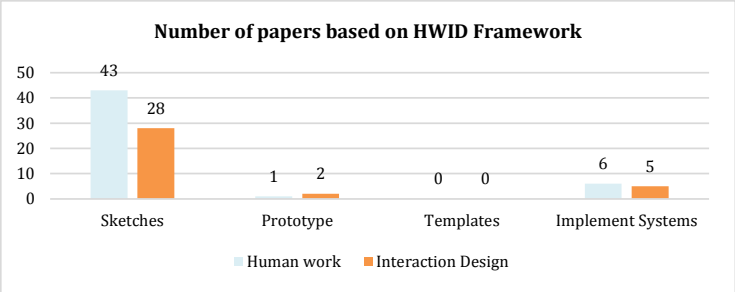

Figure 3. Number of papers based on HWID Framework.

Fifth, the work in this field has just started, and during the period that we analyzed, we had 38 empirical papers and 16 theoretical papers in order to explore concepts for the emerging area in HWID. Table 1 shows the number of papers per year we selected for the last six years, and the country of researchers. More researchers from more countries should be involved in this research, as human work and interaction designs may have many forms.

Table 1. Country of researchers and Number of papers per year.

Year	*Country of researchers*	*Number of papers*
2009	*Denmark, India, Japan, UK.*	*9*
2011	*Australia, Austria, Denmark, India, Portugal, Spain, UK.*	*7*
2012	*Australia, Canada, Denmark, Finland, Iceland, India, Japan, Portugal, Sweden, UK.*	*17*
2013	*Brazil, Canada, China, Denmark, Germany, Japan, Sweden, Switzerland, USA, UK.*	*11*
2014	*Austria, Denmark, Finland, Germany, Greece, India, Netherlands, Norway, Portugal, UK.*	*10*

In summary, we believe that the papers presented in this review illustrates that researchers have developed the understanding of the HWID notion by experiencing and testing

the contextualization of the concepts and framework, either empirical or theoretically. This is a good basis for future research in this area and focus on new challenging topics such a smart workplaces.

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Appendix – The 54 Papers included in the Review

Theme: Exploring UX and Designs for Smart Places in Work Environments

Abdelnour-Nocera, J., Barricelli, B., Clemmensen, T., (2013) ICT Design and evaluation for trans-mediated workplaces: towards a common framework in human work interaction design. Workshop at INTERACT 2013, Cape Town, South Africa.

Bobeth, J., Gattol, V., Meyer, I., Müller, S., Soldatos, J., Egger, S., Busch, M., Tscheligli, M., (2014). Platform for Ergonomic and Motivating ICT-based Age-Friendly Workplaces. Workshop HWID, NordiCHI, Helsinki, Finland.

Burns, C. (2012) Cognitive Work Analysis: New Dimensions. Working Conference HWID, Copenhagen, Denmark. HWID 2012, IFIP AICT 407, pp. 1-11, 2013.

Campos, P., Noronha, H. (2012) On the Usage of Different Work Analysis Methods for Collaborative Review of Large Scale 3D CAD Models. Working Conference HWID, Copenhagen, Denmark. HWID 2012, IFIP AICT 407, pp. 12-21, 2013.

Clemmensen, T., Barlow, S. (2013) Identifying user experience goals for interactive climate management business systems. Workshop at INTERACT 2013, Cape Town, South Africa.

Gonçalves, F., Campos, P. (2014) Towards Pervasive and Inspiring Workplaces for Creative Writers: Simple Interactions for a Complex Domain. Workshop HWID, NordiCHI, Helsinki, Finland.

Guribye, F., Nyre, L., Torvund, E. (2014) Viz Reporter *in vivo – Design Implications for Mobile Journalism Beyond the Professional Newsroom*. Workshop HWID, NordiCHI, Helsinki, Finland.

Law, E., Abdelnour-Nocera, J., (2014) Towards a sociotechnical understanding of smart and pervasive technologies used by high-managed and low-managed teleworkers, NordiCHI, Helsinki, Finland.

Lind, T., Cajander, Å., (2013) Mind the Gap - Towards a Framework for Analysing the Deployment of IT Systems from a Sociotechnical Perspective. Workshop at INTERACT 2013, Cape Town, South Africa.

Meerbeek, B., Loenen, E. (2014). Understanding User Experience of Smart Workplaces: mixed methods. Workshop HWID, NordiCHI, Helsinki, Finland.

Murer, M., Tscheligi, M., Fuchsberger, V., (2014) Staged Inquiries: Studying Contextual Interaction through Industrial Showcasing. Workshop HWID, NordiCHI, Helsinki, Finland.

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Yadav, M., Clemmensen, T., (2014) Multiple Data Stream measurement of UX in a work context. Workshop HWID NordiCHI, Helsinki, Finland.

Theme: Improved Qualities in Health and Support in Work Design

Bhutkar, G., Katre, D., Ray, G., Deshmukh, S., (2012), Usability Model for Medical User Interface of Ventilator System in Intensive Care Unit. Working Conference HWID, Copenhagen, Denmark. HWID 2012, IFIP AICT 407, pp. 46-64, 2013.

Clemmensen, T., Hertzum, M., Yang, J., Chen, Y., (2013). Do Usability Professionals Think about User Experience in the Same Way as Users and Developers Do? Workshop at INTERACT 2013 Cape Town, South Africa.

Chino, T., Torri, K., Uchihira, N., Hirabayashi, Y. (2012) Work and Speech Interactions among Staff at an Elderly Care Facility. Third IFIP WG 13.6 Working Conference, HWID, Copenhagen, Denmark.

Katre, D., Bhutkar, G., Karmarkar, S., (2009) Usability Heuristics and Quality Indicators for the Usability Evaluation of Touch Screen Ventilator Systems. HWID 2009, IFIP AICT 316, pp. 83-97, 2010.

Scandurra, I., Åhlfeldt, R., Persson, A., Hägglund, M., (2013) Challenges in Applying a Participatory Approach in a Nation-wide Project -The Case of 'Usability of Swedish eHealth Systems 2013'. Workshop at INTERACT 2013, Cape Town, South Africa.

Serra, J., Leitão, J., Alves, P., Lopes, A., (2014) How to Improve the Interaction Quality of Psychologists and Patients: a Mediated Interface. NordiCHI, Helsinki, Finland.

Silvestre, R., Anacleto, J., Fels, S. (2013). Designing a Health-care Worker-Centred System for a Chronic Mental Care Hospital. Workshop at INTERACT 2013, Cape Town, South Africa.

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Valtonen, T., Kalakoski, V., Paajanen, T., (2014). Using Well-being Data to Support Work Design, Workshop HWID NordiCHI, Helsinki, Finland.

Theme: Supporting Human Collaborative Work and Cognitive Strategies in a Global World

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Theme: HCI and Usability Research in Educational, Cultural and Public

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Theme: Exploring Scenarios to Create Design Ideas

Dai, Z., Paasch, K. (2012) A Game-Like Interactive Questionnaire for PV Application Research by Participatory Design. HWID 2012, IFIP AICT 407, pp. 65-72, 2013.

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Pedersen, R., Clemmensen, T. (2012) A Design Science Approach to Interactive Greenhouse Climate Control Using Lego Mindstorms for Sensor-Intensive Prototype. HWID 2012, IFIP AICT 407, pp. 73-89, 2013.

Theme: Applications and Evaluations

Amaldi, P., Smoker, A., (2012) An Organizational Study into the Concept of Automation in a Safety Critical Social-technical System. Working Conference HWID, Copenhagen, Denmark. HWID 2012, IFIP AICT 407, pp. 183-197, 2013.

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Reflections on Design-Based Research

- In Online Educational and Competence Development Projects -

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Abstract.
Design-Based Research is an intervention method that researches educational design (products or processes) in real-life settings with the dual purpose of generating theories about the domain and develop the design iteratively. This paper is an integrative review with a personal ethnographic narrative that draws on Design-Based Research literature, and identifies and discusses elements from Interaction Design and Action Research that the Design-Based Research approach could apply, situating the research in online educational projects, where participants are distributed in time and space, and where the learning process expands to everyday work and life practices, as in competence development projects. The elements discussed are: to broaden the concept of users, to include the various roles in the organization; to be explorative and work with potentials, suggestions and alternative designs; and to develop the theory generation and rigour in the analysis phases.

Keywords: Design-Based Research (DBR) · educational research · design science · online and pervasive learning · competence development ·

1 Background – Problem Space and Method

Within the field of education the Design-Based Research (DBR) approach has really taken off in the last years - from 0 puplications in year 2000 to a total of 1.940 in 2010, with app. 375 publications in the year 2010 [2]. DBR is an an intervention method that researches educational designs (products or processes) in real-life settings with the purpose of generating theories in the domain and to further develop the design through iterative processes. Researchers have found it useful when investigating technological developments that support learning and learning processes. I research digital learning processes, and came from the human computer interaction and information systems sciences, with many projects carried out as action research and interaction design studies. I find that there are elements from the design science approaches in these domains that the educational design-based research approaches could benefit from (and certainly vice versa, just not the scope of this paper). In this paper I give a brief (historical) introduction to Design-Based Research, where I among others utilize a couple of the good reviews that were written in the last 5 years, which encapsulate some of the key characteristics of DBR. I reflect on the various approaches

used, and on the critical perspectives raised, and do this in relation to what I have experienced when discussing with peers and conducting DBR research projects. These projects uses technological developments in educational settings, where the users are primarily online and distributed, i.e. the learning process takes place and transfers into a daily work practice that is not possible to directly observe.

This paper is not a traditional literature review involving the full scale of going through the full body of literature, though it does rely on a process of: identifying the key terms, locate literature, critically evaluate and select the literature and write a literature review [8]. It differs in that it consists of both experiences from existing empirical and theoretical research, similar to an integrative review [32], combined with a narrative ethnographic approach [30 and 8].

An integrative review can contain papers, case studies etc. that apply different methodologies (quantitative and qualitative, experimental and non-experimental research), which according to Whittemore and Knafl increase the complexity [33]. "*The integrative review method can summarize past empirical and theoretical literature on a topic of interest….Incorporate diverse methodologies in order to capture the context, processes and subjective elements of the topic. The integrative review method has been critiqued for its potential for bias and lack of rigour*." (ibid, p.552). Whittemore and Knafl bring rigour into this process by among others applying Miles and Hubermans [22] processes of data reduction and data display in the qualitative analysis process. I take this a step further by applying an interpretative layer through personal experiences in own research projects, in a reflective narrative [22].

A couple of years ago, I made a shift in research groups do to employment opportunities at another university. I was in a Human Computer Interaction (HCI) research group doing research in areas within learning and knowledge acquisition, applying in particular interaction design theories and methods, researching the development of learning technologies. Also, I have often then and now dealt with projects that had some dimension of (participatory) action research. When I made the move in 2008 from Copenhagen Business School to (what was then known as) the Danish School of Education at Aarhus University, I came to work as an associate professor in the research program: Media and ICT in a Learning Perspective. Today, I work in a similar but somewhat larger group, the resarchLAB: IT and Learning Design, at Aalborg University. Consequently, I used to be in an HCI group, having expertise in the educational area. Now, I am in an educational research group, with expertise in the design sciences, working with digital learning processes.

Back in 2008 many of my new colleagues at Aarhus University applied Design-Based Research. I found that the design sciences that I came from with an Interaction Design (ID) and Action Research (AR) intervention approaches, and what I was introduced to as Design-Based Research in education had many overlaps, but certainly differences. Due to lack of writing space empirical projects are included on a vignette and reference level representing the potentials and critical points raised.

Thus the paper is primarily a discussion / reflection paper on a methodological level, and it is not a rejection of DBR; rather it is an attempt to show where some of the critical incidents are hidden, leading to identification of possible elements for future action. The elements discussed are: to broaden the concept of users, to include the

various roles in the organization; to be explorative and work with potentials, suggestions and alternative designs; and to develop the theory generation and rigour in the analysis phases.

2 Design-Based Research

When searching: "design based research" OR "design-based research" in web of science, scopus and google scholar, the first appearances of one of these two terms is within Engineering, in a talk from 1973 on production technology [15]. Earlier appearances can exist as the databases may not contain a digital version of the papers, or the papers from before this period, are scanned versions, where the body text are not searchable. For sure the discussion on design science appears much earlier, which for example Cross provides an introduction to in Designerly Ways of Knowing: Design Discipline versus Design Science [7]. Cross shows that within the technological domains, design science has primarily been about how to increase the knowledge pool on design methods (from various perspectives), and less about how design processes used in research can improve theory generation in any domain [7]. This was however the focus of intervention methods as action research, which was primarily coined by Kurt Levin in the 1940-50, where Levin made his famous argument that in his objective one cannot understand something unless you change it, and he formulated the unfreeze, change and freeze phases of action research, relying among others on group dynamics and democratic research process which today has evolved to more continues action research change models. [16]

DBR primarily emerged as response to the need of more usable theories and models in educational design, or what Juuti and Lavonen [18] calls bridging the gap between educational research and practice. The first two papers which have later been named the classical or first movers are Collins 1990 [6], who framed this a design science of education and Brown 1992 [5], who talks about design experiments. One of the first papers to use the design-based research term is the design collective, with the *Design-based research: An emerging paradigm for educational inquiry* from 2003 [10]. Many of these people came from a psychological or teacher education research background, where experiments used to be lab settings that tested hypothesis. It was the move to real contexts and working with practical usable methods and theories, which were the primary objective, and so DBR was (and for some are) still an hypothesis driven approach to theory development [5, 6, 10, 12]. "*Through a parallel and retrospective process of reflection upon the design and its outcomes, the design researchers elaborate upon their initial hypotheses and principles, refining, adding, and discarding - gradually knitting together a coherent theory that reflects their understanding of the design experience.*" [12, p. 106]

According to Wang and Hannafin in 2005, DBR is "*a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real - world settings, and leading to contextually sensitive design principles and theories*" [31, p.6-7]. This is not much different from Anderson and

Shattuck, who through a review of the five most cited papers in each year deducted the characteristics shown in the below list [2]. The bullets are the title of each section from the paper (and I will return to this list at the end of the paper). DBR are [2]:

- Being situated in a real educational context
- Focusing on the design and testing of a significant intervention
- Using mixed methods
- Involving multiple iterations
- Involving a collaborative partnership between researchers and practitioners
- Evolution of design principles
- Comparison to action research [which the authors describe as different from]
- Practical impact on practice

DBR in education primarily focus on an already designed artefact (perhaps a prototype) and its application in an everyday context, with all its messiness, chaotic and divergent nature. This artefact or first version of it are then improved in iterative manners, through several interventions [e.g. 13 and 20], which gives knowledge about how this artefact works, and informs the educational domain about how similar designs and situations would work. The artefact being used in the intervention is a new technological product [20], or a technological enhanced learning process [32].

The DBR mind-set rest on an assumption that we as researchers can learn from the participants (teachers and learners) take on the design and the experienced learning process. Amiel and Reeves calls it a democratic research practice for researchers who believe in research as value-added, and that it is a possibility to use DBR to investigate in social responsible research [1].

DBR researchers argue that learning processes are complex in nature. This makes it difficult to measure and differentiate between the dependent or independent variables, as many factors influence. Juuti and Lavonen mentions: classroom settings, social and psychological atmosphere, pupils' motivation, affection and conceptions toward a topic to be learned or toward schooling as such, and moreover, students' experiences outside the school [18, p.55].

DRB research results in understandings and knowledge which has the objective to be useful for and often change practice. Pragmatism is by many authors seen at the underlying paradigm [2, 3, 18, 31]. This entails an ontological perspective of the world as complex and chaotic, where people with ideas and solutions through interaction change the context and the reality; and an epistemology that we need to try our ideas and solutions in real world settings in order to gain knowledge of the world; that the theories we generate need to be practical solutions to real world problems, and the methodological validation, that we can know something substantial about this world through repeated interventions. This is not similar to an understanding that a solution or a theory is final and will always work.

There are however inherent challenges on a methodological level, which has also been discussed and raised by several researchers. I have in particular learnt from the work of Yrje Engeström [14] and Chris Dede [9]. Not everyone who criticizes rejects DBR, but to do this to be aware and work with these factors as the DBR method matures. The most discussed issue is over-methodologized studies: Applying mixed methods strategies often means using many and varied methods in the same DBR

study. The extremely large data-sets which these methods lead to makes alignment and analysis difficult [9]. Another criticism is that it can be difficult for a researcher to stay trustworthy and unbiased, when being involved with the design and the intervention (designing, planning, conducting and evaluating) [3], but at the same time this is also seen as the quality of this research practice [2], which is comparable to the epistemology in a constructivist and interpretionist viewpoint. A third issue is that the design evolves over time, and with this the methods applied may shift as well [9]. As such, DBR lack rigor in the research process, which means we need robustness of evaluations, as well as ways to determine what a successful design is [9, 18].

Lyon and Moats point out in a paper on intervention research in general (i.e. on reading interventions not specifically DBR) that it may be difficult to replicate interventions because we do not have enough insight in a number of factors [19]. They mention: Sample Heterogeneity and Definition, Poorly Defined Interventions, Inadequate Control Groups, Inadequate Intervention Time and Transfer Effects, Effects of Past and Concurrent Instruction, Method or Teacher Effects, Consistency Across Teachers, and Generalization and Maintenance Issues [19, p.580]. Though some of these factors shows a desire to aim at a more positivistic paradigm of wanting to find the rules that govern the world (as the desire to replicate), they raise interesting issues relevant for research interventions. Issues that I find are seldom discussed explicitly: as the effect of the teacher and consistency across teachers (sometimes this issue is mentioned, but is not shown as something which is analysed for). Another discussion is that there are many projects that have very well defined interventions, but because of the evolving nature of these, it is difficult in papers to disseminate knowledge about these precisely enough, to document what took place.

Engeström criticizes that design experiments have what he calls a linear view: "*In discourse on 'design experiments', it seems to be tacitly assumed that researchers make the grand design, teachers implement it (and contribute to its modification), and students learn better as a result. Scholars do not usually ask: Who does the design and why? This linear view is associated with notions of perfection, completeness and finality*." [14, p3] A point Dede also raise when stating that: "*People fascinated by artifacts also are often tempted to start with a predetermined "solution" and seek educational problems to which it can be applied, a strategy that frequently leads to under-conceptualized research* "[9, p.107].

Engeström shows how DBR seldom discuss that the linear view makes some research studies blind for how interventions also brings about resistance to change from participant; how people reinvent a strategy and perhaps changes it, while it is being implemented. He sees resistance as natural force (as in action research) and discards design experiments and argues instead for formal interventions, where he among others presents a model to analyze and understand the interventions, namely his renowned model of activity theory [14]. He argues that all actors thereby get a language to talk about what is and has happened in the process. He also argues that the formal intervention unlike DBR has an open starting point, and that the intervention is subject for negotiation, with the aim to focus more on a localized solution than general applicable solutions, and thus a research role that have the aim to foster expansive

transformation owned by the participants rather than a process where the researcher tries to control all variables [14].

In the following sections I look to interaction design (ID) and action research (AR) for inspiration to some of these issues. Majgaard, Misfeldt and Nielsen made similar use of a comparison between DBR, ID and AR in their case study, though raising different perspectives than I do here [20]. All three approaches apply some level of mixed methods, and all three have an onset in pragmatism that makes it possible to get inspiration from each other.

3 Online and Pervasive Settings

Where DBR projects were relatively small to begin with, many projects today are large in scale, are longitudinal studies, involves many participants, and/or several research partners [e.g. 21 and 23]. The projects I work with have an extra dimension of participants working distributed in either time or place or both, and in settings, which physically or mentally are not strictly classroom-like [24, 32]. This means the use situation, the intervention, is not always easily identified, but permutate into other everyday situations and the question becomes how we as researchers' deals with a design and intervention, which we cannot follow directly due to its pervasive nature.

Anderson and Shattuck [2] shows that in the approximately 50 DBR studies they reviewed, none of these were explicitly in the competence development domain. They did categorise 5 studies to teacher training, but teacher training does not necessarily entail competence development, and the citations they use refer to results that are presented as useful in pre-service teacher training [2]. However, as the teachers often play a vital role in the studies, a competence development perspective as training experienced teachers could certainly be part of some of these studies, just not an explicit mentioned objective.

Even though many of my projects are situated in a formal educational system, they often have competence development for teachers as one of the objectives, and I have also worked with knowledge workers in consultancy firms, and health care professionals. All of these situations differ from the traditional classroom setting, not only because of the online time and space distribution, but also because the primary learning objective is different. Learning objectives in school contexts (regardless of this being primary school or higher education), are often related to learning outcomes and retention. Of course engagement and satisfaction are important factors, but in the end students are assessed on their knowledge and ability to utilise their domain knowledge, also in more constructivist approaches in for example project work with empirical data, problem-based learning approaches etc. Nearly everything is measured at an exam. However, in competence development transfer from learning context to working contexts is the key factor. And if users are online, how can we gather information about both the users' interaction with the solution and the intervention, how do they communicate with and reflect with peers, and how do we know about the effects that intervention have afterwards on their everyday practice?

In the IFIP working group 13.6 on Human Work Interaction Design a number of tools and techniques for exploring the relationship between extensive empirical work-domain studies and interaction design has been presented. The workgroup encourage empirical studies and conceptualizations of the interaction among humans, their variegated social contexts and the technology they use both within and across these contexts (see the proceedings and activities at http://blog.cbs.dk/hwid_cbsdk/). The methods: sketching and mobile probing and probes are relevant in this context and methods that I have worked with in our HWID group. Sketching can work as a way of getting to user needs and requirements as well as unaffordable ways of trying out alternative designs [35]. Mobile Probes and probing is a method in between cultural probes and interviews, where the unknown are explored through questions send via SMS, about what people are doing here and now, what they have done in a particular area that day, which challenges they met etc. A fruitful method, when the users are distributed in time and space from the research team [11].

Methods that work with uncovering the unknown and serve as a catalyst for the daily practices opens for areas that we as researchers did not know we could or should ask about, and that partcipants' had not hitherto verbalized as interesting issues [11, 35]. Other methods that can carry results in these pervasive settings are auto-ethnographic methods of digital nature - as in self-reporting on use via log-books, rich qualitative questionnaires, and digital storytelling / narratives. Interestingly this coincide with the effort to use digital narratives in DBR to communicate with fellow researchers in [18] with reference to Bell, Hoadley, and Linn (2004)). Finally, of course many traditional mixed methods strategies are applicable in online environments, as online interviews and focus groups using video conferences, online surveys etc.

In conclusion, I argue that as DBR expand to educational settings that exceed the traditional formal educational classroom setting, so must the methods applied embrace this.

4 The Participants and the Organisation

DBR emphasize interventions in a representative real world setting understood as the classroom setting; investigating learning, learning strategies, perhaps teacher-student relations or even political agendas [2, 31]. Juuti and Lavonen [18] says that design research has three parties: (a) a designer (e.g. researcher), (b) a practitioner (e.g. teacher), and (c) an artefact (e.g. web-based learning environment for science education), but do not mention any other roles in the organization. However, there are many more roles, structures and activities which could be considered, than those present in the classroom. For example the team of teachers, which the teacher in the intervention collaborate with on a daily or almost daily basis, the it-people and administration, the management, or other intangible artefacts as the culture at the school, the voice of the municipality, perhaps even national or international strategies etc. The objective here is not to make educational research into grand scale organizational, social or financial studies, but to illustrate that if real world settings are important, then the organization as a whole is important, and we need to understand or at least reflect upon its role.

There are many action research methods, but one of the common denominators is that researchers co-construct knowledge together with the practitioners (of course to various degrees in the various methods) [16]. Though there is here some similarity to AR and DBR, AR often provides the opportunity for participants to take ownership over the design and the interventions to a larger degree - sometimes even to a degree where the participants' finds that the process the organization has been through would have happened anyhow, i.e. without the researchers being present, which is in a way a positive thing. I have also seen, how too much ownership from management means that teachers then almost tacitly agrees to thinking less constructive and engage less in the DBR study. This is in line with the previous mentioned thinking of Engeström who works with resistance as a natural force [14], and in much organizational development literature resistance to change is seen as inherent human trace.

The parties involved may have different interests, not necessarily opposing interests, but with variation in what they priorities. One example is the difference in focusing on a micro or macro pedagogical level or on differences in time scale. The learners may be interested in learning and motivation with respect to their own learning process (here and now), where the organization is also interested in changes over time (next year students, other classes etc.), and the researchers may be interested in what can be learned from the intervention, which can inform theories and practices in general (meaning even bad examples can be learnt from). Also, who is concerned with the afterlife of the project in the organisation - after the researchers has left. Therefore it is pivotal to start from understanding and working with participants needs, and perhaps even clearly identify the success criteria's' for all parties / stakeholders.

5 Problems and Potentials, Solutions and Suggestions

"*The idea that DBR is initiated to address problems that are both scientifically and practically significant has been repeatedly addressed in the literature*" [21, p. 98], and this objective to make practical useful research results are also present in AR and ID. AR has a similar starting point of addressing problems, whereas in ID one can also work with potentials (as developing design innovations that there is no observed need for yet).

In both ID and AR the underlying belief is to work from a starting point that is explorative in nature, identifying needs and requirements of users in the context, before settling on the design specifications. This initial starting point is somewhat different in DBR, where many are hypothesis driven (in particular in the first papers of Collin [6] and Brown [5]), and many starts with a technological design, full functioning solution or a working prototype (as shown earlier). Ejersbo et al presents two types of DBR studies, which had different starting points and different iterations. One where the design came first and another where a more ethnographic process of understanding the context was first applied [13]. They do not claim one is better than the other, but argue for what they call the "osmotic mode" of balancing the development of an artefact and the theory generation, and claim that as such DBR is not linear (which can be related to Engestöms [9] critique of DBR as linear discussed earlier).

In AR and ID a distinction is made between user centred and participatory, when it comes to the participants. The first is an approach that values users, but where users are not directly involved in making the actual design or change process; whereas in participatory approaches, users are co-designers and not only co-creators of the knowledge, but make co-interpretations [16, 26]. Educational research could certainly work with both user-centred and participatory aspects, and just need to be explicit about the choices made. What is interesting is that the element of being 100 percent participatory may not always be an adequate solution in educational arenas, when for example the participants are on new grounds. This is perhaps best highlighted in the classic Spinuzzi paper [28], where the argument raised is, that users do not always know about thinking creatively about their own situation and henceforth cannot be as innovative as experts are (to put it briefly). When participants are at the same time learning about an area, that they now little about, this may very much be the case.

It is noteworthy that even though ID and AR researchers start with explorations of user needs and have them participate in the development of the change process / design of product or solution, the researchers always comes with their expertise in a certain domain, and so the area of research is bound to be within this researchers practice. For example I seldom see empirical studies where the solution is abandoned (it happens, but is rare). In a worst case scenario, intervention research of any kind may end up investigating large scale technological eLearning solutions for problems and opportunities, where a simple paper poster could have done the work. My point is that this form of bias is seldom discussed in any of the three approaches – DBR, ID or AR.

Working with solving practical problems and trying solutions to these are valid pragmatic approaches, but sometimes making explorations into opportunities and co-evolving the design is worth spending time on too.

6 Working with Alternative Designs

When working with people in educational research whether in small design experiments or larger DBR projects, I have often asked if we are in the project iterating on the best idea or the first vision. (Of course other and probably equally or even more troublesome questions that shows my blind spots could be asked to me.) One of the suggested criteria for determining if a design is successful are when there are comparable experiences across participants' roles (as students and teachers, boys and girls etc.), across contexts and when an exhaustion level has been reached (e.g. [23]). This is however only possible with smaller incremental changes of the design, and what we are comparing are if version 2 works better than version 1. So how do we define criteria's and find a process for when to abandoning designs, rather than seeking to improve a design (a learning solution or process) which may be better off discarded?

Perhaps researchers are in fact already applying alternative designs, but are not doing so explicitly. It is unclear when reading the many studies (that the sheer volume of a reference list cannot cope with in this paper, but for lack of examples look to [2] and [31]). If a design or intervention has changed significantly over time, well how many changes can one make, before it is no longer the same design? My point here is not

that designs cannot change over time, they will, but rather that there seem to be no work on alternative designs early in the DBR process, that act out the first vision.

Working incrementally with prototypes with real context serves great purposes - it was and still is a well-renowned ID and systems development approach. In 2005-8 Bill Buxton gave a series of talks with clear distinction between sketching and prototyping, where prototyping leas to refining the same idea, sketching was seen as a way of quickly and affordably trying out various ideas. (This discussion with reference to his talks and book is also shown in [35]). Trying out various ideas of the original vision, has shown me, how the vision in projects, may be fair and reasonable suggestions to an opportunity or problem, and that there are sometimes better ways of realizing that vision in concrete designs.

This and similar arguments has permutated into ID models. For example, in the period between two edition of the renowned interaction design book by Preece, Rogers and Sharp, the simple interaction design cycle change from having the second phase called: (Re)Design (in fig. 6.7 in 2002 and in the 2007 editions), to its name being Designing Alternatives (in the 2011 and fig 9.3 in the 2015 editions)[26].

I believe working with alternative designs is one of two suggested mechanisms for aiding us working in educational contexts and with DBR, that is to get pass the desire to or risk of confirming existing assumptions. The other mechanism is about rigor in the analysis. The challenge is to implement this to larger DBR projects with external funding that demands relatively set project timelines and milestones.

7 Theory Generation and Rigor in the analysis

Many DBR studies often gives rich conducts of the research methods and tools applied when creating and gathering empirical material (as observations, interviews, questionnaires, log-files etc.). The process of analysis on the other hand seems less in focus. Publications include discussion of theories that talks about the same phenomenon as seen in the research results, with quotes from students or teachers, but no signs of how did the researchers choose these citations over others, how were the various data compared, worked-through etc. [13, 20]. Of course the journals allowed paper length means that all processes cannot be documented, nevertheless DBR creates a huge number of data and as any qualitative study, the need to perform meaningful data reduction and data displays exist [22].

As Baskerville and Pries-Heje [4] I have found great use in grounded theory as a mean for bringing rigour into the analysis process of data in AR projects and as mechanism for theory generation [34]. Though criticized for being a-theoretical this is far from the situation today (if ever), merely grounded theory makes a deliberate starting point in the data, not the theories, as in informed grounded theory [29].

While discussing DBR lifecycles and video analysis, Mike Rook wrote in his blog (quoting Doris Ash), that dialog progress discontinuously, and that we need tools to scientifically make sense over time and make connections [27]. Discontinued discussions and learning process are certainly part of online distributed educational and competence development projects, and digital analysis software have enabled me to

analyse multimodal material that are dispersed and disjoint. The analytical software present today, as Atlas.ti and NVivo do not focus on written transcriptions, but provides the possibility to make open and axial coding, which allows for mapping of concepts, working with displays, and applying theories, without loosing the link to the original empirical material. This supports the validity and verification process bringing visibility to myself and others, who can follow the arguments made in the studies.

Nortvig presents a project on video conferencing, where the DBR process did not evolve as planned, and she used grounded theory to align the varied input into categories of mutual and conflicting factors [25]. In this perspective it is the participants in the DBR study, who talks about findings. They point to theory-generating subjects via their utterances about what works, about experiences, what motivates and engage, and about what does not work, engage etc. I.e. the participants points to events of interest, and the researcher(s) have the right and responsibility to interpret how these utterances interrelate, and to relate them to which theories says something relevant about this phenomenon.

Another aspect which is seldom visible in the publications on larger DBR project is how research collaboration and findings in-between researchers take place. It is difficult to see how researchers agree on the aforementioned input from the participants. In ID the evaluator effect in usability studies has been discussed for the last almost 20 years. A new large and systematic study published in 2014, walked through previous studies, and conducted a major study confirming the evaluator effect [17]. Here, it was found that nearly 1/3 of the reported incidents by 19 experienced expert evaluators, which were found to be major incidents of high importance by one evaluator, were at the same time reported as a minor incident by another evaluator. The authors found that: it is important to have several evaluators on a design project; evaluators can benefit from consulting local or domain knowledge; evaluators can consolidate and gain further insights through group processes; unmoderated (and thus also remote evaluations) resulted in the same evaluator effect (and that it can be a cost-effective way of gaining insights); and that reliability as perfect reliable reported incidents are not the objective (but that the process converge through iteration and re-design) [17].

The big issue in this DBR context is not so much that experts within a design science, find and priorities differently. The issue is how we match these findings. Though a group process may be used in DBR, it is not clear how this matching occurs, neither in the literature nor from the discussions that I have with my peers. This entails two perspectives. First having clear objectives and criteria's for what we are valuing in the specific DBR project is pivotal. (For example in a study of what authors deem as effective eLearning when doing empirical development studies (in general not just DBR), we found that 10% did not say what effective learning meant for them [24]). Secondly, if we as researches want to make our arguments robust by combining and do collaborative analysis, how can a group process ensure that we are not enlarging rather than diminishing our blind spots? If we in this process for example omit the less critical incidents or if we agree to focus on those that we agree is important – could it be that we are omitting those rare incidents that actually changes learning or are vital symptoms of something more crucial? I do not have a clear cut

answer, but as being aware of the evaluator effect seem to be a way forward in itself [17], similarly being aware and explicit of DBR-researcher-effects can be important.

8 Findings and Conclusions

This integrative review with a personal narrative element is an argument for an approach to DBR that stays true to the ontologies and epistemologies, which open for being explicit about the factors that influence research results in all its phases.

It could be argued that DBR with ID and AR perspectives result in solely localised knowledge that is tied to the intervention or the design, however results can also be general insights. Majgård et al illustrates this in their ID and AR inspired intervention in the domain of mathematic that led to insights about how children enjoyed and engaged more in the formal learning process, when they could experiment with huge numbers with many digits, than smaller and in the children's eyes uninteresting small numbers [20]. This type of knowledge could be criticized of concluding the obvious common sense knowledge for people with educational experience, as Dede claims many DBR studies do [9]. However, if no one makes these observations explicit, then common practical phenomenon may not be translated into what they mean for learning designs and learning materials in the future. In this case, teachers, developers and publishers of learning materials claim that children are not ready for large numbers and need to learn more about the smaller ones and their structures first, when in fact the opposite in this situation seemed the case. Perhaps the children need a dosage of both, and the teachers, developers and publishers need to change their practice.

In conclusion, I suggest expanding on Anderson and Shattuck's headings [2] (shown earlier in this paper) based on inspiration from ID and AR. DBR is still an evolution of design principles and have practical impact on practice, but can also expand on the headings as shown here:

DBR are [2]	**And could be inspired from AR and ID, particular in online educational and competence development projects, as follows:**	
Being situated in a real educational context	Broaden the concept of users to include the various roles in • the organisation • its stakeholders • the culture, • administration • etc.	Understand users and the context first, and then begin designing. Working with • potentials as well as problems • with suggestions as well as solutions
Focusing on the design and testing of a significant intervention	Work with alternative designs	I.e. there can be several designs (rather than refining on the same first vision)
Using mixed methods	contemplate distributed online environments and with uncovering the unknown	As getting inspiration from digital methods and tools, and from sketching and mobile probes.
Involving multiple iterations	of the chosen design	Establishing requirements or setting criteria's for • when to abandon designs
Involving a collaborative partnership between researchers and practitioners	Consider how to align when several research partners analyse data	and provide rigour in the analysis for example through grounded theory

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Insights from UX Research in the Factory: What to Consider in Interaction Design

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Abstract. During the past few years we investigated humans' work in a semiconductor factory, both in relation to digital and non-digital artifacts. With this paper, we provide an overview of aspects that are relevant in production environments. In particular, we present factors accounting for workers' experience as well as influences on their user experience (UX). Based on a meta-interpretation approach, we analyzed our previous studies on the basis of publications that presented our previous research results. In total, we annotated 22 publications, which reported results from qualitative (e.g., ethnographies, interviews) and quantitative approaches (e.g., questionnaires). Overall, this work contributes an orientation for designers and researchers regarding the interplay between user, system and context in a factory environment by pointing out relevant aspects of and influences on workers' experiences.

Keywords: factory, production environment, user experience, interaction, design, context, user, system, work

1 Motivation

Research on user experience (UX) is often highlighting the relevance of the context, in which the interaction with an artifact takes place. Consequently, rich descriptions of contexts are needed, but according studies are still rare [1]. Many studies only focus on particular aspects of experiences, but widely ignore the multidimensionality of UX and the interrelationship of UX dimensions in specific contexts. Further, UX research has primarily been focusing on art and consumer products, while lacking devotion to work contexts [1]. This might be due to access restrictions, i.e., research faces a variety of limitations when trying to investigate competitive or safety-critical environments (e.g., [2], [10]). Another reason could be that the potential of performing experience research is less obvious in a factory context [18].

This paper represents an attempt towards summarizing a series of different studies in the context of a semiconductor factory in order to identify relevant aspects with regard to UX (i.e., workers' experience). We aim to provide an

orientation for researchers and designers by creating awareness that workers' experience is crucial for their well-being and performance. We present aspects that account for workers' experiences in a factory context which can be researched and designed for, reflecting that workers' experience is multifaceted. In order to better understand this context with regard to UX, we conducted a range of qualitative and quantitative studies. These provided us with a comprehensive understanding of workers' routines and experiences and helped us to identify aspects that are of particular relevance for UX in the factory[1] (e.g., trust, stress).

In this paper, we provide an overview of relevant factors, which we found in our previous work. These factors include aspects of the workers' experience when interacting with systems in such a context, as well as influences on workers' UX in form of system properties (e.g., efficiency), user characteristics (e.g., attitude), as well as characteristics of the social (e.g., hierarchy) and physical (e.g., space) context. Although these aspects are not independent from each other, they address specific notions of users' interactions that need to be taken into account in the design of interactive systems for the factory.

2 Background

2.1 Research in the Factory

In general, industrial contexts pose a variety of challenges and restrictions, for instance, fieldwork must not impact work practices [2], [30]. For decades, scientists have been occupied with investigating factory work from a point of view of classical or social psychology (e.g., [3]). A great number of research addresses health or safety aspects, as well as ergonomics. Regarding humans' interaction with systems, the factory context has been less prominent in HCI research and publications. Few material can be found that puts factory workers into the focal point of attention when designing interfaces. In the beginning of the 1990s, an IEEE Colloquium was held on "HCI: Issues for the Factory", dealing with the psychological basis for computer system design, operator support systems and industrial inspection [11]. This colloquium, however, remained a unique event and was not continued in the following years. Similarly, Fallman [7] points out the importance of investigating new technologies in the factory context, considering the industrial use of information technology (IT) as "paradigm shift".

2.2 Research on (Workers') User Experience

Researchers still stress the need for a precise understanding of UX as well as a comprehensive formulation of the concept and its constituting factors (e.g., [14]), covering a range of contexts and situations. According to McCarthy and Wright [15], experience is constructed out of the interplay of the human and the technology in a situation. Thus, experiences are dynamic, situated, and never the same (i.e., holistic approach on experience). In contrast, Hassenzahl and

[1] in the following considered as "UX factors"

colleagues [9] suggest categorizing experiences on the basis of psychological needs and link them to affect and product perception. They highlight the need for some kind of generalization of experiences in order to be useful for HCI, and for designing interactive products (i.e., reductionistic approach on experience). In our research, we acknowledge the situatedness of interactions, which we take into account by investigating very specific, situated interactions. At the same time, we aim to generalize our findings in the sense that we summarize and cluster the observations to provide an overview of relevant aspects in order to open up the research and design space of production environments.

Often, it is difficult to measure UX, or to investigate which characteristics would contribute to a positive UX. In particular, this may affect research on UX in production environments, as the context poses a variety of further constraints and challenges that increase the complexity of such investigations. Within the Christian Doppler Laboratory "Contextual Interfaces" (CDL), a nationally funded seven year research project, we address this issue. In particular, we aim to research contextual interaction from different viewpoints, e.g., understanding users in contexts or designing interfaces and interactions for challenging contexts [8]. For example, we already stressed the importance of UX in the factory [18] and provide initial insights on workers' everyday experiences and contextual influences on it [33].

3 Approach

3.1 Study Context: The Semiconductor Factory

The overall goal of the semiconductor fabrication plant is a "zerodefect" production of microchips, i.e., ideally there are no defects during manufacturing, as they would be very costly. Consequently, the following aspects are crucial: continuous improvements of the work place, processes, and equipment, fast feedback loops, detection of weak spots, avoidance of redundant work, and ongoing enhancement of wafer quality. The production is made in hangars, so called cleanroom areas, which are categorized in different micro dust halls. The cleanroom poses several challenges for research, e.g., 24/7/365 production, high complexity of processes, interfaces and interactions, or the need for special equipment, like cleanroom suits.

3.2 Method & Procedure

In order to summarize and cluster UX factors based on our previous work, we drew on the approach of meta-interpretation [29]. According to Weed [29], our first step was to identify the overlying topic according to our research goal, i.e., UX in the factory. Afterwards, we established the "meaning in context", i.e., we collected an initial set of relevant publications and analyzed their content in terms of the goal of the literature synthesis. Based on this initial analysis, we included further studies and excluded those, which did not fit our objective (e.g.,

studies that did not address or detail their understanding of UX). The analysis was continued until theoretical saturation was reached, i.e., no further findings regarding UX were identified in the publications (see an overview of publications included in the subsequent subsection). Finally, we summarized the findings.

3.3 Overview on Materials Used

All publications that are mentioned in this subchapter were included into the analysis for this paper. In order to provide an overview of how they relate, their origin, objective, or approach is described in the following.

Overall, our research in the factory was both holistic and reductionistic. Initially, we followed a rather holistic perspective on UX in order to get an understanding of the heterogeneity of the contextual constraints in the cleanroom and the task diversity of different workers (e.g., operators, shift leads, maintainers) in this area. By applying qualitative methods like contextual inquiry, interviews, probing, or creative workshops (e.g., [12], [13], [18], [20], [31], [33]), we gained a comprehensive picture of workers' routines and experiences.

In this early phase of our research, we focused on the uniqueness of experience, aiming to describe individuals' situated experiences in detail. Based on these findings we identified different factors, which play an especially important role in this context (e.g., trust, stress). In later stages of our research, we focused on these selected UX factors to explore them in detail, reflecting the adoption of a rather reductionistic perspective. In particular, the changes of specific UX factors over time when introducing new interfaces turned out to be a promising field for future research [5]. For instance, we conducted a study on industrial robots in the cleanroom, where we accompanied the deployment of a new robotic arm over one and a half years [5], investigating changes of the workers' experience. Based on the findings from studies in the cleanroom (e.g., [5], [30]), we focused on specific UX factors relevant in the factory by conducting lab studies. In terms of human-robot interaction, we studied the role of feedback [23], anthropomorphism [24], training [22], social cues [32], or input modalities and task complexity [25–27].

Furthermore, the studies were the basis for designs and UX prototypes. In these designs, we focused on wearable devices [19], [21], or ambient persuasive displays in the factory [4], [16], [17], [28].

4 Findings

In this section, we describe relevant aspects of the interplay between user, system and context regarding workers' experiences in a factory environment. With *user* we refer to the workers in the factory. With *system* we mean interfaces, devices, or robots, the user has to work with in the factory. *Context* refers to the physical or social environment in which the factory work is accomplished. Our findings are structured in form of *UX factors* (i.e., aspects of experience) as well as *influences on UX* stemming from the user, the system, or the context.

4.1 UX Factors Identified

UX factors represent a component-oriented approach on UX, decomposing UX into specific aspects, which account for the users' experience when interacting with a system in a context. They represent measurable units of UX and thus support the operationalizability, measurability, and comparability of UX. UX factors, which we have identified as relevant with regard to interactions in the semiconductor factory, are outlined in the following.

One aspect regularly mentioned by workers when interacting with systems in the factory is **perceived workload** ([4], [13], [16], [21], [22], [27], [31]), meaning the cognitive effort required by the interaction with a system in order to solve a task. Attention and awareness are needed when interacting with a factory system; information overload increases the perceived workload.

Perceived workload is closely related to **stress** ([5], [17], [18], [20], [24], [33]), which reflects the workers' tension and perceived pressure induced by the interaction. Time pressure, shift cycles, problems with equipment and priorization of interfaces were often mentioned in relation to stress when interacting with the system.

Feeling of control ([4], [23], [24]) is another relevant UX factor, meaning the workers perceived influence on the system's actions. Particularly, this factor is crucial in human-robot interaction, e.g., that the human stays in control of the robot. Further, unnecessary information on interfaces promotes a feeling of losing control.

Another UX factor crucial in the factory is **perceived usefulness** ([4], [17], [20], [22], [30], [33]), which denotes the utility attributed to interacting with the system. In the factory, a system is perceived as useful and supportive if it improves, for example, the workers' efficiency or effectiveness. Otherwise, if a system works slow or even freezes sometimes, it is perceived as a hindrance regarding workers' performance.

Perceived ease of use ([4], [12], [13], [17]), i.e., how easy the interface is to handle in the interaction, is closely related to learnability and intuitiveness/complexity of the system. Information overload and slow performance of interfaces in the factory are perceived main problems regarding their usage. Such problems are often mentioned as a source of stress for workers.

Performance Expectancy ([24], [26], [27], [28]) means the degree to which a worker believes that using the system will support his/her performance. In the factory context, the expected performance is often decreased due to external factors like technical problems, bad work organization, or equipment related issues such as slow delivery of lots or too many equipment items in service.

We further identified **satisfaction** ([12], [13], [25], [27], [33]), i.e., the contentment with the interaction, as a UX factor. Workers are satisfied when they think that their performance is good or when they get positive feedback regarding their performance from others (i.e., colleagues or superiors). The more difficult a task, the more satisfied they are.

Another UX factor is **perceived safety** ([5], [21], [23], [24]), describing the workers' perception of the level of danger when interacting with a system. This

aspect of UX is especially relevant when dealing with robots. For example, certain security mechanisms (e.g., emergency stop button) or displaying the robot's current and next state convey a feeling of safety in human-robot interaction.

Trust ([4], [12], [23], [22], [27], [33]) is also an important issue regarding workers' experience at the factory. With trust we refer to the extent to which the user feels confident that the system will behave as intended. Trust is closely related to perceived safety and the feeling of control. Reliable and error-free system processes as well as feedback modalities that inform about the system's current state might help to improve the trust towards the system.

Emotions and feelings, i.e., affective states of positive or negative valence, further shape the workers' daily experience in the factory. Negative emotional experiences we identified were **anger**, **fear**, and **frustration** ([18], [31], [33]). Regarding anger, workers often mention usability and work organization as a cause. For example, workers bother when the machines are difficult to handle, or when action space is limited. Similarly, frustration is, for example, related to slow response time of the interfaces or information overload and thus closely related to stress. Fear is often related to human-robot interaction, as workers are afraid of being replaced by robots. Overall, production tasks (in contrast to administrative tasks) rather relate to negative emotions. Positive emotions mentioned with regard to factory work are **joy**, **fun**, and **pride** [33]. In contrast to production tasks, administrative activities are experienced rather positive by the workers in the production and foster emotions like fun, joy or pride.

4.2 Influences on UX

Influences on UX can arise from characteristics of the user, the system, or the context (e.g., [9], [15]). In our work, we differentiate influences from system properties, user characteristics, and context parameters on the UX.

Influences from User (e.g., [4], [5], [12], [19], [22], [24], [27], [28], [33]).
Motivation can be considered as a characteristic of the worker influencing his or her experience. Sources for motivation are, for example, an increase of the productivity despite having a lot of equipment down, working passionately for a common goal, or getting invited for a coffee to speak about the company. Further, the workers' **attitude** towards the system to interact with is crucial. Another influence on the experienced interaction is the workers' general **well-being**. **Pre-experience**, i.e., already gained know-how, was also found to influence the workers experience, similar to **reflexivity** (in the sense of conscious retrieval of knowledge and competences). Further, the workers' **flexibility** as well as their **routines** influence their UX.

Influences from System (e.g., [4], [12], [19], [21], [22], [23], [24], [25], [26], [27], [28], [33]). In the factory, the system's **appearance** in the sense of aesthetics and form as well as **visibility** of information and transparency of actions was found to influence the workers' experience. **Autonomy**, **adaptivity**, as well

as **flexibility** of the system also shape the UX. **Consistency** of the systems procedures, actions, or representations is important, as well as the **persuasiveness** of the system in the sense of guiding the user in his/her actions or tasks. **Reliability** of the system in the sense of trustworthiness and functionality influences the workers' experience. Further, the **complexity** and **intuitiveness** of the system are crucial. This includes issues like training needed to interact with the system, understandability, or learnability. **Efficiency** (i.e., the systems performance) and **effectiveness** (i.e., error rate) are further properties of the system affecting UX.

Influences from Context (e.g., [5], [13], [18], [19], [20], [23], [27], [28], [33]). With regard to the the physical context, **noise** was found to be characteristic in the factory, representing a physical constraint and an influence on the workers experience. **Light** as well as **temperature** (i.e., heat) represent further characteristics of the physical context of the factory. The special **clothing** required especially in the cleanroom is another constraint, closely related to the **contamination** which has to be kept as low as possible (especially in the cleanroom). Additionally, the **action space** workers have shapes their experience.

We found the following factors from the workers' social context to affect their experience. **Interpersonal reliability**, i.e., the trustworthiness of colleagues, is influencing the workers' experience. Further, **equal treatment** in the sense that everybody is treated in the same way by colleagues and superiors is another influence factor of the social environment. **Appreciation**, e.g., positive feedback from colleagues or superiors, is also crucial for workers, shaping their experience. Finally, **hierarchy**, in the sense of fulfilling formal roles and associated expectations, affects UX.

5 Discussion

In the light of the factory being a challenging and hardly investigated application context of HCI, the main intention of our work was to identify and collect UX factors as well as influences on UX towards a comprehensive picture of relevant factors regarding UX in the factory. The restricted accessibility of the factory context makes the importance of our contribution, i.e., factors accounting for workers' experience in the factory, even more obvious and allows designers and researchers to better understand this context. To the best of our knowledge, such an overview of what affects UX in the factory does not exist so far (e.g., [1], [2]).

With the meta-analysis presented in this paper, we aim to create awareness that UX in factories is worthwhile to investigate and design for and give indication of differentiated needs and sources for the design of appropriate interactive systems. Thus, we provide reference points for designers which they can draw on when conceptualizing and developing systems for the factory context that support a positive experience at work. Certainly, the factors presented above are subject to limitation, as they have been collected in a specific factory on basis of case studies, or within studies in a laboratory where the production context

was simulated. However, the differences to other production environments may primarily affect the degree of occurrence rather than the question whether the factors play a role at all, though the set of factors may be extended through further studies in other production environments.

Regarding the identified factors, (some of) them may be less surprising, given the context of a production environment, (e.g., perceived workload, stress, performance expectancy). Others, however, are more surprising (e.g., emotional experiences, such as fun, anger, or pride), pointing out possibilities for design that may not be initially thought of in this context. For example, we found that negative emotions like anger, fear or frustration are much more prominent regarding workers' experiences than positive emotions like joy or fun. An implication of this finding may be to focus more specifically on positive experiences in future designs. This knowledge (i.e., what accounts for positive experiences in the factory) is provided by our work. Similarly, the results help us understand why designs may lead to different actions than imagined or intended (e.g., technology appropriation [6]). Thereby, the complexity is even increased through the interplay of the various factors and aspects. This poses serious challenges, especially to the design of interactive systems, as it is difficult to decide what exactly to design for. Nevertheless, being aware of the situated nature of interactions and the range of experiences that may occur, as well as what may influence them, will help to explicitly decide for or against certain aspects, depending on their likelihood of appearance.

Critically reflecting our work, it represents an exception as we had the opportunity to conduct studies in a sensitive context which is challenging and hard to access for more than five years. Thus, our research could advance from initial studies aiming to get to know the context to very specific studies investigating defined factors in detail. A particular challenge we were confronted with was to gain the trust of the responsible stakeholders in the factory. This was especially hard at the beginning, when the stakeholders were skeptical about research in this challenging context. With progressing time, trust and openess towards the researchers increased and made it possible for researchers and stakeholders to work together closely.

6 Conclusion

This paper presents an analysis of UX in human-work interactions, which is based on several studies in the context of a semiconductor factory. Factors relevant in this context were identified and clustered to reveal the multiple facets of user experiences and influences on this experience. We presented UX factors occurring in the factory, ranging from stress, performance expectancy, trust, and satisfaction, to joy, pride, fear, and anger. Those factors are influenced by user characteristics, such as the user's attitude, well-being, flexibility, or routines. Furthermore, system aspects affect the users' experiences (e.g., complexity, appearance, visibility, accessibility, or persuasiveness). Contextual specifics may also influence human-work interactions, i.e., the physical context (e.g., noise,

light, clothing, or action space) and the social context (e.g., interpersonal reliability, equality, or appreciation). Focusing on these factors as well in the design of human-work interactions is, thus, a promising approach to improve users' experience at work, which eventually results in motivation and well-being at work.

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User-Created Personas – A Micro-Cultural Magnifier revealing Smart Workplaces in thriving Katutura

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Abstract. Participatory Design (PD) and service design have shown great potential in co-designing feasible solutions with marginalised societies. This study is part of a research project where dwellers in the informal settlement of Havana in Windhoek engage in context analysis for the establishment of a community centre offering technologies and services supporting the unemployed in finding work opportunities, self-employment and training. Participants first walked us through their neighbourhood pinpointing existing challenges they then communicated through persona sketches of local disadvantaged individuals like prostitutes and criminals. Societal issues, collective representations and sociotechnical gaps emerge, and participants reimagine these into work opportunities, enterprising, community cohesion, and overall alleviation and life improvement. The object of research is to align social realities, existing technologies, and design requirements to ensuring suitable usability, financial affordability, fulfilment of User Experience, and the ultimate self-sufficiency of community and overall project. This paper ultimately argues User-Created Persona (UCP) in PD as a fruitful inquisitive proceeding to explore and augment pervasive and smart work possibilities in locales with limited opportunity and resources.

Keywords: Work Analysis, HCI4D, Micro-Cultures, Walking-Method, Personas, User-Created Personas, Participatory Design, User Experience.

1 Introduction - Research Area and Focus

Human Work Interaction Design (HWID) endeavours to better understand relationships between concepts and methods in Human-Computer Interaction (HCI) and their meanings to local and indigenous groups [6]. A paucity of empirical HWID projects in developing venues, however, contrasts with ventures in HCI for development (HCI4D) that strive to enable and empower people in underserved or marginalized populations worldwide [1]. Some of these projects test, question and repurpose re-

search and usability methods [2], [4], [5], [14], while others propose processes where engagement with locals is in their own terms [7]. The array of perspectives parallels, nevertheless, present rates of unfruitful deployments [3], which some argue due to ideas in developing venues maturing slowly and over time [19].

Groups coexist in developing contexts with specific historical and geo-physical conditions characterising dwellers and environments like in townships. We postulate these are micro-cultural possibilities to develop a small model of culture that could either be gradually expanded into a larger model, or, to our current aims, evolve into a more manageable assembly of people's characterisation and placing regarding socio-otechnical needs, requirements and aspirations [15].

Our endeavours spawn in Havana, an informal settlement in Katutura, Windhoek. Katutura means *we do not have a permanent habitation*, as black communities were forcefully allocated, and tribally segregated here by apartheid during the 1950s and 60s [13]. This heritage makes Katutura to hold on to a historical susceptibility towards unemployment, lack of services and amenities [8]. This is despite more and more people move to Windhoek hoping to find employment and a better life, and yet approximately half of Windhoek's population lives in Katutura with a traditionally overwhelming majority of rural-urban migrants [16].

2 Introduction to the "Live Design. Transform Life" Project

This project stems from an ongoing venture by the School of Computing and Informatics at the Polytechnic of Namibia (PoN) into co-designing new services and technologies with marginalized youth in urban and rural Namibia. The overall project aims to explore how mobile applications and innovative service design balance formal education to develop youth, thereby opening new and viable career opportunities.

One of the pilot sites of this project since October 2014 has been the Kabila Community Centre in Havana, where an initial group of PoN and international students explored challenges and possible technical solutions. Since then, a second generation of PoN students engaged in developing a job-matching-ranking system as well as promoting entrepreneurial activities through a participatory approach. Havana participants have since the inception varied across the different activities. Most of the participants are youth, which come on a voluntary basis and most of them have attended more than on session. The number of participants per session also varies between four and fifteen, with often a great number of late comers in the middle of started sessions.

Participants undertook an initial work analysis in preparation to launch a community centre and a technological job-search tool previously identified as a need in the community. Both items aim to alleviate local unemployment by providing training and work opportunities. The present objective of research is to identify sociotechnical gaps to then device optimal community interactions around physical spaces, available technologies and logistics anew. Participants thus walked us around the neighbourhood first to pinpoint existing challenges. Then, they communicated such defies through persona sketches of deprived locals. Concurrently, semi-structured interviews attempt to find individuals' needs and hopes, while a further session introduced par-

ticipants to a set of initial prototypes of the job-search tool. In a later intervention, participants further developed the above personas to consolidate the societal issues, individual and collective representations and technological gaps.

The pragmatic aim is to establish socio-technical requirements and align them both, with existing situations and the technologies available. This is so as to continuously ensure a suitable usability, financial affordability, the achievement of an overall acceptable UX, and the ultimate self-sustainability of project and technology. Theoretically, though grounding on previous empirical experiences in Namibian contexts [9], [10], [11], we explore UCP as an inquisitive procedure to investigate, elicit and communicate processes for pervasive and smart work possibilities in communities in deprived cross-cultural locales such as Havana.

Each section below, hence, presents the method initially chosen and its intended utility, as well as the actual deployment and the outcomes provided using it.

3 Walking Havana – Revealing Sociotechnical Gaps

Walking Havana assisted five female and male locals and five PoN researchers to initially identify local realities by mapping-out the area's physicality (Figure 1). Walking got proposed as "location scouting" for a pilot TV-series based on the joint activities to be undertaken in Havana. So, it got filmed and photographed for such purpose and for research analysis as well. Participants pinpointed an overall paucity of electrical reach, grim access to potable water, wastelands round inhabitants' shanties, drunkenness, and scarcity of hygiene resources where public decaying open-showers serve locals for sanitation (Figure 2).

Fig. 1. Participants walking Havana.

Fig. 2. Hygiene, spirits, illegal wiring, water, wasteland.

They also indicated regular power cuts (as occurred in the persona session below), and remarked ongoing brick structures and cementations intermingled with shanties.

Mapping Havana hence revealed social and technical issues typically attributed to slums [19] for their basicness in needs and nature. For the purpose at hand, however, this seemed material enough to consecutively propose to create personas from locals.

4 UCP - Embodied Underrepresented Sketches

Scaffolding from the above walk, and continuing with the plans for the TV-series, participants plus two new late-arrivals created characters depicting Havana locals. Pens, markers, newspapers, magazines and A4/A1 paper were layout and participants split into Groups A and B. The aim was to explore who from the community gets characterised and why such choice; what information emerges from characterising; how much resonates with issues from walking session, and how participants create characters. It is worthwhile noting participants have not yet been introduced to HCI personas. We postulate this legit to avoid rhetorical hurdles, jargon impediments, and the unnecessary inconvenience of some abstractions in technicality and HCI concepts [5]. Instead they were asked to create "actors" for a movie to be co-directed by them.

After 20 minutes Group A presented a written narrative entitled "Living like Slaves – Havana Location", where 19 year-old Eddy came to Windhoek aged 16 and currently lives in a shanty cooking with firewood and with no electricity or water, (Figure 3). Group B produced a collage entitled "Unemployed Youth" from press cut-outs and handwritten written text (Figure 4). The collage consisted of collective characters and joint-background scenarios telling why and how a local female and male turn into prostitute and gang member through time and unfavourable conditions in the vicinity.

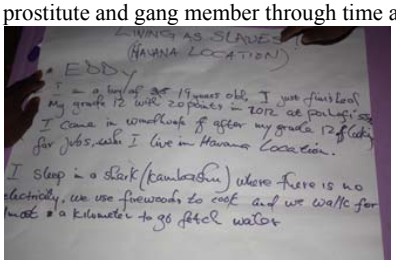

Fig. 3. Description of "Eddy" Character.

Fig. 4. Collective characters - holistic stories.

"Tselestina and her friend undergo hardship and decide to stand outside a club "for hunting" foreigners looking for escorting (Fig. 4, centred); Sequentially Alomgombe and Johanes got stopped and arrested to custody in a shopping mall (centre right). Meanwhile top left corner, 5 year-old Tselestina, Alomgombe and Johanes are "playing at their location" while dogs eat from a dumping site beside them. Top right, a press cut-out and written text tells on parents rallying against (1)high youth unemployment, (2)children standing by dumping sites, and (3)to achieve better housing. This is further supported by another cut-out (far right) where there is a casserole with the words Education and Success embedded and steaming from the pot, and a burning fire underneath with the words Teachers, Parents, Pupils rooted in the logs. Bottom-left the pictorial shows people rioting with fire and tires, while the narrative describes shanties burnt because of paraffin stove and candles' indoor usage.

Group A portrayed a brief written description on Eddy's housing situation, this delivered no further detail about situational causes or Eddy's life effects.

Group B, however, provided relational causes and consequential effects through graphic and text association in the narratives of the two main characters of choice. Relationally, they interwoven Tselestina and Johanes' background stories from childhood and implemented mothers as supporting characters, rioters playing 'extras', dogs, food leftovers, and car wheels as commonly encountered props, and sceneries as backdrops. This also conveyed a particular pairing of pictures whereby people and settings were side-by-side. Consequentially individuals' personal issues came together with a strong community support that illustrates an enrooted sense of holism in family union and public resilience that prevailed throughout the years before apartheid [18]. This also parallels previous accounts of UCP research in Namibian settings [10]. The accounts and major concerns perceived and expressed by the dwellers themselves resemble previous narratives collected with unemployed youth in the capital [17].

5 Individual Interviews

Along the group interventions, individual stories are continuously collected in form of separate interviews. While this data will be used for different research purposes, the main aim in relation to this study is to compare the "real stories" with the created actors stories to evaluate the usefulness of UCP in this context. Moreover, we established a baseline data on a wide ownership of basic cellphones and few smart phones.

Informal conversations with one participant revealed a genuine, quasi-adamant interest in acquiring a set of musical instruments for the community center. As part of the overall community-centered system in Katutura, there are dated recounts of 'the tribal court' and the brass bands ethnic groups living in Katutura until terminated by apartheid [18]. This may not seem part of work analysis to practitioners outside the Arts world. Yet, it provides with an array of implicit possibilities for the future of technological pervasiveness in these settings.

6 Job-Search Prototype - Focus-Group Presentation

In this focus-group two PoN student assemblies introduced initial high-fidelity prototypes of the job-search tool to sixteen locals to get feedback from potential users. Students successfully related to participants by using both the local language, namely Oshiwambo, and a dialectal rhetoric and jargon understood and related to participants. Others, however, utilised English and formal technology jargon for presenting. They eventually obtained weak engagement and a minimal number of questions afterwards.

Participants hence responded livelier and with in-depth usability and usage-related questions and comments when prototypes were visually appealing and with presenters engaging lively and in the native language. This may be because participants are not well equipped with tools and language to comment on flawed interface design [5]. Hence, this needs readdressing towards future and successful cognitive walkthrough practices as exercised by the students when presenting to low computer literate users. Students were actually requested to present their prototypes using personas and scenarios, yet failed to deviate from their standard presentation skills

7 Reshaping UCP: Establishing Sociotechnical Gaps through Sticky-Note™ Scenarios

From the personas in the first UCP session, a further session attempted to reassess, align and consolidate sociotechnical gaps through the development of the personas.

Sixteen participants (eight new in this session) were reminded or introduced to the previous personas. Then, they split in 2 groups provided with markers, pens, Sticky-Notes™ and A1 paper. Group C was compounded of children and teens, and facilitated by a PoN researcher. Group D were older participants, some with genuine interest in entrepreneurship, and no one facilitated them. Group C scaffold from findings in the previous personas and developed a list of further issues affecting them. They wrote these in Sticky-Notes™ and tucked to the A1 poster. Issues were consistently related to the characters initially presented. This occurred by intermingling persons, personas or character alike when referring to the issues discussed, as well as including oral accounts of what that persona would sometimes say or think at a particular point.

Meanwhile, Group D layout the challenges stated in the persona introduced from the first session and engaged in the politics involved in the issues at hand. This did not provide any further insights to the existing personas in regards to adding on explicit needs, requirements and aspirations. However, by discussing issues of politics, they were able to imply further stakeholders and proposed ways to tackling interactions with them. The session ended with participants thanking researchers for what they seemed to have learnt in the session and requested when the next session was to be.

Fig. 5. Group C - UCP further developed.

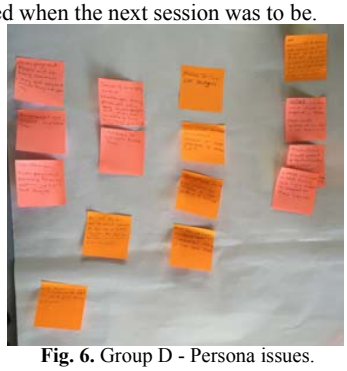

Fig. 6. Group D - Persona issues.

In this session we found that when participants work in homogeneous group-ages, results evolved in two ways: groups of older participants with a flair for entrepreneurship conveyed more formal, bureaucratic, and implicit ways of embedding challenges in the community by extrapolating them to the involvement of other stakeholders such as councils, political representatives, police forces etc. Yet, personas were not developed as such. Younger participants, though, stuck-in to the task at hand and implemented further user-data to the original personas. Besides, they explicitly and repeatedly referred to the characters dealt with as, we argue, these were youngsters like

themselves. Thus, the personas were more relatable to youngsters, whereas experiences of older participants where to other mature community members and organisations.

8 Conclusions and Further Work

This work-in-progress attempted to elicit sociotechnical gaps in the informal settlement of Havana towards establishing a community centre and launching a job-search tool to alleviate youth unemployment in the community.

In testing methods, walking the neighbourhood provided researchers with an indication of the challenges faced as shown and explained by community members. Therefore, we corroborate walking as suitable in this setting to spot challenges and also in establishing those as part of work analysis. Further future walks may hence provide with on-site solutions to the challenges of unemployment. It can also create further awareness in possible actions to undertake by youth involved in the project.

The two UCP sessions have provided with both, an effective and engaging workability in using the TV-series proposal throughout and a provision of collective persona representations that acknowledged the main "actors" as local youth that could somewhat be anyone in the community due to the present challenges. Moreover, Group B in the first session showed a natural understanding in: (1)characterising main actors, (2)depicting and joining background stories, (3)supportive and engaging secondary characters, (4)extras, and (5)the props supporting and (6)enhancing scenarios. They have also shown a natural skill constructing narratives compounded of preparation (i.e. childhood), climax (i.e. characters' present situations) and resolution (i.e. mothers protest, others riot). This approach has hence enabled participants to elicit the risks undergone by youth in Havana, as well as sociotechnical gaps to be filled.

Group C were older participants who referred to issues beyond youth personas. While these concerns did not provide to the personas elicited, they enabled a further understanding of the pervasiveness and organisational and political issues in the community. Group D was formed by younger participants who readily related to the initial personas and provided with further relevant data both, orally and on paper. This all has shown UCP elicited in PD as a useful method to combining skill and experience, while forming complementary groups of in-situ stakeholders and those beyond.

Sketching personas in PD must thus be considered in developing pervasive systems for these settings, as the latter showed to provide towards community reliability, coexistence, cohesion, and mutual support as societal positives to nurture and maintain, as well as being fruitful as an inquisitive process to initially explore and augment pervasive and smart possibilities for work in locales with limited resources.

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Pervasive Technologies for Smart Workplaces: A Workplace Efficiency Solution for Office Design and Building Management from an Occupier's Perspective

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Abstract. Corporate Real Estate (CRE) Management and office design are increasingly considered as a strategic resource for developing businesses and competitive advantage. Measuring the added value of CRE, as well as managing smart workplaces are an issue for academics and professionals. We consider that pervasive technologies offer potential for increasing workplace efficiency on a long-term basis. Colliers International France deployed Schneider Electric's WorkPlace Efficiency solution to support the effective use of shared office resources. The paper presents our experience of this solution in the context of our Paris office and discusses its potential for building smart and sustainable workplaces.

Keywords. Office Design, Real Estate, Pervasive Technologies

1 Introduction

Corporate Real Estate (CRE) Management and office design are increasingly considered as a strategic resource for developing businesses and competitive advantage. Rather than a way of reducing costs, real estate decisions address challenges such as productivity, employees' wellbeing, innovation and flexibility. In this context, building and managing smart workplaces are an issue for both, academics and professionals. In order to meet these demands, an increasing number of companies choose to implement "activity-based" work (ABW) environments. These open office solutions are aimed at better supporting the "new ways of working". Indeed, today's knowledge workers are likely to work anywhere, anytime and face growing requirements for cooperation and coordination of tasks and activities [2] [3]. ABW relies on the idea that space should fit the needs of employees' specific activities and the company's

strategic goals in order to provide a basis for an effective CRE Management [1]. While, ABW may be a good starting point for building smart workplaces, it raises several issues related to the effective use of shared office resources such as space but also energy. In order to build flexible workplaces that truly fit organizations' needs and are able to adapt to corporate growth, downsizing and restructuring, there is a need to both design and manage ABW. We think that pervasive technologies offer great potential in order to measure, manage and increase workplace efficiency on a long-term basis. In what follows, we first briefly present Colliers International France as well as our office in Paris. We use our building as a "living lab" in order to gain insight on flexible working and ABW environments. Then, we introduce a solution based on the Radio Frequency Identification (RFID) technology aimed at monitoring the occupancy rate of our building as well as at supporting the effective use of shared office resources. The solution was developed and implemented in partnership with Schneider Electric, a global specialist in energy management and energy efficiency. We started to monitor WPE performance in April 2013 and began to analyse the data for 2014. Finally, we discuss the implications of this solution for building and managing smart and sustainable workplaces and buildings.

2 Colliers International France

Colliers International France is a global independant Real Estate and Workplace Consulting and Project Managment company. We help our clients to implement high performing flexible work environments, like ABW, and to reduce occupancy costs. In order to do so, we rely on a wide range of expertise (real estate and workplace consultants, architects, space planners, construction engineers) which allows us to address the different functional layers of buildings [4]. In our view, the design of smart and sustainable workplaces is that of a building, but also that of the practical conditions of building management on a long-term basis from an occupier's perspective. In order to gain a deeper understanding of workplace and building management in practice, our Paris office is organized as a "living lab". The design team implemented a flexible work environment based on desk sharing and a set of activity-based workspaces. Figure 1 provides a view of some of the workspaces available in our Paris office.

Fig. 1. Different types of workstations and workspaces in Colliers International France.

3 The Workplace Efficiency Solution by Schneider Electric

Schneider Electric's WorkPlace Efficiency (WPE) is a solution designed to manage comfort and occupancy as well as to provide services to users in large office buildings. Colliers International France implemented the WPE occupancy monitoring system which connects a network of sensors with anonymous RFID tags inserted into employees badge holders. The tags transmit information to the sensors via radio which allows a real-time monitoring of occupation of the different spaces ("bubbles", meeting rooms, workspaces). The data transmitted by the tags includes the user category (for instance employee, trainee or visitor) as well as the detection zone (which are numbered and associated to different types of workstations or given workspaces). The WPE provides data on the actual use of different workspaces. Thus, Colliers is able to measure the frequency rate of a given workspace (time of use/availability) and its occupancy rate (occupation/capacity).

4 Implementation in an Activity Based Workplace

The ABW's underlying principles imply that employees choose their location according to their needs and preferences. While teams and services each have a dedicated area, people can eventually choose to work anywhere in the building. ABW is thus supposed to provide means to an efficient management of peaks and troughs in users' demand. Furthermore, functional characteristics of space are designed to match employees' needs (concentration, interaction, cooperation). For instance, open space meeting areas should support serendipitous interactions and trigger knowledge-sharing and workplace learning. In this context, the WPE system's data allows us to make hypothesis on the users' needs as well as on the current workspace "fitness" for employees' activities. Figure 2 shows the occupancy of the cafeteria as well as one of the bubbles from June to September 2014. Occupancy refers to the maximum number of tags detected per hour of a working day over a five-month period.

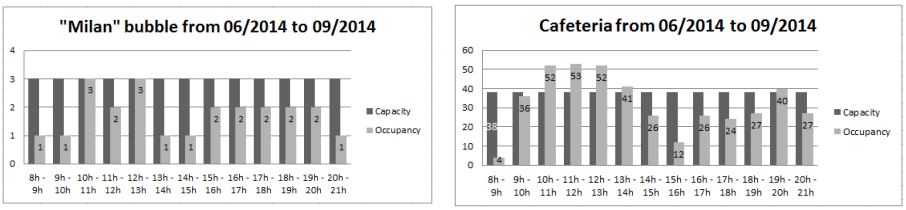

Fig. 2. Occupancy of the cafereria and a bubble from June to September 2014

We found that "bubbles" (fig. 2, on the right) are frequently used by only one person over a day-long period, while their intended purpose is to support both concentration

work and cooperation (2 to 3 users). Likewise, while meeting rooms are intensely used, they are under-occupied (1 to 4 users). The meeting area (figure 1) appears as under-used while the cafeteria is regularly occupied outside lunch hour (figure 2 on the left). In 2015 we redesigned our Paris office. The WPE provided a basis for identifying issues to be further investigated within other studies.

5 Discussion and Future Work

So far, our results suggest that there is a gap between intended and actual use of shared workspaces and point at the need to better support concentration activities. The study also shows that successful implementation of WPE solution requires to design its practical relevance for design and facility management professionals.The WPE's use, in our experience, raises several issues related to its acceptance by employees. While monitoring workspace utilization provides valuable input for design and has proven to be an effective "medium" for user involvement during workshops, further investigation is needed in order to assess and to deal with workplace "fitness" to employees' needs. Furthermore, the WPE guarantees the anonymity of employees. Still, our experience shows that it can be perceived by users as a way of monitoring people rather than the use of space. In order to improve the acceptance of the system by employees, we recently introduced removable badge holders. Users are now able to separate their badges from the RFID badge holders and eventually swap with someone else's badge holder. A mobile application was also presented to employees. The application provides additional services such as a meeting room finder based on real-time occupancy data, a 3D building navigator designed to help users find their way in the building, as well as a comfort remote control. We are currently looking to develop the use of existing data in regard of sustainability issues such as energy efficiency.

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From Bottom-up Insights to Feature Ideas: A Case Study into the Office Environments of Older Computer Workers

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Abstract. Given recent demographic changes, adapting the office environments of older workers to their needs has become increasingly important in supporting an extension of working life. In this paper, we present a case study research of older computer workers in Romania, with the goal of gaining bottom-up insights that support the ideation, design, and development of features for a smart work environment. Utilizing a multi-method approach, we combine contextual interviews and observations, an analysis of needs and frictions for deriving insights, an ideation workshop for eliciting potential features, and an online survey among experts to evaluate the final feature ideas. Following this comprehensive yet efficient approach, we were able to gain a rich understanding of the work realities and contexts of older computer workers and to transform that understanding into a concrete set of prioritized feature ideas.

Keywords: Computer workers; older adults; requirements analysis; multiple methods; contextual inquiries; needs-frictions analysis; NUF prioritization

1 Introduction

Within the European Union labor market participation rates currently reduce sharply along with age: while participation is high for the age group of 50–54 years (75.5%), it drops noticeably for the age groups of 55–59 years (61.5%) and 60–64 years (30.5%) [1]. The OECD predicts that by the year 2050 the number of retired persons aged 50 and above will surpass the number of active persons in the workforce in Europe [2]. Given these demographic changes, policies geared towards motivating older persons to work longer have become more and more important. From a company perspective, older employees hold important knowledge and know-how, have high quality standards in their work, and are typically very loyal and dedicated to their organizations [3]. Moreover, positive effects on productivity have been reported for age-diverse teams, with performances of both younger and older team members being significantly higher compared to less age-diverse teams [4]. Thus, the challenge is

adfa, p. 1, 2011.

how we can support an extension in working life. On the one hand new policies are needed that strike the right balance between older employees' rights and interests and in increasing their employability [5]; on the other hand, efforts are needed that put a clear focus on innovation in the immediate environment of older workers.

In the present research we focus on the latter by means of a case study into the work environments of older computer workers in Romania. The case study was part of a larger project, following the vision of developing a smart work environment that supports "a prolonged, productive and satisfactory involvement of older employees in working life" [6]. The aim of this case study was to provide feature ideas as input for the technical specification of a smart work environment. We followed a multi-method approach, combining contextual interviews and observations for mapping the workplace environment, an analysis of needs and frictions for deriving insights, an ideation workshop for generating feature ideas, and an online survey among experts for prioritizing the feature ideas. As a result of this case study we were able to gain a rich understanding of the work realities and contexts of older computer workers and to transform that understanding into a concrete set of prioritized feature ideas. Such a list of feature ideas is a valuable source of inspiration in the development of smart workplace solutions that cater to the specific needs of older computer workers. Our main contribution to the research community is an elaborate description of our comprehensive and efficient multi-method approach and the related results that can be obtained with this approach. We are confident that this approach will serve as a helpful tool for designers of smart workplace solutions.

2 Background and Related Work

In recent years, daily work in our increasingly knowledge-based economy is demanding a high degree of flexibility and adaptability [7] in order to perform tasks anytime and anywhere [8]. Within this context, smart work approaches as alternative ways of organizing work by the support of technology have emerged. One indication for this trend is the already widespread use of mobile devices in business contexts, which blurs the boundary between work and personal life by enabling people to complete work tasks at home [9]. The office workers of this study adopted this behavior themselves (e.g., checking emails at home, etc.). However, the goal-oriented development of smart technologies requires a deeper understanding of workers' tasks and needs. Otherwise the adoption of smart work technologies remains rather low [8]. To increase adoption, offering trainings for new technology is beneficial for all employees but should take specials needs of older employees into account. Especially for older workers, some authors recommend providing printed scripts or reference books and the regular attendance of a personal contact person in the first two weeks [10].

One approach for designing supportive technology based on a designer's understanding of how the user works is referred to as *Contextual Design* [11]. According to this approach, great feature ideas evolve from the conjunction of a designer's detailed understanding of the users' needs (through direct involvement in data collection and interpretation) and his or her own in-depth understanding of the technological possi-

bilities. Thus, designers of supportive tools need to visit the companies in order to understand working procedures and collaboration aspects before technologies are customized for the company [10]. Visiting means in this case to apply some form of ethnographic research method, such as observations [12] and contextual inquiries [11]. Blomberg and Karasti [13] reflected on the benefits of ethnographic research in the domain of computer supported collaborative work. They emphasize that useful strategies for addressing the challenge of drawing design implications from the results of the ethnographic work analysis have been developed within the community. Examples include *Design Ethnography*, which abandons the idea that designers only visit a workplace but that design interventions may take place on the spot [14], and *Co-realization* which demands the long-term engagement between designers and users as the full implications of new technology for work practices can only be revealed in and through the system's subsequent use [15]. *Human Work Interaction Design* (HWID) is a multidisciplinary framework combining work analysis (e.g., Cognitive Work Analysis, [7]) and interaction design to promote a better understanding of the relationship between humans and work domain contents and the interaction during their tasks [16].

Given that ethnographic approaches require considerable efforts in time and resources, we position our multi-method approach as a comprehensive yet efficient alternative to study the work realities and contexts of older computer workers. A key benefit of our approach is that it leads to a concrete set of prioritized feature ideas based on the involvement of relevant stakeholders.

3 Multi-Method Approach

In line with the overall goal of providing feature ideas as input for the technical specification of a smart work environment for older people, we followed a multi-method approach as depicted in Fig. 1.

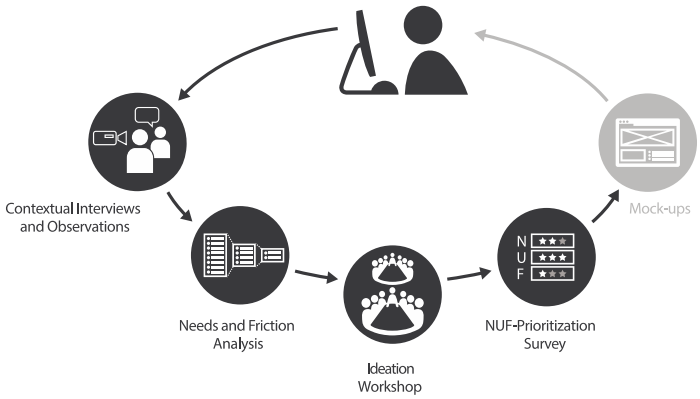

Fig. 1. Overview of the phases in the multi-method approach. Black circles represent the phases covered in this paper, the grey circle represents future work.

Within the first phase (see 3.1), we aimed at gaining bottom-up insights into the work environments of older computer workers. Inspired by ethnographic approaches (see Background and Related Work), we analyzed the work environment as a whole, utilizing a combination of semi-structured interviews and observations at the workplace. The goal of the second phase (see 3.2), was to identify needs and frictions from the interview transcripts and observation reports, which were then combined to insights. The goal of the third phase (see 3.3), was to derive feature ideas based on these insights by conducting an ideation workshop. Finally, the goal of the fourth phase (see 3.4), was to prioritize these feature ideas in an online survey among experts.

3.1 Contextual Interviews and Observations

Participants and Setting. A convenient sample of eight older computer workers (two women) in the domain of fiscal accounting volunteered to take part in the contextual interviews and observations. The mean age was 55 years (*SD* = 3.93). All participants were recruited from two small IT companies in Bucharest. They were frequent users of smartphones, tablets, and laptops. The interviews and observations took place directly at the participants' workplace (see Fig. 2 below) and lasted for 60-90 minutes.

Fig. 2. Example of one participant's workplace and the setting.

Procedure. Each session started with informal conversation and the participant signing an informed consent document. Afterwards, we started recording with a Blackberry Z10 smartphone and proceeded with the contextual interviews and observations. The choice for using an unobtrusive smartphone camera rather than a professional camera was made deliberately, so that participants would not feel intimated .

In line with the open character of our approach, we relied on a loose structure ensuring that participants still had enough leeway to act and speak spontaneously. Participants were encouraged to present their work environment and typical tasks. Behavioral prompts (e.g., "Can you show us around your desk?") and follow-up questions (e.g., "Why do you prefer to take down appointments in a physical calendar?") were used to direct the attention to specific aspects. The contextual interviews and observations were conducted by two researchers with backgrounds in design and psychology. They were supported by a local interpreter who was crucial in overcoming cultural barriers, building rapport, and generally ensuring proper translation. The researchers spoke English, the participants answered either in English or Romanian.

3.2 From Needs and Frictions to Insights

Data Preparation. More than 10 hours of video material was transcribed using the open source software *easytranscript*[1]. For those participants that answered in Romanian, only the English translations were transcribed. All names were anonymized.

Data Analysis. The goal of the analysis was to identify needs and frictions from the interview transcripts and observation reports, which were then combined to insights. For our purposes, we defined needs as something required in the execution of work, frictions as a certain issue that stands in the way of satisfying a need, and insights as an intuitive grasp of a need–friction situation (e.g., 'I need to meet objectives but sometimes I forget them.'). The analysis of the data involved two steps:

- Step 1: Reading the transcripts, highlighting relevant utterances and observations, and categorizing them to themes (i.e., certain recurring patterns). For example, "staying in touch with distant colleagues" and "being stressed by the daily email load", would both be coded to belong to the theme *Communication*. The themes (see Table 1) structured the process of identifying the needs and frictions.
- Step 2: After categorizing the relevant utterances and observations to themes, we identified underlying needs and frictions. Insights were formed by combining a specific need with a specific friction and formulated from the user's perspective (e.g., 'I need to communicate via email but I cannot handle the high email load'). In some cases, more than one insight could be identified for a specific need due to several frictions for the same need.

3.3 Deriving Feature Ideas in an Ideation Workshop

Participants of the Ideation Workshop. In order to generate a wide range of ideas we involved 15 professionals with backgrounds in software engineering, wireless communications, user experience design, marketing, psychological evaluation, sociological research, serious gaming, eLearning and telemedicine.

Procedure. For having a structured yet flexible way of brainstorming, we slightly adapted the World Café method [17] by using insights of the needs–frictions analysis as input for deriving feature ideas. Thus, we formulated the overall question as: Considering these insights, which concrete features would be helpful for our users?

We prepared four tables, each equipped with post-its, markers, and 9–10 insights. Each table was moderated by a host who stayed at the same table and took notes of the discussion. The other participants switched tables after each round (4 rounds in total). One round lasted for 20 minutes and always followed the same procedure: (1) *Introduction*: the host read out the insights and summarized the ideas discussed in the previous round; (2) *Brain writing*: each participant was given five minutes to write down as many ideas as possible; (3) *Discussion*: at each table participants discussed

[1] http://www.e-werkzeug.eu/index.php/en/

and developed feature ideas. At the end of the fourth round, the hosts consolidated the features ideas.

3.4 Prioritizing Feature Ideas in an Online Survey

Respondents. The goal of the fourth phase was to prioritize the feature ideas that resulted from the ideation workshop. For this purpose, the participants of the ideation workshop were asked to fill in an online survey. The prioritization was not part of the ideation workshop, as we wanted each expert to evaluate the ideas individually with no time pressure and unaffected by groupthink. We received 10 completed surveys.

Survey Design and Procedure. The survey relied on a simple design introducing each feature idea by its name and a short description, along with the insights from the needs–frictions analysis. The respondents' task was to score each feature on the three dimensions *newness*, *usefulness*, and *feasibility* (following the NUF approach, [18]). For each of the dimensions, respondents assigned any number of points ranging from 1 ('not new/useful/feasible at all') to 10 ('very new/useful/feasible'). Moreover, respondents were given the opportunity to leave comments in a text box for each feature. The survey was designed to take about 30–60 minutes to complete.

Data Analysis. The goal of the NUF is to arrive at an overall index score per feature. First, a total score per feature was calculated across the dimensions of newness, usefulness, and feasibility. Second, means and standard deviations were calculated across respondents in order to generate a rank-ordered list of the feature ideas (see Table 2 for the 10 highest ranked feature ideas).

4 Results

Our comprehensive multi-method approach (see Fig. 1) allowed for gaining bottom-up insights into the work realities of our target group, which were then used to generate feature ideas for a smart work environment. In Table 1 we provide two examples of insights for each theme that resulted from a needs–frictions analysis of the contextual interview and observation transcripts. While some insights left room for creative ideas, other insights were so straight-forward to suggest an easy solution (e.g., 'I need to write proper Romanian but the default English keyboards come without diacritics.') or so general that smart workplace solutions cannot help (e.g., 'I don't want to work at home but sometimes I have to').

Table 1. Themes and Insights

Themes	#	Insights (examples)
Task Management	i1	I need to keep track of open tasks but carrying them over (e.g., from my agenda to Outlook) takes effort.
	i2	I need to meet objectives but sometimes I forget them ("Out of sight, out of mind").

Communication	i3	I want to be able to send instant messages to both private and business contacts but without mixing contacts.
	i4	I need to communicate via email but I cannot handle the high email load.
Collaboration	i5	I need to solve bigger and complex problems but effective collaboration is difficult when people have different backgrounds/expertise.
	i6	I need to share information digitally but there is no efficient way of digitizing hand-written information.
Mind & Body	i7	I want to train my mind but I don't know how to do it effectively ("To train my mind I'm reading, solving crosswords, and checking Facebook").
	i8	I need to take breaks but since I stoped smoking I remain mostly at my desk.
Work Conditions	i9	I want to be flexible in the choice of my work environment but accordant company policies are required for that.
	i10	I need to write in proper Romanian but the default English keyboards come without diacritics.
Personal Development	i11	I would like to train general skills but the company does not foster it.
	i12	I would like to learn on my own but there is no dedicated eLearning content (e.g., video tutorials, interactive materials).
Personalization	i13	I want an always visible external memory resource for frequently needed information (e.g., important deadlines), but my current solution (i.e., post-its) is not reliable and cannot hold a lot of information.
	i14	I want to work on my tasks in different contexts/environments but there is no seamless way of doing so.
Tools	i15	I need to compile lists and make calculations but do it by hand because I lack the necessary computer skills (Excel).
	i16	I plan my day on paper because I don't see the benefit of digital solutions.

Note. The insights were synthesized from the needs and frictions analysis and formulated from the perspective of a user. Quotation marks are used to indicate utterances that originated directly from participants.

In Table 2 we present the top 10 feature ideas that resulted from the ideation workshop and the online prioritization survey. As can be seen from the list, some of the features obviously are more innovative than others. For example, the feature 'Private Digital Notebook' (#1) is certainly more new to the world than the feature 'Walking Break Scheduler' (#9). By contrast, the 'Walking Break Scheduler' is certainly more feasible—that is, less complex and therefore easier to develop—than the 'Private Digital Notebook'. Yet, both of these features are useful in the sense that they address a real need—supporting a healthy lifestyle and staying on top of things, respectively.

Table 2. The 10 highest ranked Feature Ideas

#	**Feature name** (ref. to insights)	**Feature description**	**NUF score**	
			M	***SD***
1	Private Digital Noteboard (i1, i2, i13)	Always visible second screen at personal desk: • Urgent tasks are highlighted • Tasks are clustered according to projects/teams • Finished tasks can be crossed out • To-Do's/notes can be sent to public noteboard	23.90	3.78

2	Cognitive training games (i7, i11)	A selection of serious games to train cognitive skills to prevent mental decline with personalized training sessions.	23.20	4.34
3	Exercise Prompter and Demonstrator (i7, i11)	A friendly exercise reminder: • Prompting physical/mental exercises through pop-ups • Avatar might demonstrate exercises • Connected to calendar to know about ongoing meetings/deadlines	22.70	3.71
4	Flexible Self-Learning Mini-Modules (i3, i12, i15)	Tutorials on how to use new software/tools: • Ca. 15 min per session • To be completed until a fixed date	22.10	4.12
5	Public Digital Noteboard (i1, i2, i13)	Always visible second screen at a wall: • see #1 Private Digital Noteboard • To-Do's/Notes can be sent to private noteboard	21.50	4.12
6	Knowledge base (i5)	Central internal knowledge base within organization: • "in case of problem X, contact Mrs. Miller…" • Wiki on frequent problems to post questions	21.40	5.83
7	Healthy Email Mgmt (i4)	Organized as e-learning content (e.g., Guidelines/tips on how to better cope with the email load).	21.30	6.04
8	Digital Paper Calendar (i6, i16)	Paper calendar capable of automatically digitizing handwritten notes: • Digital paper or digital pen as input device • Tagging system (e.g., offline with different stickers or directly on the tablet/PC)	21.00	4.90
9	Walking Break Scheduler (i8)	Walking time in nature as part of the daily schedule and encouraged by various means (e.g., calendar reminders, pop-ups…).	20.91	4.66
10	Remote Access (i9, i14)	A cross-platform tool to support task portability via secure remote access to company resources (i.e., files, software…).	20.40	5.06

5 Discussion and Conclusion

A primary goal of this case study was to map the contexts and environments of older computer workers in order to gain bottom-up insights that can support the ideation, design, and development of features for a smart work environment. In line with this goal, we followed a comprehensive multi-method approach combining contextual interviews and observations, an analayis of needs and frictions for deriving insights, an ideation workshop for eliciting potential features, and an online survey among experts for evaluating the feature ideas on the dimensions of newness, usefulness, and feasibility. We want to emphasize that this list is not intended to be prescriptive or followed blindly but to serve as a basis for further specifications in the design and development of a smart work environment that caters specifically to the needs of old-

er workers. Thus, its main value lies in providing food for thought to all project stakeholders and to inform rather than to enforce the decision on which features to select for further development.

The main contribution of this case study is the successful application of the compiled multi-method approach. Following this comprehensive approach, we were able not only to gain a rich understanding of the work realities and contexts of older computer workers, as is typical of ethnographically-inspired approaches in general (cf., [12]), but to transform that understanding into a concrete set of prioritized feature ideas. In the following, we briefly reflect on our experiences for each of the phases:

1. *Contextual interviews and observations:* using a smartphone camera rather than a dedicated camera to record turned out to be the right choice. Participants quickly forgot about the presence of the camera, which in our view helped to create a more natural setting. As a limitation we think it would have been useful to visit each participant not just once but more frequently, to align it more with the tradition in Co-realization that emphasizes the importance of a long-term engagement between developers and users [15].
2. *From needs and frictions to insights:* we followed a practical approach in transcribing the contextual interviews and observations, which put emphasis chiefly on what was said rather than how it was said (as might be of interest from a more sociological perspective). This turned out to be sufficient for the purposes of our analysis that was focused on identifying needs and frictions.
3. *Deriving feature ideas in an ideation workshop:* a positive element of the workshop was the small number of people that sat at each table (three to four) that allowed for an active involvement of each participant. As a negative element, we noticed that having nine or ten insights per table was a bit overwhelming. We think that the number of insights discussed at each table can be reduced to around five.
4. *Prioritizing feature ideas in an online survey:* from our experience, it was a good choice to separate the prioritization of the feature ideas from the ideation workshop to prevent groupthink effects. However, if a 'safe environment' can be created during the workshop, then this phase might be merged with the previous one.

To conclude, our multi-method approach serves as a comprehensive and efficient means of informing the design and development process, based on direct involvement of users and other stakeholders. As the next step in the user-centered development process, the resulting output will be used for the creation of mock-ups visualizing the feature ideas to gather further input from the target group (as indicated by the gray icon in Fig. 1). Thereby, our approach also allows for a continuous involvement of end-users in the design process, as demanded by existing approaches such as the *HWID framework* [16] or *Co-Realization* [15].

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Characterizing Context of Use in Mobile Work

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Abstract. The context of use has been widely acknowledged as important when designing and evaluating systems for work related activities. This paper describes in case of mobile news making the synthesized findings on context of use categorized to five components and nineteen subcomponents based on twelve cases studies. The presented findings validate a previously presented model for mobile context of use, extend it, and elaborate the definitions for the components. The presented elaborated model with described components and subcomponents can be applied by academics and practitioners when designing and evaluating systems for mobile work. Findings support understanding how circumstances can contribute to user experience and acceptance of the systems.

Keywords. Context of use, mobile, user experience, model, component, work.

1 Introduction

The importance of understanding and characterizing the context of use when designing and evaluating systems for work activities and their user experience has been widely acknowledged. In this research we approach context of use as the *circumstances under which the activity [of mobile work] takes place* (adapted from [1]). Mobile work is characterized by flexible use of time and place [2], that is, a person is able to move and carry out tasks "anytime and anywhere" [2],[3, p.14] with the help of wired or wireless technology [3, p. 14]. However, relatively little research exists that explicitly concentrates on the characteristics of context of use in mobile work.

This paper addresses mobile news making as an example of mobile work. Mobile news making activity takes place in a mobile context of use by using mobile handheld technology, in this research smartphones, in one or several subactivities in the news making process. News making consists of the four main activities: 1) *discovering* the potential news item [4], 2) *gathering* the news material [4], [5], 3) news *production* [5], and 4) *distribution* [5]. These activities can be sequential or simultaneous [5]. They can be carried out at the spot of the event with mobile handheld devices by a mobile reporter, or specific activities, such as discovering and gathering can be done at the spot while others can be carried out in a café or by editors in the news room.

Mobile workers are *"employees that work at and move between different places"* [6, p.6]. In mobile news making mobile workers refer to 1) employees of the news organization [7], 2) other professionals in the news industry, such as freelancers that work, for example, for the news organization on event based contracts [7], or 3) mobile crowdworkers [8] or reader reporters, who carry out news reporting related tasks

based on the news organization's initiative with open, coordinated, or focused calls for content, expertise, or reports [9].

This paper synthesizes findings reported in twelve publications based on twelve case studies carried out in the context of mobile news making, characterizing the components and subcomponents of context of use. The findings validate the model of context of use for mobile HCI, CoU-MHCI model [10], extend it, and elaborate the definitions for the components. The presented elaborated model with described components and subcomponents can be applied by academics and practitioners when designing and evaluating systems for mobile work that utilize location technologies or context-awareness, such as for identifying typical combinations of context characteristics. Findings also support understanding how circumstances can contribute to user experience and acceptance of the systems when planning system uptake and selecting solutions for use.

The paper is organized as follows. Next section describes related work followed by the methods and results. The paper ends with conclusions and proposes future work.

2 Related work

The CoU-MHCI model [10], which is based on an extensive literature review of components and characteristics of mobile context of use, describes five context components with their subcomponents and properties for a mobile context of use: 1) physical, 2) temporal, 3) task, 4) social, and 5) technology and information. As this model is one of the most comprehensive models presented in the field of HCI and specifically addresses the mobile context of use it is used as the framework for categorizing our findings as well as for summarizing previous literature on characteristics of context of use in mobile work in Table 1 and briefly exemplified below.

Usage of mobile handheld devices in a mobile context of use is characterized by distractions, interruptions, and fragmented attention [20; 13; 24; 27]. Distracting characteristics of the mobile context of use, such as reflections on the screen and parallel tasks can influence user experience [28]. The split visual resources when interacting with the mobile devices (tapping with a stylus on a PDA) and walking, simultaneously trying to maintain an awareness of the environment, increases the task completion times, error rates, and work load, as well as reduces walking speed [29].

In relation to task context, the task hierarchy and task characteristics are important. The primary task, such as observing animals [24] or focusing attention on other tasks external to the mobile device: to avoid danger, to monitor progress, or to handle other objects [13], may call for a high level of attention and limit the use of hands for interaction with the mobile device. Multi-tasking, such as communicating on the phone while pursuing a target in police work, splits the attention of the user [14]. The fragmented attention caused by context characteristics, including interruptions (physical context), parallel tasks, multi-tasking, and the handling of other objects related to the task at hand, needs to be considered when designing for a mobile context of use.

The characteristics of temporal context, i.e., time-criticality, urgency, deadlines, and time-pressure, is emphasized in mobile work. In the case of freelance work, the hours of work are described as unpredictable and extended [23]. The physical context

characteristics include environmental conditions, location, and dynamism of the environment, as well as interruptions, e.g., caused by traffic lights in police work. In relation to the technology and information context, availability and access to technology and information, and their uncertainty in a mobile context of work, or alternatively the opportunities offered by technology and available information has been emphasized. Finally, in relation to social context, bystanders affect the comfort of using mobile systems, as users consider whether bystanders experiencing the use of the system find it appropriate to the situation such as in case of firefighting [12]. Also, in the case of police work, unobtrusiveness and discreteness of using mobile systems can contribute to experience of users [14]. From the five components of context of use, social context has received relatively little attention in literature of mobile work.

Table 1. Characteristics of the mobile context of use for mobile work from prior literature**.**

Component	Characteristic	Reference(s)
Task	Parallel primary task	12, 13
	Multi-tasking	14
	Handling of other physical objects simultaneously	13
	Evolving tasks based on locality and situation	15
	Task complexity, irregularity	16, 17, 18
	Task interdependence	16
	Work in dead time, in transit, in waiting	19
Temporal	Available time span	19, 20
	Time-criticality, time-pressure, deadlines, urgency	12, 21, 15, 18, 14, 22, 16, 25
	Hours of work – extended & unpredictable	23
Physical	Environmental conditions	14
	Location	23
	Dynamic environment	24
	Interruptions	20, 23
	Location dependence of the task	16, 25
	Frequency of mobility	25
Social	Bystanders	12, 14
Technology and information	Available technology and access to information	19, 26 23

3 Methods

This paper presents a synthesis of findings for mobile context of use from twelve case studies carried out in the context of mobile news making that are reported in twelve scientific publications: [30], [31], [32], [33], [34], [7], [35], [9], [36], [37], [38], [40]. The reported findings were categorized to the components and subcomponents of the CoU-MHCI model. Two new subcomponents were created. Definitions for the components of context of use were elaborated.

The research approach of the twelve case studies is primarily qualitative with observations, interviews and focus groups as the main methods of inquiry. Seven of the studies include the usage of a mobile service client for newsmaking in the mobile context of use. Two of the twelve studies concentrate on reader participation in news making as a form of mobile crowdsourcing. The rest of the studies focused on professional use. Over one hundred participants participated in the studies, of which a majority were students of visual journalism with prior work experience in journalism.

4 Findings on context of use in mobile news making

The findings on the factors of context of use that influence user experience in mobile news making are categorized to five context components and their subcomponents according to the CoU-MHCI model [10]. Our findings validate the model, elaborate the definitions for its components, and extend the model by two subcomponents based on the findings. Task context is extended with mobile assignment characteristics, and social context by stakeholders who are not physically or virtually present when interacting with the device, but who assess the quality of the news material and reporting.

4.1 Temporal context

Temporal context refers to the interaction and carrying out the activity with the mobile system in relation to time and it captures the nature of the activity in terms of time (adapted from [10]).

Table 2. Summarized findings on the temporal context.

Findings related to the subcomponents	Publication(s)
Duration – the length of interaction, activity, or the event in which interaction takes place	
Time (delay, response time) to start up photo and video recording	34, 7, 37
Time spent on the activity, task or carrying out a sub-activity, such as recording, editing,submitting	30, 31, 34, 7, 35, 9, 36, 37, 38
Time of day, week, and year	
Deadline, schedule, or continuous deadline	30, 31, 7, 35
When the mobile reporter is available for locating and receiving mobile assignments	35, 36
Before, during and after	
Preparations for capturing, editing, and submitting	34, 7, 37, 39
Following up on submission, calling up the newsroom after submission to check on the success of mobile delivery	35, 38
The action's relation to time	
Hurried, waiting, speed, urgency, time pressure	30, 31, 34, 7, 35, 37, 38
The unexpectedness of events that call for action	30, 31
Synchronism (synchronous–asynchronous)	
Communication by phone calls, SMS, MMS, email, chat, mobile assignments	35

Temporal context is characterized by 1) duration - the time spent on the interaction, activity, subactivity, or task, 2) time of day, week, or year of the interaction, activity or task, 3) actions prior, simultaneously, or after the interaction with the mobile system or activity, 4) the action's relation to time, and 5) synchronicity or asynchronicity of communication (Table 2). Time is one of the key characteristics related to news making, as the work is time critical and calls for immediate publishing of breaking news or on the other hand is planned, scheduled and organized. However, a surprising event may occur, that changes the plans and calls for immediate action and attention interrupting the current activity. Temporal context is also related to the news qualities in terms of immediacy, unexpectedness, and timeliness of news.

4.2 Task context

Task context refers to the user's tasks and activities surrounding the interaction with a mobile system or when carrying out the activity with the system

(adapted from [10]). Synthesized findings on subcomponents (multi-tasking, interruptions, task domain, and assignment characteristics) are presented in Table 3.

Table 3. Summarized findings on the task context.

Findings related to the subcomponents	Publication(s)
Multi-tasking – multiple parallel tasks alongside human mobile computer interaction that compete for cognitive resources	
Primary task interviewing, secondary task recording audio, photo, and video footage, or writing notes with the smartphone	34, 37, 38
Keeping track of the number of characters in the story while writing	37, 38
Keeping track of time and the deadline	37
Awareness of the surrounding physical conditions or constraints of the used smartphone that need to be taken into account when shooting footage (photo, video) or recording audio	32, 34, 7, 37, 38
Parallel tasks while receiving mobile assignments (no parallel task, during free time, when working or studying)	35, 36
Interruptions – events that break the user's attention from the current task to focus on the interruption temporarily	
Passers-by	31
Interruptions by bystanders who make contact while the reporter is editing at a public location	31, 39
The primary task is interrupted by a mobile assignment	36
Task domain – macro level of task context by dividing the situation of an interaction into two groups – goal-oriented (work) and action-oriented (entertainment) tasks	
Primarily goal-oriented for professionals, but can include action-oriented characteristics	30, 31, 34, 7, 35
Primarily action-oriented for readers, but can include goal-oriented characteristics	9
Assignment characteristics (added sub-component)	
The type of assignment or reporting to be carried out or the content asked for and attributes of content (no. of characters in text, length of audio and video footage, count of photos, requested quality, special requests like camera angles)	35, 36
Monetary incentive, incentive mechanism	7, 9, 36
Voluntariness of carrying out the task	9
Autonomy in reporting	35
No. of receivers	35
The creativity needed or allowed	35
The needed skills and equipment	35

Parallel tasks and activities included instances of interviewing while audio or video recording, taking notes or writing a story, for example. Mobile reporters keep track of typed characters while writing if a specific length has been assigned for the story, as well as time and possible deadline. When capturing photos and video footage, surrounding physical circumstances need to be taken into account to ensure the sufficient technical quality of the footage. This may call for action from the users, such as turning on lights indoors, choosing an appropriate direction for shooting footage based on direction of natural light or taking into account the ambient noise conditions. Parallel tasks also contribute to the willingness to receive mobile assignments.

Interruptions are one of the important subcomponents of the task context as they influence the activity carried out. As the mobile reporters typically work in public spaces, there may be interruptions due to passers-by, or bystanders may take contact and talk to the mobile reporter and interrupt the task being carried out. On macro-level the task context is proposed to be divided to goal-oriented tasks in work related use and action-oriented tasks for entertainment [10]. In mobile news making, for pro-

fessionals the tasks are primarily set by the organization or customer, but secondarily, the tasks may include action-oriented elements that could be related to concepts such as flow and enjoyment of the activity as such. For reader reporters participating to news making the enjoyment of the activity may be the primary motivation to participate. Participation may, however, also include elements related to goal-oriented activity and motivations that professionals have. The goal-oriented task setting may also apply to crowdsourcing, if the participation is primarily motivated by monetary benefit and has no hobbyist or enjoyment, or other motivational element.

The assignment characteristics, whether delivered as mobile assignments to the smartphone or received more traditionally, were added as a subcomponent as it frames the properties of the task context, and was addressed in our studies. Identified assignment characteristics include the type of assignment, reporting, content or its attributes, perceived voluntariness of undertaking and carrying out the assignment, perceived and expressed extent of autonomy and creativity, needed skills or equipment as well as the incentives. Assignment characteristics can contribute to user experience by moderating the willingness to undertake tasks and be motivated by the goal.

4.3 Physical context

Physical context refers to apparent features or physically sensed circumstances while interacting with the system or carrying out the activity with it (adapted from [10]). Its components include 1) location, place and space, 2) sensed environmental attributes, 3) movements or mobility, and 4) artefacts (Table 4).

Table 4. Summarized findings on the physical context.

Findings related to sub-components	Publication(s)
Spatial location, functional place and space – the aspects of location and material characteristics of location, functional space and in distance participation	
Geographical location (vicinity or distance)	31, 35, 36, 37, 38
Third workplaces – cafés, hallways, canteens, waiting halls etc.	30, 31, 37, 38
The precision of locating mobile reporters	35, 36
Attributes related to the area, location or country such as shady, totalitarian, unacceptable place, safe, dangerous	35, 36
Sensed environmental attributes	
Light, lighting	31, 34, 37, 38
Temperature	31
Ambient noise, sounds	31, 37, 38
Movements and mobility – the position and motion of the user's body, the mobility of the user and the motion of the user's physical and functional environment	
Sitting while editing, reaching out to record footage	31, 34
Placement of artefacts in relation to the user's body (e.g. on the knee, on a table, on a sofa)	31, 37
Working while commuting	7
Artefacts – physical objects that surround a human-mobile computer interaction	
Proximity of artefacts (e.g. a notebook)	37
Chairs, sofas, tables	31, 37

Mobile reporters work in multiple workplaces and dynamic locations. The work is often carried out in public spaces, either outside or inside. Stationary workplaces include cafés, or waiting rooms, for example. Typical mobile workplaces are trains, cars or airplanes. The proximity of the reporting spot to the reporter's current location as

well as the precision of locating mobile reporters can contribute to participation preferences in case of assignment-based processes. The sensed environmental attributes such as lighting, temperature and ambient noise can contribute to carrying out the activity and influence the capturing of photos and video footage. Physical context is also characterized by movement of the user's body while interacting with the system. User may be sitting or standing while writing, capturing photos or video footage, or kneeling or reaching out while using the system for capturing photo or video footage. The tools may be placed on the user's body such as on the lap or attached to arm, or placed on surrounding objects, such as on a table or sofa. Furthermore, smartphones were in some instances attached to surrounding other objects, such as a book, a bike or a window for photo or video capture enabling new ways of content capture and reporting. The characteristics of the area, location, or country were found to be relevant in relation to privacy and safety issues when locating reporters and location-based assignments were studied.

4.4 Social context

Social context refers to other persons present physically or virtually while interacting with the system or using it for the activity, or to other stakeholders of the activity who perceive and assess its outcome (adapted from [10]). Subcomponents include persons present in the situation, stakeholders not physically or virtually present, and culture (Table 5).

Table 5. Summarized findings on the social context.

Findings related to subcomponents	Publication(s)
The persons present in the situation classified to self, group, organization or public, physically or virtually present.	
Interviewees, bystanders, peers (colleagues) present while interacting with the smartphone-based system	30, 31,32
Stakeholders not physically or virtually present while user interacts with the device or carries out the activity to produce an outcome (**added sub-component**)	
Editors, colleagues in the newsroom or from another newsroom, customers, audience/readers who asses the quality of the produced material or news (stories)	30, 7, 39
Culture – The macro level of social context including the values, norms, and attitudes of a certain culture, such as the work and organizational culture	
Journalistic and news values, norms etc.	30, 7, 38
Profession related values, identity, ideal, norms etc.	30, 7

Persons physically present while interacting can include interviewees, bystanders, and own colleagues or peers of the mobile reporter. Newsroom staff or a colleague working elsewhere in the field can be virtually present using synchronous (e.g. video or online calls) or asynchronous means of communication (instant messaging or social media services). Other stakeholders may also not be physically present, such as freelancer's customers or the audience that consumes the news. The opinions and anticipated impressions and expectations of persons present or of other stakeholders on the used mobile system and the outcome of its usage can influence the user experience of a mobile reporter. The social acceptance of the used tool is important for users and it may differ based on the user group. Social acceptance may also change over time. Furthermore, culture and practice of journalism and participatory journalism or the

culture of the organization in question incorporate values, norms and ideals, that can as a subcomponent contribute to user experience.

4.5 Technology and information context

Technology and information context refers to the relation of other relevant systems and services to the user's interaction or activity with the mobile system. It includes as subcomponents other systems and services, interoperability between and across devices, and informational artefacts (Table 6).

In case of journalism, this can include external components, such as microphones, keyboards and displays or alternatively, applications or services that can be used for mobile journalism. It also includes the wireless network with its attributes as well as the interoperativity in transferring data or material from one device to another or to the editorial system. Paper notebooks with hand-written information on preparations, interview questions, and interviewee's quotes as well as plans for editing video footage are still important informational artefacts for mobile reporters. In addition, smartphones enable with the available connectivity to the Internet access to open information or organization's archives, for example. All in all, multipart and complex systems form ecosystems of devices and services that can contribute to user experience when used in mobile newsmaking.

Table 6. Summarized findings on the technology and information context.

Findings related to subcomponents	Publication(s)
Other systems and services – the device, applications and the network related to the user's system or service (note: in this study components external to the smartphone or installed after purchase on the smartphone)	
External components of a smartphone-based system, such as microphones and keyboards.	31, 34, 37, 39
Mobile journalism related applications	30, 34, 7, 35, 9
The wireless network and related attributes (availability, reliability, speed, interference)	30, 31, 34, 7
Interoperability between and across devices	
Transferring data from one device to another or material delivered from the mobile system to the editorial system	37, 38, 39
Informational artefacts and access to other artefacts that contain relevant information	
Notebooks	30, 31, 7, 9
Access to information via the Internet	7

5 Conclusions

Findings related to five components of context of use (temporal, task, physical, social and technology and information context) with a total of nineteen subcomponents were reported in case of mobile news making. Two subcomponents were added to the original CoU-MHCI model [10]. Task context was extended with assignment characteristics, and social context by stakeholders who are not physically or virtually present when interacting with the device, but who assess the quality of the news material and reporting. Situation as circumstances described by a combination of components, subcomponents and properties of context of use, can have significance for the users that influences their evaluation of the system quality and its appropriateness to use. The findings illustrate context of use related components and characteristics that can

influence user experience in the field of mobile news making. Further studies could address the context related characteristics in other work domains to test and extend the model. Model and presented findings can also be used as a framework in planning of studies and data collection and measurement of context related aspects.

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From Transactions to Relationships: Making Sense of User-Centered Perspectives in Large Technology-Intensive Companies

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Abstract. In this paper we analyze interviews from four technology-intensive companies, focused on service and service development. All companies have during the last two decades introduced interaction design units, and the corporations were selected due to their interest in also expanding the service share of their business. This service shift has been a top-down initiative. However in only two companies, the initiatives have led to the establishment of enterprise wide service development processes, and in the other two companies, the service development is more ad hoc. It is argued that even if interaction design has close theoretical relation to service design such combination has so far been limited. We discuss the shift from product to service view of the offerings within these companies, and relate this to user-centered perspectives. We argue there is a window of opportunity within technology-intensive and engineering focused industries to include user-centered design when formalizing service development.

Keywords: User-centered design · Service design · Service development · Usability · Technology intensive companies

1 Introduction

Today, technology-intensive product manufacturers go through a shift that addresses fundamental parts of their economy, when business models go from transaction based to relationship based. This transition process is called servitization and create organizational, structural as well as process challenges [1]. To some degree, the servitization process seems almost inevitable for the technology intensive product manufacturing companies, and in management literature, powerful arguments are put forward to integrate service into their core offerings along three lines, economic arguments, customer demands and competitiveness (ibid.). Taking a service perspective put a focus on how the processes are deployed and for whom, rather than focusing on the technology in itself. One might say that service has a focus centered on the experience and fluency relative the business customer. This resembles in a sense imperatives of user

adfa, p. 1, 2011.

centered design and interaction design where the user and user experience are in focus. Put into comparison, the concurrent drive for service in part mirror how businesses adopted and incorporated the user centered design (UCD) and usability movement. The UCD and usability movement started academically as early as 1940's but it was through the extended use of computers in industry during the 1980's and forward that made companies employ usability experts. Today larger companies often have at least smaller units with UCD and interaction designers. The process of introducing UCD and usability departments in companies has been slow, in most cases bottom-up and customer demanded [2]. This UCD shift has been playing out differently in different domains. The engineering heavy industries, well-grounded in the industrialization, have put much pride in their technology and few engineering companies have until recently been advertising their products as user friendly or with similar connotations. Instead the excellence of their technology has been focused on the product; the technology itself.

While UCD and interaction design brings focus to user needs and task decomposition relative computerization, service offerings put focus on a higher level of experience which include all forms of aspects relative the business that the industries are offering. Neither UCD nor service development ignores or diminish the technological part, but both put more emphasis on aspects which more or less presuppose that the backend of the technology is there and is (excellently) functional. It is interesting to compare such perspective shifts in general but specifically it is interesting to see if and how the two perspective shifts can be combined.

This work explores the view on service and service development among people working in-house in four global industrial companies and is based on interviews and observations. With help of the empirical material we discuss central concepts in UCD and compare it to the ongoing perspective shift in these companies.

2 Background

The companies within which we have done interviews, are industrial and technology-intensive. However, the focus of the technology is to solve a particular problem in a certain setting and to center technology around certain contexts implicitly include an understanding of a person that use the technology. Below we will present two different approaches which explicitly focuses on this addressed person.

2.1 Evolving User-Centered Approaches

Although human-computer interaction (HCl) is a relatively young research field it has undergone rapid changes and new sub areas have emerged in a fast pace. The perspectives within the field has evolved and is reflected in various user focused practices. HCI has it origin in the disciplines ergonomics and human factors, which are experimental approaches and treats the interaction as an isolated phenomenon. The focus is the machine performance and the unit of analysis is user actions of one person in front

of a display. Human factors is criticized for isolating actions from the complex context in which they take place [3].

As a result of the increase in number of computers in working life, demands for ease of use emerged as well as for practical, not so costly, methods to develop usable systems. Usability emerged as a topic and in the end of the 1980s the user-centered approach evolved as an emphasis for the designer to focus more on the user and to give users an active role [4]. Usability was defined by an international standard as "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [5]. Furthermore, the computer supported computer work (CSCW) research community grew out of the need to extend the user concept into involving groups of users as well as a multitude of computers. Further on, the technical evolution of a networked society resulted in new challenges and concerns. Earlier clear boundaries between work and leisure have become vague and the significance of the physical location has been altered. Bødker points to the need in HCI to extend the view of context to also include settings outside the physical workplace and she outlines new interests in culture, emotion and experience growing from the shift from always designing purposeful and rational solutions [6]. Such perspectives on HCI have been coined interaction design which have a more design oriented, in contrast to analytical, view on HCI and UCD.

2.2 Evolving Marketing Approaches

Studies of service development started as early as in the 70s marketing research [7], and the evolvement of this subject has mainly been done within the marketing and management disciplines. Service marketing has a history of breaking out of marketing research, i.e. the goods marketing perspective, and has thus reinforced the differences between service and goods to justify the sub discipline.

In the 2000s new arguments was formulated on how to describe and conceptualize service. Vargo and Lusch presented their service dominant logic describing service in a value creation perspective [8]. They are arguing for an interpretation of value as “value in use” contrarily “value in exchange”. They defined business processes as service and argue to not distinguish goods and service, instead goods are means for service delivery. A central theme in their arguments is that customers are integrating knowledge and capabilities with the service provider’s personnel and artifacts in a co-creation of value. This way of describing value has changed how market research characterizes customers, from passive to active co-creators, and puts an emphasis on the importance of involving customers in the development process [9]. So far, the discussion in market research has been on a conceptual level, with little result on how to put these ideas into practice [10].

2.3 Where the Strands Meet

Branching out from the HCI field in the 2000s, service design became a new interdisciplinary movement with a root in design thinking [11]. It was based primarily on two drivers; firstly the growing service sector supported by experience focused and

knowledge-intensive solutions, and secondly initiatives in user-centered disciplines where people recognized the benefit of combining user-centered practices with service development and innovation. For example, Holmlid discusses how service design can help to open up the earlier sometimes impeding focus on computer mediation and the computer as a tool perspective in HCI [12]. The argument is that this movement can give complementing views to earlier approaches, using multiple channels and a diversity in possible ways to create user value. Wetter-Edman has researched the contribution of design practice and design theory in realizing the service dominant logic ideas [13], [14]. She shows how user-centered methods are complementary for user involvement and co-creation and can open up new perspectives on value. She also shows that the valuable role of the designer as an interpreter and intermediator between customer and company, is lacking in marketing research approaches. The possible connection between user-centered approaches and service development points towards positive future concurrence.

Since the implementation of user-centered methods has been slow and gained relatively little impact in industrial product development, we approached service practitioners within these companies. These service practitioners do not always have an outspoken task to realize their respective organizations demand on an increased share of service. With an underlying interest in seeing where user-centered perspectives can meet service development, we aimed to investigate how these practitioners talk about service, how they perceive their role and how the servitization process has been played out within these companies.

3 Method

The material for this paper has been collected from four large international companies selling business to business solutions in different domains, here denoted company A, B, C and D. All four companies are global, with a history in traditional engineering fields, and they all have operations in at least Africa, America, Asia, and Europe and more than 35 000 employees each worldwide. At company A, 7 interviews were conducted, labeled 1:A to 7:A. To further broaden the picture, 5 additional interviews were done with representatives from company B, C and D, i.e. 8:B, 9:B, 10:C, 11:C, and 12:D. The sample of interviewees have been chosen in consultation with contact persons with a good knowledge of their companies view on service, and where based on two criteria, 1) perceived long experience of service delivery/development within the company and 2) some kind of responsibility in regard to this. The 12 semi-structured interviews took place between April 2013 and June 2013.

All interviewees had some kind of management role; concerning projects, methods and/or personnel. 9 out of 12 worked close to or in relatively close connection to customers. Two worked with technical development enabling service delivery, and one worked on a strategic level. 11 out of 12 had an engineering background, and one had training in service management. One of the persons mentioned knowledge of UCD. The interviews took around one hour each, and 14.5 hours of recorded material were transcribed verbatim. 7 of the interviews were done in Swedish and 5 in English. The

original Swedish quotes were translated to English by the authors. Moreover, to gather more information, 3 on-site observations were conducted in company A. The observations were focused on delivering value to customers; two cases of remote service and onsite service delivery. Additional material was also collected from respective companies' web site.

The transcribed material was collected in Atlas.ti, a common qualitative data analysis software. Furthermore the data analysis were made primarily by the first author, using techniques from grounded theory, specifically inspired by the constructivist grounded theory approach described by Charmaz [15]. During the initial coding the transcribed material was worked through in detail, followed by a more focused coding phase were some key issues was followed up and further explored. These key issues formed emerging themes that were in an iterative process, revisited and refined, together with the field material and information from the web sites.

4 Results and Analysis

In this section we will both recount what status service development have in these four companies and contrast service development with user-centered design and usability through some key concepts.

4.1 Service Status in the Studied Companies

The companies studied for this paper are all mainly technology-intensive organizations with a prevailing engineering culture and have all a long tradition of developing and selling products, where providing spare parts for the products have been their main service business. In line with this prevailing engineering attitude, the format and the specifications of the products produced becomes noticeably important. This is reflected in the organizational structure where different parts of the organizations are dealing with specific product families. When service packages are created, our interviewees explained that these are often seen as separate components added on to the products. In the same vein, service departments have been added as isolated entities into the existing organization. Budgets, tools, and resources often follow these organizational boundaries, which contribute to silo thinking and complicate collaboration between different departments.

Frequently, you find several pieces of equipment from the same producing company at one customer site, but with limited coordination between the departments delivering these products or service. Our interviewees explain that there is a tension between adding service components onto existing products, and by so reinforce the silos, and the wish to solve the customer's problem regardless whether it is a motor or a robot that stopped the production for the customer. This is similar to what Winter et al. have observed, where the organizational set up created conflicts of interest between departments, and giving cause to breakdowns in communication [2]. Hence, there are budding service initiatives within the studied companies, but their organizational belonging is still under construction.

4.2 Top Down Incentives for Service

Within all the studied companies, the top management have emphasized the importance of increasing the percentages of revenues coming from service which is manifested e.g. in strategies and policies. Hence, these companies are compelling examples of the current servitization process as exemplified by the following quote from company C: *"As times goes on, the greater scope service will get, I'm quite sure [...] it is more and more important you have value-added service. There is probably a stated goal [...] we should have a certain proportion of service. We will be more service oriented as a company" [10:C]*

However, these top down encouraged initiatives does not necessarily mean there is a widespread knowledge about service and service development within the companies we have studied. Hence there is a frustration among people working with service, they are encouraged, or even prompted to develop service revenue, but they seem to be lacking clear goals on what this would be as in the following quote: *"The closest they [the middle management] has come to service may be that they have purchased a TV subscription as a service, they have poor understanding of what service is all about, so now when they get this directive from the top management, 'now, work with service', of course, they do not know what to do" [11:C]*

Not only is there a lack of knowledge, our interviewees also express a concern that support for those supposed to implement the service initiatives are also largely lacking: *"they expect the most and put the least in the service organization" [7:A].*

Service in these organizations could be more than something on top of their products, it could include also the knowledge base of what and how the products may provide value in specific contexts. Still as the quotes above indicate this has not yet become a central position of their business - possibly a consequence of a firm grounding in a product focused mindset. The top-management initiatives have not been that thoroughly grounded in the practices of the organization and their employees which may hinder the servitization process.

4.3 Service Development

All of the studied companies had standardized and clear product development processes, but only two of the organizations had at the time for the interviews defined the processes for service development. Some of the interviewees from companies with defined service development processes, describes that it is difficult to diffuse the process: *"the difficulty that I've seen anyway, is how we roll out the stuff and get this to work practically out there" [10:C]*

Worth noting is that despite there being defined processes in two of the companies, most services in all four organizations were actually developed ad-hoc. As a consequence of this, service is developed in different ways in different parts of the organization, and the resulting solutions are often not coordinated. There are initiatives to mitigate this problem and to create company-wide offerings out of these ad hoc solutions, as explained in this quote: *"the service is created out there, sold and delivered*

a couple of times before it is washed off a little before it is introduced into the global portfolio" [8:B]

Reports of the ad-hoc development process are mixed, mentioning both positive as well as negative aspects. There is a pride in the solutions that have been made, but at the same time people feel out of control and without any overview, as exemplified in the following quote: *"there is a mentality to fix things, an entrepreneurship, and this has created very good stuff, what is worse then is that you might not know what you have done, and what opportunities are available" [1:A]*

At this point in time it is difficult to elaborate on the role of a service process in these companies since they are in two cases nonexistent and in the other two cases not widely spread. What can be deduced though is that the interviewees express a wish to have a more structured way of working.

4.4 Use of the Concept Service

The word service, is not well-defined and agreed upon in these organizations. Even if the interviewees worked with service in their daily work, they had difficulties explaining the concept. This was common in all companies, the interviewees expressed a confusion about what other people working in the same organization meant by service, as indicated by these two quotes: *"it is all context dependent, of course, talking internal [A] how I see it, it [service] is very wide and very unclear" [6:A], "the service concept is so unclear [...] it means that there are lots of people who develop this who does not understand it is service they develop" [12:D]*

Also the very different categories of service can complicate the communication, especially since maintenance and spare parts are viewed by many as being equal to service in this context. As of today service in these companies can cover for example; agreements, training, spare parts, software, maintenance, consulting, analyzes and financing. This complicate things as this interviewee explains: *"if you talk to people, they will mix all those things together [...] if you talk to some people, they talk about the services needed to get the system going, a bunch of people see services to operate [x], so it is a confusing picture to people" [9:B]*

From the interviews, it is clear that the term service must be defined and grounded in the organization, in order for the service development to work satisfactorily.

4.5 The Customer in Focus

Traditionally, service in these companies has meant maintenance and spare parts tightly coupled to particular products but the perspective oriented towards more product transcended knowledge has begun to gain some support. The former is firmly based on a technological orientation, where the product has a central role, while the latter case is focusing more on what the customer wants to be done, more or less independent of what products might be used. These two views have different implications as the former will focus on one form of equipment while the latter will focus on how different equipment can be combined and integrated in order to fulfill a certain objective. Our interviewees talk about their offerings in terms of a whole, with a cer-

tain goal to make the clients work process work smoothly and it is this system that delivers the value for the receiver: *"We handle both our own products that can be installed there and our competitors, we handle maintenance of automation products, systems, electrical equipment, mechanical equipment and everything else, so we take total responsibility for the maintenance. For a production site [...] we have a common goal together with the client" [4:A]*

This perspective puts the customer in the center, and this is a strength the interviewees point to, the tradition of long term relationships to the customers. Previously this has been due to the long life time, sometimes decades, of the equipment they are selling. However, the customer is not necessarily the user or operator, but sometimes they are as in the following quote: *"what we aim for is to reduce the operator workload, operator stress, and if we don't know how they handle things then to sitting next to them, to see what, if we do something wrong, what could impact on their working day, that is, that could be something, that is important I think, to really feel, sitting next to them and get the impression what, is it important or is it not" [5:A]*

Consequently, a shift towards services seem to put the customer, and perhaps the user, more readily in mind in the developers of services. Since the users are the main focus within an HCI perspective this is an interesting correspondence between service and UCD.

4.6 Service over Time

An important aspect shared between HCI and service development is that the value of the result is created over time. In contrast to a product perspective where the product is finite and defined at the very moment of construction, both a HCI and service perspective presuppose a user who becomes acquainted with the system and becomes more skilled over time. Both HCI and service perspectives values long relations and the learning process which the users or customers provides. When it comes to services, this long relationship also involves a continuous development as in this quote: *"One of the challenges for us is to find other service opportunities that enables us to have a more continuous contact with the customer, so we can have that ongoing relationship, and [remote] services are very good, very good area that makes sure we have a more continuous contact with those who actually use the services, first we get to know our customers better, they can tell you continuously what are the problems, it becomes a more natural contact with them because they understand, well they can actually help me with something" [12:D]*

It even seems like the service perspective, at least from our interviewees point of view, naturally includes a life-cycle awareness: *"you need a life-cycle view, you can not only have development because then you miss the big maintenance an end of life part of service" [8:B]*

This would imply that at least for these interviewees, a within the HCI field sought after perspective of longevity comes naturally when working with services and service development.

5 Discussion

This paper has elaborated on results from interviews with people working with service at four global technology-intensive companies. The interviews showed that the increased focus on service is an initiative from top management, but also that new ways of thinking is hard to implement. This is due to, on one hand, that the product oriented view reinforces a silos structure of the organization, while services to some degree need to transcend several departments, and on the other hand, service as a concept has so far been ill-defined and can connote different things. Note that both size of the company and the market probably is of importance for servitization and this analysis do not claim to inform the situation for smaller companies.
Furthermore, the large range of service types and the rapid technical development leads to the introduction of new types of services, e.g. software-supported services, and it also increase the confusion. What is referred to as service or product depends on your perspective, or viewpoint [17], often related to what view the company want to market.

One consequence of the concept confusion is that it makes service difficult to relate to during service development [18]. It is important that everybody involved in development has a similar idea of the service and it is likewise interpreted by all [19]. Rexfelt et al. found in an industrial context that a non-agreed upon definition about service turned it into a concept with no real meaning for the participants taking part in the studied service development project [20]. There were negative consequences for development of new service in this case.

Analytically we have scrutinized how service as a contemporary perspective is related to UCD and usability. We can see many similarities such as a focus on the client's needs and goals, as well as how the value of the result is created over time. However the focus on the client or customer can differ somewhat between service and UCD, since UCD as a systems development process is focusing on the actual user of a computer system. In contrast, service perspectives fluctuate between different roles with responsibility for certain processes within the recipient organization, as well as the actual user of a system or several systems. To complicate things even more, these systems might not originate from the delivering organization. Consequently, the service organization of a supplier company must then also have knowledge of the client organization and how they can be integrated in with the supplied products and services. This kind of value creation on a higher hierarchical level for the organization as a whole is lacking in definitions of usability [5], where the goal is met as long as the end-user is satisfied. Taking a service perspective on the other hand, thus makes one not only focus on the actual product, but also the value and enablement of the product for the client. A service perspective in the organization may impose more focus on the value of the reliability of the product than on the constitution of the product. Service thus is value-sensitive rather than product sensitive, interestingly such perspective have also been advocated within the UCD community [16].

The move towards an increased number of service solutions puts a focus on the experience of the receiver. In turn, this places new requirements on the delivering organization, which has to act in harmony and give the impression of acting as one entity

towards the beneficiary. To make this possible, the people involved, their tools and policies, as well as their tasks needs to be understood and related to each other as a larger system. Development of solutions adapted to this reality, calls for a multi-level approach taking tasks, tools as well as organizational aspects into account.

In the interviews, we have noted an understanding of key concepts important for UCD, among people working with service. At the same time, there are economic incentives for upper management in these companies to invest in service. We argue that this is an opportunity to build on already established practices for user-centered design applied within these organizations for service development, a development currently done to a large extend by engineers. The access to professionals with UCD competence is limited today in these types of companies, and will be during a foreseeable future. Hence, a pre-understanding of these concepts will possibly facilitate introduction of a new way to approach service development building on experiences and learnings from the UCD tradition.

When shifting the focus from the product and hence the transaction, to service, there is also a shift to the relationships. Consequently, we see the opportunity for the usability community to take advantage of an increased attention on shared interests. Following this shift in perspective, we feel the hope for an increased perceived significance of what is considered foundations of UCD.

6 Acknowledgments

We would like to thank those we have been in contact with within these companies. We would also thank the anonymous reviewers for their input.

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Human Work Interaction Design of the Smart University

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Abstract. In this paper we present human work interaction design challenges and opportunities for the vision of the Smart University as a platform that provides foundational context data to deliver the university of the future. While learning analytics have enable access to digital footprints of student activities and progress in terms of data such as demographics, grades, recruitment and performance, they cannot provide information about activities and interaction in the physical study and work spaces in a university. The smart university proposes a novel platform that will provide context aware information to students through the integration of learning analytics with data sensed using cyber-physical devices in order to provide a holistic view of the environments that universities offer to students. However, designing the interaction of students and staff in the smart university ecology of information and sensing devices requires an understanding of how they work as individuals, as members of teams and communities. Through two use cases we illustrate how insights obtained from social cognitive work analysis can be used for the design guidelines of the different interfaces part of the smart university ecology.

Keywords: smart university, human work interaction design, cognitive work analysis, user interface design.

1 Introduction

The Smart University is a vision where the university, as a platform, provides foundational context data to deliver the university of the future. As higher education funding in Europe continues decreasing, universities are more reliant on income generated from students. Thus, understanding student progression and identifying ways to improve the students experience are vital to any institution. To improve their students' experience, universities are increasingly reliant on technology to improve and expand their services to students. In this paper we present our proposed version of the smart university and how human work interaction design (HWID) [1] can support the im-

plementation of this platform at design level. Although, as part of Smart university ecosystem, some applications have been already implemented [2,3], the discussions in the paper refers to a conceptual design of the Smart University platform.

Smart campus platforms have been researched and reported in the literature and some aspects have been also implemented in some universities. For example, Lei et al., [4] propose the design of a smart laboratory that measure, analyse and regulate the thermal comfort by use of cyber-physical devices. The University of Southern California implemented smart buildings management in the building. A more holistic vision has also been proposed; iCampus, as envisioned by EBTIC[1], is an initiative that proposes the university of the 21st century be composed of six functional areas or pillars, designed to enrich students' experiences throughout their learning lifecycle: iLearning, iGovernance, iGreen, iHealth, iSocial, and iManagement. Although this is inline with our perspective, this initiative is still at the development stage and has a very broad scope. Our proposed platform is different in that our emphasis is on the design of the software platform that will allow the delivery of the vision. The implementation of the platform will take a data-oriented architecture approach. The focus is on how to develop a high-quality platform that will allow the use of cyber-physical devices and data analytics for the university of the future. Students' interactions with university systems are leaving an increasing amount of digital footprint which can be harnessed to understand behaviour and activities of students as well as help them become more effective in their studies and preparation of their career. Learning analytics have used these digital footprints left by students to gain insight on the students' progress and to build a personalised learning environment. However, most of Learning analytics projects have been looking at the monitoring of the digital environment that the institution offers to the students. Smart university vision is to provide a novel platform that will provide context aware information to students through the integration of learning analytics with data sensed using cyber-physical devices in order to provide a holistic view of the environments that universities offer to students. Additionally, this will augment the traditional learning analytics with data related to the physical environment and allow the investigation of these intelligent buildings and their effect on the learning processes.

Designing the interaction of students and staff in the smart university ecology of information and sensing devices requires an understanding of how they work as individuals, as members of teams and communities. HWID approach studies how to understand, conceptualize, and design for the complex and emergent contexts in which information and communication technologies (ICT) and work are entangled. In this paper, through two use cases we illustrate how insights obtained from HWID analysis can be used for the design guidelines of the different interfaces part of the smart university platform.

[1] http://www.ebtic.org/pages/the-intelligent-campus

2 Learning Analytics

Students' interactions with university systems are leaving increasing digital footprints which can be harnessed to understand behaviour and activities of students as well as help them become more effective in their studies and preparation of their career. Learning analytics have used these digital footprints left by students to gain insight on the students' progress and to build a personalised learning environment. However, most of these projects have been looking at the monitoring of the digital environment that the institution offers to the students. Data that is used for these analytics rely on management data, such as student demographics, grades, recruitment figures and the traces left by the students as they use the university IT systems such as virtual learning environment (VLE) or Learning management system (LMS).

Masses of data can be collected from different kinds of student actions, such as solving assignments, taking exams, online social interaction, participating in discussion forums, and extracurricular activities. This data can be used for Learning Analytics to extract valuable information, which might be helpful for lecturers to reflect on their instructional design and management of their courses. Usable Learning Analytics tools for lecturer that support cyclical research activities are still missing in most current VLE or are far from satisfactory [5]. Data mining tools are usually designed for power and the flexibility of the analytics rather than for the simplicity. Most of the current data mining tools are too complex for educators to use and their features go well beyond the scope of what they might require [6] If tracking data is provided in a VLE, it is often incomprehensible, poorly organized, and difficult to follow, because of its tabular format. As a result, only skilled and technically savvy users can utilize it [7]. Many lecturers, using learning analytics are motivated to evaluate their courses and they already have questions related to their teaching in mind.

3 The Smart University

Over the past decade, innovation in design and manufacturing throughout the industry has enabled the cost, size, power consumption of sensors and the associated networks to improve dramatically. Consequently, sensor-based systems have been proposed for a broad range of monitoring applications; more recently, these technologies have allowed the integration of the cyber world to physical world and effectively blurring the gap between the two.

The smart university proposed a novel platform that will provide context aware information to students through the integration of learning analytics with data sensed using cyber-physical devices in order to provide a holistic view of the environments that universities offer to students. Additionally, this will augment the traditional learning analytics with data related to the physical environment and allow the investigation of these intelligent buildings and their effect on the learning processes. The platform aims to combine a responsive architectural environment with an intelligent virtual environment in order to offer a truly personalised learning environment. The respon-

sive architectural buildings will be providing optimal heating, ventilation and lighting based on the requirements of the learning environment (i.e. chemistry lab or ICT lab), the learning models and the behaviour of the occupant of the environment. The behaviour of the occupant (learner or tutor) can be monitored by their interactions with the IT systems as well as some wearable devices. Sensors measuring temperature, humidity, noise and air quality would be used to monitor the behaviour of the building. Figure 1 illustrates the platform that could be used collecting, processing and visualising the data in a smart university. The platform will need to be scalable, data oriented and distributed with a friendly usable interface while, at the same time, being powerful and flexible enough for the repository of data of heterogeneous sources, integration of data sources in real-times, providing real-time exploration and interventions.

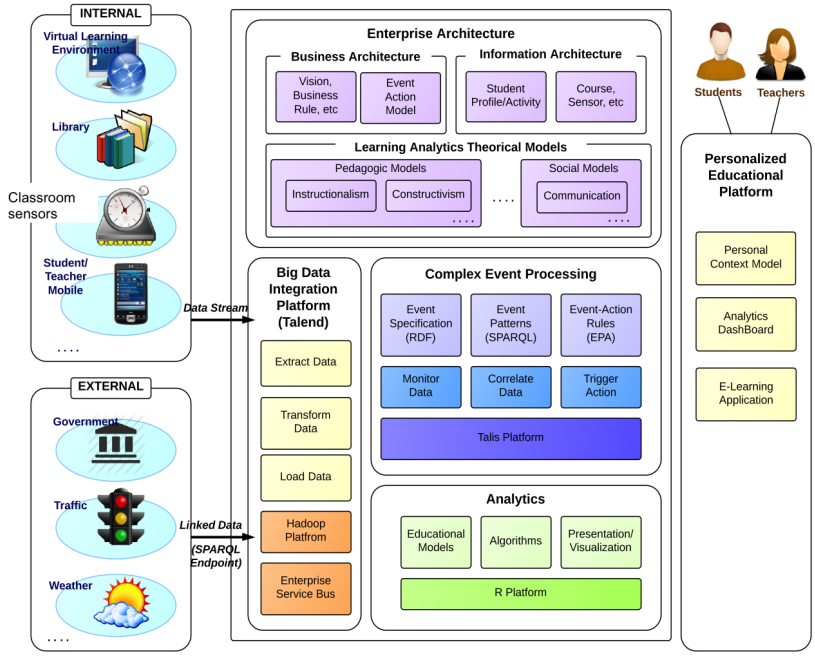

Fig 1. Example of Smart University platform

The platform will need to provide the following capabilities:

- Pre-process data sensed from cyber-physical devices, aggregate sensor data based on pre-determined contexts
- Use data mining and machine learning techniques to identify patterns, trends and anomalies on the general physical environment of university facilities and usage of those facilities.

- Diagnostics and prognostics capabilities
- Student engagement based on facilities usage
- Lab/classroom/building capacities
- Attendance of events
- Learning analytics
- Integrating influence of intelligent buildings on student learning
- Localised based information useful to students/tutors
- Interventions based on alarms, diagnostics, prognostics of student experience level based on usage of university facilities, student's study load and requirements, etc.

4 Human Work Interaction Design

Human work analysis is focused on user goals, user requirements, tasks and procedures, human factors, cognitive and physical processes, and contexts (organizational, social, cultural). For instance, Hierarchical Task Analysis [8] and Work Domain Analysis [9,10] are used to study goal-directed tasks and to map the work environmental constraints and opportunities for behaviour. The study of HCI has historically adapted work analysis methods such as hierarchical task analysis to the design of computer artefacts. Ethnographic methods [11] with a sociotechnical perspective have also been used in HCI (e.g.,[12]). These approaches focus on work as end-user actions performed collaboratively with other people in a field setting: the worker activity is seen as a social and organisational experience. In this context, human work analysis and HCI are interlinked in such as a way to form a distinct field of knowledge, namely HWID.

HWID studies how to understand, conceptualize, and design for the complex and emergent contexts in which information and communication technologies (ICT) and work are entangled. Several aspects influence the way humans work and the work itself. For humans, language, culture, education, skills, knowledge, emotions and cognitive abilities contribute to define the profile of users and their approach to individual and collaborative work. For work, its goals, functions, available tools and content contribute to delineate its characteristics and challenges. In this paper, we illustrate the use of Cognitive Work Analysis (CWA), a well known work analysis technique, to support design considerations for the Smart University system. This technique is driven by a framework that supports and structures the analysis needed when designing a flexible and adaptive system [9, 13]. The framework focuses on analysing the limitations and constraints on workers behaviour; and mapping these constraints is the design of the system that will support the workers.

The CWA framework comprises five different phases; work domain analysis, control task (or activity) analysis, strategies analysis, social organisation and co-operation analysis, and worker competencies analysis. Using CWA has two distinct advantages. First, CWA is a multi-dimensional analysis that incorporates the physical and the social environment to provide a rich description. Secondly, CWA can be paired with Ecological Interface Design (EID) [14] to generate designs for new in-

formation systems. EID has shown success in the design of analytic information displays in power plant displays [15]; social systems [16], healthcare decision support [17] and community building [18]. For these reasons, CWA may be a promising approach in cyber physical systems like the smart university.

5 Applying HWID to Smart University Scenarios: two examples

In this paper, HWID concepts and tools will be applied to two types of activities in high education domain; exemplifying two aspects of the smart university platform; the learning analytics aspect and cyber-physical devices. The analysis that is discussed in this paper will shape the guidelines of the user interface of the smart university platform.

One of the activities is related to a lecturer using learning analytics to provide support to students when preparing for an exam. The lecturer uses Virtual learning platform (VLE) as the main medium for communicating with the students. Past exams, revision notes and other supporting exercises are uploaded on the VLE. The lecturer, might also initiate a special discussion board for exam support. Here we envisage that the learning analytics will allow the lecturer to monitor the effectiveness of the support that is being provided, helping him/her to adapt the materials accordingly.

The other activity is related to the smart campus; i.e. equipping the campus with cyber-physical devices that help provide responsive environment. An example of such environment is an ICT lab. The lab is equipped with a number of sensors; Students usually take a 2 hours practical session in this ICT lab. Each student has a set of exercises that they have to complete using the computer. The session is typically supported by an academic staff and an assistant; typically a PhD student.

In this section we present two possible scenarios for the Smart University platform analysed from a HWID perspective. This involves applying CWA and then translating insights from this process into interaction design guidelines for the different interfaces on this platform.

5.1 Scenario A: supporting exam preparation

A lecturer, who offers weekly online exercises has the intention to help his/her students to prepare for an exam. But she is not sure if the currently available exercises are helpful enough for this purpose. Therefore, he/she would like to know if those students who practice with her online exercises on a weekly basis are better in the final exam than students who do not use them. A Learning Analytics toolkit could help him/her to do research on this hypothesis by automatically collecting, analyzing, and visualizing the right data in an appropriate way. The smart university platform should allow for interactive configuration in such a way that its users could easily analyze and interpret available data based on individual interests.

We now look at this scenario through the lens of the different phases of CWA.

Work Domain Analysis:

Work Domain Analysis (WDA) provides an overview model of the work environment with a view to understanding what kinds of information should be included in the user interface and how this should be presented. The learning analytics toolkit is part of a sociotechnical system whose main goal is maximising learning outcomes and the learning experience for students. The following presents an Abstraction Hierarchy (AH) typically used for WDA [17]. This is made of five levels, which are now described in terms of the learning analytics scenario:

WDA: supporting exam preparation	
Physical form	for student (type, program, year of admission, status, performance level); for learning material (type, date available); for evaluation material (type, date of evaluation, grades achieved), for lecturer (level, name, availability); for student record system (type, data available, dates accessed)
Physical function	Student , VLE, Lecturer, university student record system, material to be learned, evaluation material
Generalized function	Student accessing material, lecturer creating and uploading new material, contributing to discussion board, monitoring and evaluation of student's progress
Abstract function	Balance the ratio of evaluation to learning
Functional Purpose	Maximize learning outcomes, Maximize student experience

Table 1. Work domain analysis for learning analytics scenario

Since education is a core goal of this scenario, learning needs to be present in the functional purpose and generalized function levels. The scenario indicates that there is a concern that weekly exercises might improve learning, as evaluated through exam results, or might not be helpful. This is why we have chosen to describe at the abstract function level that there must be a balance between evaluation and learning, e.g. you cannot evaluate 100% of the time, you cannot also never evaluate. The functional purpose is to find the sweet spot where learning outcomes and student experience are maximised at optimum levels.

WDA will allow us to identify the analytics data needed for designing components of the system. For instance, a key goal derived from this WDA is to enable the instructor to move that sweet spot between evaluation and learning to maximize out-

comes and experience. Those are the drivers, i.e. decisions to be made with the analytic system.

Control Task Analysis:

This is done to determine what tasks are being carried within the system and under what conditions. In this learning analytics scenario, control task analysis (ConTA), based Rasmussen's decision ladder [18], the analysis would look like in Figure 3. Is there uncertainty and ambiguity on the possible goal state? Quite possibly, if the instructor is following a new evaluation approach for students, she may move into knowledge based behavior [7] trying to figure out what is wrong. Analytics could play a role here. Instructors can then 'define a task', i.e. choose to modify their instruction approach. This implies setting a new 'procedure', more or less exercises in this case, which would then be 'executed'.

Strategies, Social and Worker Competencies:

This level of analysis can facilitate the discussion of different teaching strategies (traditional, flipped, blended learning). This could also reveal different evaluation strategies (short quick frequent evaluations, longer midterm/final, or project based evaluation).

The identification and description of social competencies could represent values and intentional constraints being conveyed by the institution. It could also consider the culture and cooperation of the students in this. As a worker, the instructor must have competency in teaching, the material being taught, and the use of the smart learning system. Skills, rules and knowledge is the base for all of these [7].

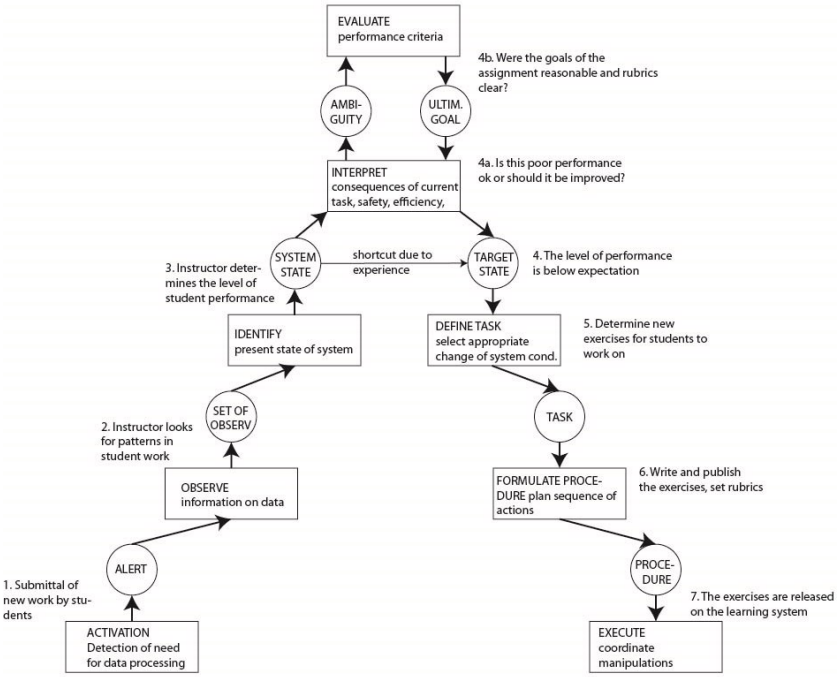

Fig. 3. Decision ladder for learning analytics scenario.

5.2 Scenario B: monitoring room temperature in the Smart Campus

In this scenario, the ICT lab at the university is equipped with an number of sensors and a display at the lecturer station with dashboard and message board for information about the room. Once the students have entered the room and started working, the information about the room is updated with an estimate of the number of people in the room and the ideal temperature for the ICT lab activity. The lecturer had a quick look at the dashboard and noticed that the room was empty for the morning and he/she understood that it will take about 5 minutes to get the ideal temperature. He/she also noticed that the noise was higher than what is expected for an ICT session and he/she first closed the windows and the door before asking students to work more quietly.

The students with wearable devices capable of giving ambient temperature readings also noticed that the temperature adjusted to the ideal temperature within 5 minutes of being in the lab.

Work Domain Analysis:

As with the scenario A, we now illustrate a possible WDA for the scenario of controlling temperature in the classroom:

WDA: Monitoring Room Temperature in the Smart Campus	
Physical form	student (type of clothing, course studying); for ICT lab (size, nb of machine, nb of windows, ideal climate); sensors(type), for lecturer (level, name); session (activity, nb of students, duration), for display(type (dashboard, wearable), data available, messages/alert)
Physical function	Student , ICT lab, sensors, snapshot of climate , ICT session, display
Generalized function	Student attending the ICT session, lecturer receiving messages about the room, adjusting the room, adjusting own clothing/noise, student receiving personalized message , evaluation process
Abstract function	Balance the ratio of climatic comfort to learning
Functional Purpose	Maximize learning outcomes, Maximize student experience

Table 2. WDA Monitoring Room Temperature in the Smart Campus (the Smart Campus)

Control Task Analysis:

This is done to determine what tasks, data, and messages are being processed within the system and under what conditions. In this monitoring ICT lab temperature scenario, inspired in Rasmussen's decision ladder [18] the analysis would look like in Figure 4. The objective here is to define and implement contextual, multi-sensory inference strategy services that are able to derive contextual information from aggregating different sources data. This will allow us to model user-based energy profiles and user behaviours in the ICT sessions. Based on the contextual models defined and considering the constraints related to comfort, it will be possible to identify diverse energy awareness rendering messages providing adequate feedback on various personalized display (wearables) or the instructor dashboard.

Strategies, Social and Worker Competencies:

Two strategies are apparent; first, to be energy efficient (i.e. suggestion of taking piece of clothing, opening a window or closing a door) or second, to emphasis on the comfort and make more use of the heating or cooling system. Ultimately, a smart university system will aim to use thermal comfort to change the expectation from largely invisible centralized control of the environment into a more active and respon-

sive approach. Furthermore, the system will implement a 2-way information exchange between occupants and buildings.

In terms of social competencies, students and staff awareness of and responsibility for environmental issues is variable. How can we facilitate and encourage sharing of thermal comfort strategies and learning from others? For example what are the alternative ways to keep cool or warm, or how to generate reflection on clothing and its role in thermal comfort? As a worker, the instructor must have the competency to understand the correlations between climatic comfort and student performance and make the right type of decisions about the required behavior.

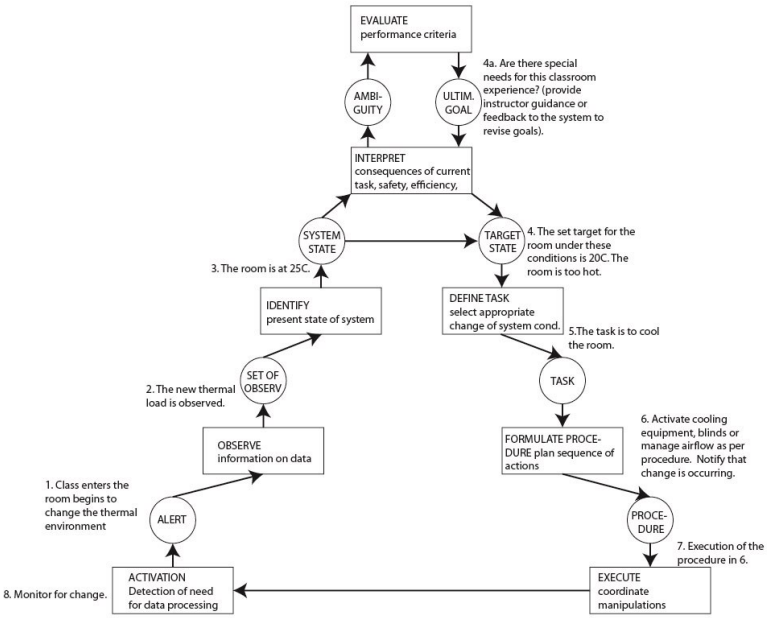

Fig. 4. Monitoring room temperature in the Smart Campus scenario.

6 CWA Moderated Interface Design

A Looking at two scenarios through the CWA approach facilitates the decision on which usability and user experience goals that should drive the interaction design of the different interface components of the smart university sociotechnical system. This also applies for the type of user interface design guidelines and levels of representation required at conceptual design level.

The CWA of the learning analytics scenario clearly points to importance of effectiveness and utility [21] as main usability goals driving the design of the user interface of the lecturer trying to establish the optimum level of exercises that should be set for students to meet learning goals in a satisfactory way.

In terms of design guidelines feedback and mapping become core objectives in the presentation of the student performance data. Good user interface design meeting these goals and principles will support the overall functional purpose of the learning analytics systems, i.e. Maximize learning outcomes, Maximize student experience. Similarly, in the ICT lab monitoring scenario, the effectiveness of the adaptive comfort messages is an essential goal since the underlying objective is to change the students environmental behaviour.

It can be illustrated how specific interface design decisions on relevant guidelines and heuristics can be derived from looking at the WDA and ConTA for both scenarios: Table 3 links key tasks to user behaviour, user interface components, design concepts and design principles and heuristics.

7 Conclusions

This paper introduces a proof of concept attempt to illustrate how HWID can be a useful framework in the design of the smart university platform as sociotechnical ecology of information sharing actors and devices. Through the application of CWA to two different scenarios we have identified the nature of work, artefacts and interactions in which smart university users will engage.

The smart university scenarios have been focused on the common functional purpose of maximizing learning outcomes while maximizing the student experience. CWA has enabled an understanding of the different task requirements in each scenario in order to achieve this: in the first scenario on learning analytics, it has been uncovered how finding the right balance between learning and evaluation is a critical goals; on the second scenario on the use of temperature sensors in the smart campus it is clear that the visualization of relations between climatic comfort and learning experience is a critical goal. Looking at these scenarios through ConTA provides an understanding of behaviours according to skills, rules and knowledge in the context of task goals. Identifying the type of behaviour the user is engaged in will provide useful information on cognitive and material elements of the tasks that should be supported. For instance, it is evident to see how in the learning analytics scenario the teacher is likely to be engaged in knowledge based behaviour more often trying to establish the optimum level of exercises for a particular group, while in the smart campus scenario a rule based behaviour is likely to be more frequent as the relation between climatic comfort and student experience will tend to be more stable.

We were then able to illustrate how this analysis of work in these two smart university scenarios can feed the interaction design of user interface components in the different points of interaction with the platform. There will be a need to prioritize different types of usability and user experience goals in terms of the functional purpose and desired goal states in identified in CWA.

Generalised Function Task:	Behaviour Type Required	User Interface Components	Design Concepts	Design Principle and Heuristic
Monitoring and evaluation of student's progress	Skill-based behaviour	Learning Analytics Dashboard: Messages/alerts	Visualise information on student performance as well as the level of instructor support.	Feedback: lecturer should receive immediate, intelligible alert if performance falls below expected levels. Mapping: data visualised should map naturally to student's activity record. Any non-technical user should be able to understand the student's position in relation to her cohort.
Lecturer creating and uploading new material	Knowledge-based behaviour	VLE content creation module	Supports the creation and upload of new exercises	Visibility: lecturer should be able to view historical performance data on exercises attempted and overall module performance while setting exercise levels. User Control and Freedom: enable lecturers maximum control of creation and uploading of as many exercises as required.
Lecturer monitors temperature and noise levels	Rule-based behaviour	Temperature and noise charts in classroom based control panel	Visualising the required information quickly and in a non-disruptive form	Throughput: monitoring temperature and noise levels should not disrupt the core teaching tasks and should be done as quickly as possible. Feedback: lecturer should receive clear indication of temperature and noise levels, with clear indication of acceptable thresholds.

Table 1. Mapping CWA to choose relevant user interface design concepts, principles and heuristics.

Even in the present examples, it is easy to predict that supporting the instructor with analytics on student performance would be a more extensive design challenge than providing monitoring of the thermal conditions of the classroom. This also has implications on data visibility, information accessibility, and information architecture. In the case of monitoring student performance, the instructor needs a deeper architecture, more data accessibility and more control latitude to develop the view he or she may want. In contrast, the thermal comfort situation may require quite straightforward information display and limited control to the instructor and students.

HWID models also provide considerations for nation, geographic, cultural, social and organizational factors shaping the activities being supported through design [22]. The smart university does not escape these considerations and any of the models and design principles and heuristics shaping the interactive points in these platforms will have to be moderated by them. For instance, Northern European universities will have challenges for design very different from those in the Southern Europe due to cultural, political and climatic factors.

In summary, we have illustrated a case for HWID in the context of the design of the smart university. Work analysis and interaction design can be integrated to support important design decisions affecting the ecology of devices and information repositories in the smart university with a clear focus on its users, their contexts and interactions.

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Providing a Holistic View and Bringing Life into the Conversation

Eliciting IT-based Administrative Work with Contextual Personas

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Abstract: The role of IT at the workplace has changed dramatically from being a tool within the work environment to include all aspects of social and private life. New workplaces emerge where IT thus become more and more divergent, embedded and pervasive. These new aspects of IT at work need to be addressed with new or adapted human centred activities. This paper present and discuss a modified version of personas called contextual personas to address the new working life. The contextual personas were developed using contextual inquiry, and focus groups as well as argumentative design. From the process of developing the contextual personas we learned that they are indeed a promising tool to understand the new work situations, and especially the holistic view of IT at work as they bring the whole working-life of the personas into focus. Finally, we discuss in what way the contextual personas could give developers extended understanding of the users' future office work environment.

Keywords: IT at work, Context of use, Work environment, Personas, Future work places, pervasive work places.

1 Introduction

Working life has been changing for many with a move towards goal oriented tasks, informal communication and virtual collaboration. Moreover, the use of IT has moved from being an isolated tool within the work environment to becoming pervasive through for example mobile apps and social media. Hence this shift has led to work that includes social and private life which is related to definition of one's identity. Often these changes of working life are enhanced through technology with the technical solutions available. It is common that people use various computer systems and use those on various equipment, such as mobile phones, tablets and laptops. More-

adfa, p. 1, 2011.

over, they are at different places while using the software systems. This creates complexities that are new and challenging. Other new ways of managing private life and working life has emerged, and one can note trends like for example BYOD (Bring Your Own Device) where the company policy allows employees to bring their own technology to the workplace. This shift makes systems development ever more complicated and there is an increasing need for illustrating this new work situation in order to better understand all the variations in the work environment that has emerged.

In this study we made extensive contextual interviews with support staff at university offices to gather information on their current work situation from a computer supported work environment perspective. In the paper, we explain a new method for describing results of such contextual interviews called contextual personas. These personas are developed to explain the various work contexts of the workers. Our results show that the employees are willing to give rich information about their work context, when prompted through the persona descriptions. Through the focus group discussions of the contextual personas real life was brought into the conversation.

In this paper we describe how contextual personas can be used to elicit IT based administrative work. Firstly the personas can be used as a tool to describe the work situation and the users within this work situation, which also extends to social life. However, we also argue that the contextual personas can be used as a reflexive tool that lets the respondents further reflect on their own work situation. Hence in our study, the contextual personas gave us information on the work environment and potential health hazards when looking at the holistic work situation including IT based tools and the overarching workload. One concrete finding from our interviews has implications for pervasive and smart workplaces, since the perceived connectedness of these administrators led to an always on status which made it hard for them to feel that they were ever free from work. Furthermore we discuss how the personas can be used in pervasive and smart workplaces such as future office spaces presented below.

2 Background

When creating the contextual personas, the healthy work model by Karasek and Theorell (1992) was used. Hence the first section below presents this model. This is followed by a presentation of future offices and the emerging trends in this area. Finally, we present a short description of research on the personas method.

2.1 Healthy Work, the Demand-Control-Support Model

When analysing the data from the contextual interviews, the Demand-Control-Support model is used. In the 1970's Robert Karasek developed a model for analysing work-related stressors associated with cardiovascular illness. His demand and control model was thereafter further developed together with Töres Theorell (Karasek & Theorell, 1992) and is now one of the most widely used models for explaining psycho-social work conditions and their effects on health. This model suggests that the

combination of perceived demands and perceived control at work is a determining factor for stress. The figure below illustrates the Demand-Control-Support Model. High job strain, i.e. high demands in combination with low decision latitude, and low social support are associated with the highest risks for health problems.

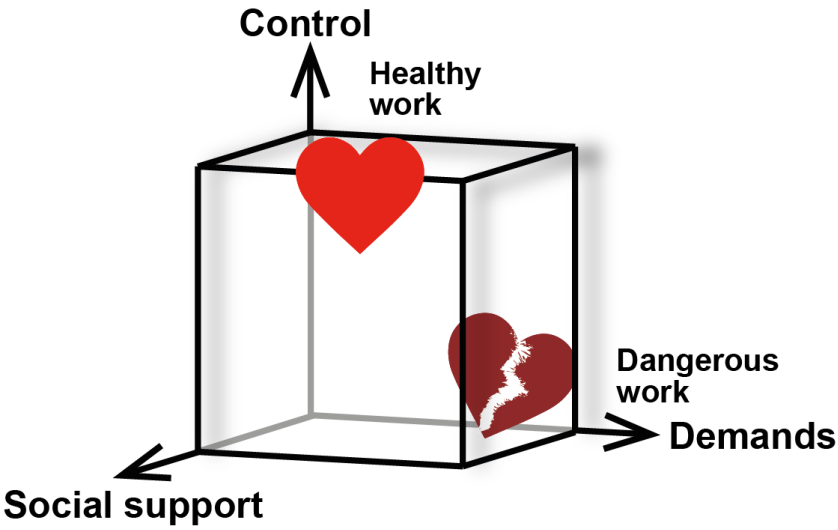

Fig. 1. The Demand-Control-Support Model of stress in a work situation.

The figure above illustrates how healthy and sustainable a work is, in relation to the experienced demands, control and social support. High demands are normally not a problem, if combined with high self-control over work situation and tools and strong social support from management and colleagues. A skilled worker can experience this as a challenging situation. She has full control over the work conditions and planning and gets full support when needed. The work is efficient and sustainable. On the other hand, if high demands are not met by strong self-control and social support, the situation will soon become dangerous health wise. If the worker does not have control over work conditions and planning, does not have usable tools and feels totally exposed if things go wrong, the work will be very unhealthy. Such work situations are associated with high stress. In this extreme, different health risks are common and people do not withstand the situation for long. Research shows that subjective control and support factors often decrease when new IT systems are introduced (Åborg, 1999, 2002).

In this research project we have focused on administrative work. The main health problems in such computer-supported work situations are: Users are bound to use the computer for a major part of their working hours entailing constrained, static work postures for long periods. The computer controls the work pace and task order, leaving the users little or no control over their work. Users suffer from stress, caused by

excessive workload, time pressure and poorly designed computer support (Bergqvist 1995, Punnett and Bergqvist 1997).

Traditionally, occupational health experts work in isolation from the software development process. They evaluate and suggest improvements to existing workplaces and tools (Sandblad et al 2003). It is, however, often too late to do something about poorly designed software tools once they have been installed and are running. Thus, poor and inadequate design leading to health problems cannot be sufficiently modified post-hoc of systems development when the computer system is in use. Instead, occupational health and ergonomics experts must be involved in the actual software development process. Work-related stress has increased in the past years and since long it is well known that it is a growing health problem (Marklund 2000). Work organisation and work content are important factors underlying stress problems, and in office work, IT support systems, especially computer software, play a major role. The mental workload tends to increase when new IT systems are introduced (Aronsson et al. 1989), and the decision latitude is lower for extensive computer users than for others (Tornqvist et al. 2000).

2.2 Future Offices and its Relevance to HCI

The physical work environment in all its variety is of course another factor influencing office workers (Bodin, 2010). Recently, flexible offices and more specifically management philosophies such as the idea of activity-based working (ABW) has attracted the interest of both organisations and researchers (Appel-Meulenbroek et al., 2011). Place is here seen as a mediating factor between people and IT. Indeed, the strategic use of corporate space is seen as the necessary, though not sufficient, factor in empowering the workforce and ameliorating many of the down-sides of computer-supported work (van Kotsveld & Kamperman, 2011). A part of the concept is increased use of IT in support of both mobility and monitoring, and not surprisingly, the IT industry itself is one of the major proponents of this new way of work (Gates, 2005). Yet, while ABW is proposed as a solution to the problems associated with open plan offices, not least cognitive stress, research is inconclusive (Too & Harvey, 2012, De Been & Beijer, 2014). In a seminal paper Humphry (2014) traces the origins of this seemingly new–anywhere, anyplace–work rhetoric and exposes some its inherent paradoxes, not least how these images of newness contribute to the conservation of old work patterns.

As IT in the workplace thus becomes more and more embedded and pervasive the scope for HCI broadens. The pioneering works of Alexander (2006) have already argued for the application of usability concepts in the field of facility management, yet the field seems to have attracted limited attention so far (Rasila et al. 2010). Instead, the most common tool seems to be variations on the model developed by Laing et al. (1998), where the amount of face-to-face interaction is contrasted with the amount of job autonomy (resulting in a matrix of four basic office types: the hive, the cell, the den and the club). While this broad categorisation of work can aid planning, other techniques, such as personas, could provide a deeper understanding on how to improve the quality of work and the work environment.

2.3 Personas

Within development of IT-based systems, the persona method has become frequently applied tool and is used extensively in both industry and in research. The Persona method is a user-centred way of representing users in situations where users cannot be available; the idea is that the overall focus and awareness of the users in development projects are heightened when working with personas (Grudin & Pruitt, 2002). However the use of the method can be manifold for example, the personas are described both as a communication tool and as a design aid. However, Guðjónsdóttir (2010) argues that by trying to separate the different ways to use the method will help the usability practitioner to more skilfully use the personas, as well as being open for alternative applications.

Within the field of Human-Computer Interaction, the persona method was originally introduced by Alan Cooper (2004), and he argued for hypothetical archetypes of real users in order to avoid designing systems that become too generic and in the end does not fit anyone. According to Cooper (2004), the personas should be based on actual users and the personas should be precise and specific since it is more difficult to ignore a detailed persona than aggregated user data. The ideas is that numerous personas initially are created through an iterative process, and then these are condensed, according to their goals, into fewer but more precise, personas. One more important claim from Cooper is that even though multiple personas can be created, the developers should focus on one primary persona (Cooper, 2004).

The extensive use of personas result in different views on what should be the basis of the personas. The most common argument is for collecting qualitative data through for example interviews and observations of real users (Cooper, 2004; Guðjónsdóttir, 2010; Pruitt & Grudin, 2003). However, the data underpinning the personas does not need to be based on ethnographic studies of real users; for example Faily (2010) describe personas within secure systems design based on assumptions. Quantitative data from for example surveys can also be used to statistically render personas, although these can later be refined by interviews and observations (Sinha, 2003). Moreover, the widespread usage of the method in disparate settings and contexts has made the resulting personas in different shapes and forms. Floyd et al (2008) outline in their paper a loose typology of personas, however, the persona kinds that are described in their paper are not exhaustive; for example, other possibilities are assumption personas (Faily & Fléchais, 2010) or a collaboration persona (T. Matthews, Whittaker, Moran, & Yuen, 2011).

The persona method is also criticised, where the most alarming critique is that the personas are being misused and that this leads to designers distancing themselves from real users (Portigal, 2008). Portigal argues that it is better to engage with users directly than to create a façade of user-centeredness (Portigal, 2008). Other types of critique is that the method is difficult to verify as (more) beneficial compared to other method (Chapman & Milham, 2006) or that it is inevitable that designers will create stereotypes (Turner & Turner, 2011). Furthermore there is literature that show when personas have failed to work, such as the case that Blomquist and Arvola (2002) present, where the persona method were not optimally used. The reason for this was

mainly because the design team was not familiar enough with the method and the interaction designers were not involved in the creation of the personas. Rönkkö et al (2004) present a case where the persona method was abandoned in the context of developing software for mass market mobile devices, although this mainly was because of the power and dominion of stakeholders outside the development organisation. Some recent studies have shown that the probability of personas being used is higher if the designer has participated in the creation of them (Friess, 2012; Tara Matthews, Judge, & Whittaker, 2012). Furthermore, Markensten & Artman (2004) presents a case where personas were used outside the development project in which they were developed. In their case the educational department adopted the personas as a way to introduce newly employed to different clusters of customers.

3 Using Contextual Personas to Define Current Work Situation

In this section the background of the study is presented as well as the data gathering method used.

3.1 The Case Uppsala University

Uppsala University is a large Scandinavian research university with about 40 000 students and 6000 employees. The business administration department of the university handles the overall strategic economy at the university, whereas the different business administrators at the departments work with the daily economical work.

The majority of the business administrators at the departments are women. The work of the business administrators at the different departments at the university are however organised in many different ways. Some work both with economy, human resource matters and study administration since they belong to very small departments, whereas others are very specialized in one area such as EU project economy and work with that full time with the support of a larger group of business administrators. Today, computers constitute the primary working tool for the business administrators at the universities, and hence comprise a major part of the work environment and procedures.

The study presented in this paper was a part of a collaborative project (KiA) between a research group of Human-Computer Interaction and the university administration (Cajander, 2013). The KiA project ran for two years, 2012-2013, and was coordinated by the university administration whereas most intellectual contributions were done by the researchers. It should be noted that the project was not a research project as such but the researchers were allowed to use the findings for scientific work beyond the project. The researchers worked within a participatory action research tradition (Heron and Reason 2006, McKay, J. and P. Marshall 2001) meaning that they were used to work closely with organisations, rather than observing without interfering.

3.2 Data Gathering

3.2.1 Contextual Inquiry

The data gathering was conducted from May to late August 2013. Field studies and interviews were conducted with 12 economics administrators at four different institutions in Uppsala University lasted approximately 2-3 hours. The field studies followed the method Contextual Inquiry and its four principles (Holtzblatt et al, 2004):

1. Studies of the work in its context: Field studies were conducted on site. Researchers are studying the users who do their tasks and discuss the systems used to solve them.

2. Cooperation: The user and researchers work together to understand the user's work. The researchers alternate between observing the user when they work and discuss what the user was doing and why.

3. Interpretation: The researchers share their interpretations and insights with the user during the interview. The user can expand or correct the researcher's understanding.

4. Focus: The researcher focuses the conversation on topics that are relevant to the survey.

During the field studies the researcher took notes using pen and paper. The first field studies were made with an open mind to understand the work and the situation, but eventually the researcher asked the business administrator more specific questions as for example to show some particular parts of the systems or tasks.

3.2.2 Data Analysis and Sketches of Contextual Personas

The collected data was analysed based on four categories from Karasek and Theorell's model of work (see above), and the fourth category was the general working environment problems. Three researchers (three of the authors), analysed the data together in a workshop in August 2013 and wrote the first descriptions of the three personas together during the workshop which resulted in rough contextual personas. The researchers worked visually with the personas and made use of large white boards where the dimensions of healthy work were visualised together with descriptions of personas.

After the workshop, the descriptions were reviewed individually by the researchers and modified. The illustrations of the personas were just modified images from Clip Art at this point.

3.2.3 Focus Groups

One researcher revisited two of the business administration departments, and arranged focus groups with four and three business administrators to discuss and reflect upon the presentations made in the personas. After the focus groups the personas were revised according to the reflections made by the business administrators. An illustrator was asked to draw the faces of each persona according to the descriptions at this point.

4 Results

Three personas were made based on the interviews and analysis of those. Each description was about one page of text describing the personal life, one day at work and the goals of the persona. Additionally, the need for control, support and the demands that the persona has are described. Each persona had a figure, illustrated by a professional illustrator. One example of a persona can be seen in figure 2.

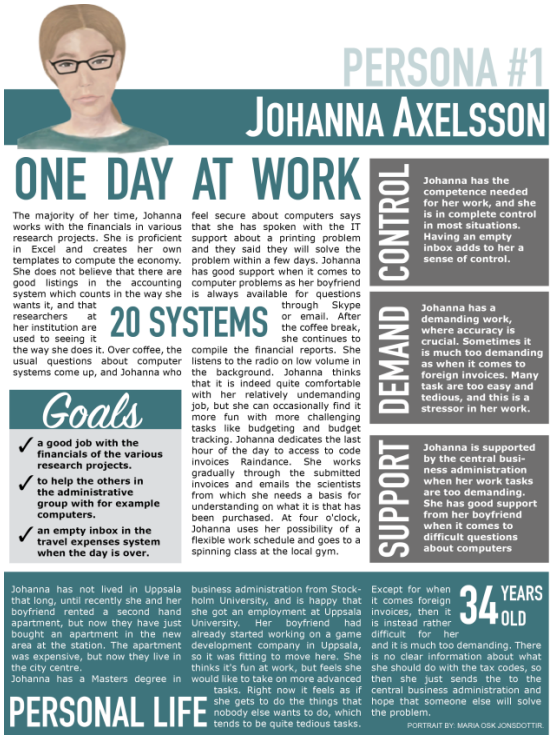

Fig. 2. Johanna Axelsson - One example of a contextual persona.

Some really interesting points emerged during the focus group discussions that did not occur in the earlier interviews. The business administrators really liked the job descriptions made, and could identify themselves with the personas. Someone said "It really feels like this person is working here".

One of the things that one of the groups wanted to add was how life was affected by their work. In their mind private life and work forms one whole, and they wanted that to be better represented in the personas. They also gave concrete examples of situations where they need to adapt their working hours, their vacation and their weekends to meet the goals of different business administration deadlines. As a busi-

ness administrator at the university in their opinion, you need to adapt life to work, and they often worked long hours before deadlines. One person described that new deadlines might occur in the calendar if researchers receive new research projects, and that these have individual deadlines for reporting. Especially EU projects mean a lot of work for the business administrators, who adapt their working hours according to the schedule of the projects.

Some business administrators also complained about the current systems at the university that does not support flexible work, and some systems require that you are on the university network to be able to work. They also wanted more possibilities to work using their mobile devices.

Another interesting discussion that emerged was the lack of a persona that would represent the elderly generation of business administrators. This persona would describe the situation that technology has changed work so much that it is not the same at all. The persona would illustrate an elderly lady who has had problems understanding the new technology, and being terrified with the changes even though they are at the very core of their work. This persona has the feeling that her knowledge is not valid any more.

5 Discussion

The contextual personas were based on the theory of healthy work by Karasek and Theorell (1992). The theory was used in a very concrete way when designing the personas, and each aspect (control, support, demand) were discussed separately to ensure the quality of the descriptions. However, during the discussions it became clear that some aspects of the workplaces were not fully covered by the theory such as for example the aspect of interruptions and doing things in parallel. Other aspects that are not covered by the model that emerged in the discussions were the personality of the persona and how that affects the perceived stress. The contextual personas method could hence be further improved in the future to cover all aspects of working life through a conceptual development of the theoretical foundations of the process.

In our contextual personas we describe the holistic work environment as it is today for the business administrators. The main difference in our way of describing personas compared to how Cooper defined personas (Cooper, 2004) is that Cooper's personas are used for improving one particular software system. The descriptions of these personas are aimed to describe their way of working solving the goals that the software system being developed will support in solving. Contextual personas are not focused on the usage of one system, they are focused on describing the whole context of work, so contextual personas could typically be using 20 software systems for solving various tasks at work. The usage of personas in new contexts is also argued in (Eriksson, 2013) where the author elaborates on how the users in the study started to more readily talk about their work situation when confronted with the personas that depicted themselves. This could be interpreted as the personas as a reflexive tool to be used as trigger material when talking with users, which in our cased highlighted the diverse and multifaceted work of the business administrators.

Contextual personas describe the current work situation, similar to Cooper's personas and to Hackos and Redish (1998) scenarios. Hackos and Redish (1998) describe two types of scenarios, "task scenarios" that describe the current situation for a persona and "use scenarios", that describe: "the future use of a computer system". Contextual personas could also be used in a similar way, using the contextual personas to give insights into future work environments. Previous research has shown that user feedback is often informal and limited (Larusdottir et al 2014). The contextual personas could work as a new human centred activity that would improve the quality of usability work for developers. In that case, the personas should be based on data from brainstorming sessions with users, so the descriptions will not be too hypothetical and superficial. Cooper (2004) and Holtzblatt et al. (2005) have emphasized that personas are grounded in interview data from users and are not based on designers' imagination.

There is a need to develop and adapt current human centred activities to better address the future workplaces, and contextual personas shows promising results in this context. One should note that contextual personas are not recommended to be used in isolation, but together with other human centred activities to fully incorporate the essence of future work places. We conclude that the personas need to be complemented with a vision work concerning the future needs and visions of the users as well as other user centred activities.

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The Work and Workplace Analysis in Social Solidarity Institutions to Address Organization Agility and Innovation

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Abstract

The mission of elderly services is to enable elders to live in dignity and to provide necessary support for them to promote their sense of belonging, sense of security and sense of worthiness. The goals of the Portuguese social security system are to oversee the activities of non-profit non-public institutions for social solidarity and to improve the quality of operations and services, as well as the interaction process of the collection, requirements and information system aligned with those of the social centers for elderly.

Firstly, our strategy was to understand the information flow and the workplace of a small institution, which needed to redesign and reconfigure his business process components combining individual tasks and capabilities in response to the environment (other social solidarity centers and the social security system) in order to be agile. Secondly, we proposed a prototype to serve the communication process among the social centers for elderly and the national social security institution. This attempt may contribute to improve the interaction among the whole partners and to address organizations' agility and innovation.

Keywords: Social Solidarity Institution, Agility, Innovation, Workplace, Work Analysis, Information Systems, Information Technologies

1. Introduction

The long-term care system, in Portugal, until recently, was not integrated in the public sector. The Misericórdias (Holly Church), independent non-profit-making institutions with a religious background, provided the service. In order to expand services, a new private/public mix centered on the public subsidizing of non-profit institutions was created in the late 1980s. It was implemented through a new legislation on the legal status of non-profit provider institutions (designated as PISS – Private Institutions of Social Solidarity). In 2006, due to the increasing number of elderly persons and the reduced offer of these services, the National Network for Continuous Integrated Care was implemented, based on the existing structure. The Ministry of Labor and Social Solidarity in each Portuguese region provided the social services. Health and social care services were, mainly, provided by private non-profit-making institutions (subsidized by the State) and by Misericórdias.

In terms of information systems and technologies these institutions face several problems. The new technologies are not used properly for management, and conversely, the software development enterprises have single applications for each purpose: staff management, accounting management, vehicle management and so on. Platforms that cover all of them do not exist. Consequently, they spend several hours filling and finding forms. On the other hand, the social security institution demands several reports to those institutions, which are difficult to prepare since information is spread over offices. For PISS, the quality management systems are outlined by the institutions of social solidarity as an important functioning guideline with all the rules that must be accomplished. However, there are bureaucracies to follow each time an intervention is made with the client, which takes out-sized the amount of information to deal with.

Facing this situation, and in order to contribute to sort specific problems of a private institution whose concerns were to increase its service quality, we proposed a prototype solution which was implemented, and later, tested and validated by the client. To arrive to the solution, several steps were carried on such as the workplace analysis - The workplace analysis is determinant of the quality of the work for the employees and the service users. It permits to increase the levels of motivation, engagement and also the levels of innovation. We questioned several factors to change the workplace environment - the user requirements and needs and work analysis of the whole solution. Our methodology approached methods and techniques of human work interaction design.

The backgrounds of work analysis came from the analysis of the process of collecting information about jobs [1]. Dierdorff and Rubin refer the theoretical issues associated with the work-related information to come to the term work analysis [2]. The change of the focus from jobs analysis to work analysis admits that the methods and concepts being applied in the workplace changes as well as the different situations that can be found. Work analysis can be approached within different perspectives: either as a methodology, a resource tool or a process and work analysis data can be obtained from a widely collected type of human resource's data in different organizations and/or during artifacts development.

Our proposal was to contribute to the institution agility. The institutions' agility was addressed to increase institution and customers' services satisfaction. Conversely, the internal and external business processes were beneficiated by agility. Gartner stated that the main contributions considered by agility are customer service, security, knowledge management, asset management and cost efficiency [3].

2. Organization' Agility

According literature, the definition of agility is very broad, although its semantics converge. Along the last twelve or thirteen years we found that this concept started to be a common sense necessity between the academy and industry. However, agility is defined from different points of view and according different focus: Oosterhout et al. define agility focusing on business process unpredictable changes beyond flexibility levels [4]. Overby et al. describe agility as an ability that firms should have to sense

environmental change and respond readily [5]. The response to the challenges posed by business environment dominated by change and uncertainty is the main aspect of agility. It helps the firm to be able to generate the required information for management decision-making. The speed in responding to variety and changes is the attempt to improve organizations' systems and architectures [6].

Considering agility within manufacturing, Jin et al. define it as the capability of surviving and prospering in a competitive environment of continuous and unpredictable changes by reacting quickly and effectively to changing markets, driven by customer-defined products and services [7]. Liu et al. refer agility emphasizing the supply chain as a forms' ability to effectively collaborate with channel partners to respond to marketplace changes in a rapid manner [8]. Kalbande focus on business process agility highlighting e-procurement as the solution [9]. Sletholt gives another perspective: he emphasis agility practices in software development and, defines it as the responsiveness to change and collaboration [10].

Agility is very important since every organization must build agility to perform effectively in unstable environments. A set of processes that allow an organization to send changes in the internal and external environment, responding efficiently and effectively in a timely and cost-effective manner, and learn from the experience to improve the competencies of the organization is defined as organization's agility [11].

2.1 Information Systems and Technologies to Achieve Organizational Agility

In order for information systems (IS) to act as an enabler of organizational agility, increasing the positive sides of information systems while minimizing the opaque sides, firms need to evaluate their information systems thoroughly, understand their dynamic environments, and modify and implement their suggestions [12]. Seo et al. identified several factors to minimize the called dark side of IS: standardization, buying, leasing or outsourcing, management skills and individual agility, and organizational structure and culture. Once organizations analyze their own situations following the proposed factors, they will be agile since they learn in every cycle and it becomes their competency and flexibility.

Information Technologies (IT) is an important agility concern of many enterprises. The main reason for this is because the agile enterprise is collaborative since it communicates among its collaborators and stakeholders. Once IT is agile, several resources such as new tools, technologies and solutions including: cloud computing, collaboration technology, application portfolio management, and IT outsourcing will empower the agile enterprise [13]. Liu et al. studied the impact of IT capabilities on firm performance [14]. They underline the importance of supply chain agility, which is all about customer responsiveness in the uncertain market [15] and is essential in ensuring the firm's competitiveness because it enables effective and efficient responses to operational changes [16, 17,18].

IT capabilities are deemed as enablers to firm performance and the alignment between IT capabilities and strategy is increasingly important [19]. In fact, performance effects not only are affected by responding to environmental change, but also may be contingent upon the congruency between design choices and strategy [20].

Organizational and technical solutions help to achieve agility. However, besides the information technology sector being fundamental of both enterprise infrastructure and

business process implementation and management it is not sufficient. The solution should fit with the enterprise agility needs and its specific situation.

Information technology is generally a barrier to business agility, the existence of inflexible systems is supposed to be a very important disabler in achieving more business agility. However, information technology enabled innovations, in general, and enterprise resource planning systems in particular, have contributed to the simplification, standardization and automation of business processes in the past [21].

3. The Portuguese Social Security System

The literature is scarce about Portuguese studies in the presented field. We found some references about the third sector and the imperative of professionalization, where non-profit organizations are defined and their objectives [22]; the social and solidarity environment is presented by [23], third sector dimensions in Portugal are described in the report "Portugal's Nonprofit Sector in Comparative Context" [24]. The information found was important to help to understand the description of the functioning of these institutions and the interactions among the stakeholders. Afterwards, the goal of this project was to analyze, in loco, the communication forms and interactions among social solidarity institutions and social security system and to design a prototype application that would permit to communicate, easily, the information shared among them.

In Portugal, the origins of several non-profit organizations were connected to the church, like Misericordias [23]. The Misericordias (holy houses of mercy) are an example of the strong cooperation between state and church, which has marked the history of Portuguese society in general. The statute of IPSS is granted to organizations that are constituted "without a profit motive, on private initiative, with the purpose of giving organized expression to the moral duty of solidarity and justice among individuals" [24].

The social security system in Portugal is managed by the state and, in principle, it applies to all individuals working in Portugal, either as employees or self-employed. It provides benefits for health care, sickness, retirement, disability, death, elderly, maternity, paternity and adoption. IPSS help children, young people and families, support social and community integration, assist the elderly and disabled, promote and safeguard health, education and vocational training, and resolve housing problems.

The relationship between the social security system and the private institutions of social solidarity (PISS) is extremely important for their functioning. The social security makes, annually, agreements among institutions, the cooperation protocols, in order to answer the institution's demands. Besides these protocols, the social security elaborates the quality manuals with guidelines to help institutions to create their own quality manual. The quality manuals are organized into validities: familiar housing, residential home, center of occupational activities, home of infancy and youth, residential canter of temporary housing, structures for elderly, day-care centers, and domiciliary services support.

These models are an instrument of good practices to help the auto-evaluation of the social answers, permitting to review systematically its performance and to support the development and implementation of a quality management system to improve the functioning of each organization. Conversely, they are a normative referential for the requirements to a social reply, independently of the legal nature of the institution.

In Portugal, at reference point 31st December 2010, there were 5800 owner's entities of social solidarity (Figure 1). Around 70% had non-profit goals. Among these, 61, 4% were private institutions of social solidarity (which included the social services of enterprises and the 'Misericórdia' (SCML); 1,4% were official entities, 2,1% other private non-profit organizations and 3% were entities equivalent to PISS. [25, 26]

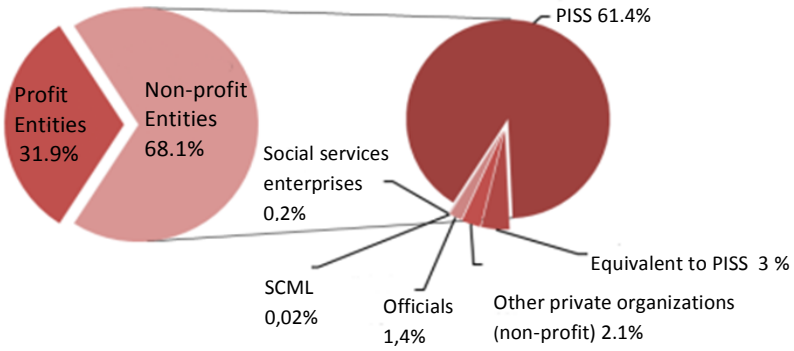

Figure 1 - Distribution of the entities ownership according their juridical nature – 2010 (Carta Social)

4. Case Study Description

We conducted this research considering the prevailing situation about the interaction difficulties among the social solidarity institutions and the Portuguese social security system. We did some interviews and observations to understand the information flow among these organizations types and the employees and user's needs.

Around 20 semi-structured interviews were conducted in a person-to-person interaction form in different social centers, private organizations, with different members of staff. The interviews were semi-structured to allow the interviewees a space of freedom to comment and/or present their concerns. Then, we decided to select one of the social centers to investigate it as an example of the workplace and to get data to develop a prototype that would contribute to improve the institution agility and innovation.

The social center SCLF was the chosen case study. The main goal of the SCLF, a private institution of social solidarity, is to help the clients who do not succeed to have, in their homes, the support conditions for the necessary care for a good quality of life. The SCLF offers several different services namely, residential structure for elderly, domiciliary support services, center of day, physiotherapy services and leisure

activities for children until 10 years old. The institution has a kitchen to prepare the meals and it is also responsible to supply and feed children of the village's school.

The center is organized as presented in figure 2. Two main groups can be distinguished, both having in charge the technical and services directors. The technical director area is divided into the technical bureau and the valences that the nursing house gives, namely the leisure center activities (LCA), day care center (DCC), domiciliary support service (DSS) and the residential structures for elderly (RSE). These services have different types of workers: direct help providers and service auxiliaries; the technical bureau has the health office with a physiotherapist, a doctor and a nurse. The social office has a sociologist and in the leisure office there is a social educator. In the area supervised by the service director we have stocks management activities and the secretariat whose tasks are developed by the director. The kitchen has six cookers and the laundry is where service auxiliaries realize the tasks.

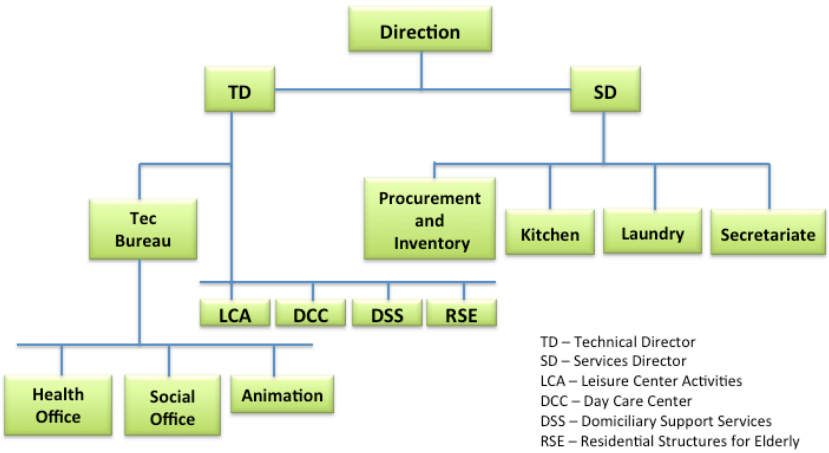

Figure 2 – Organogram SCLF

5. Proposed Solution

In order to help a social center to interact either with their stakeholders or with the social security system we proposed a prototype implementation for innovation in the organization, where staff took part, sharing their personal knowledge with other stakeholders. We analyzed the characteristics of the environment, characteristics of the organization, characteristics of the user (staff and stakeholders) and the interactions along the processes as well as the needs of the people involved.

5.1 The Design Process

The early focus on our interactive design process was the investigation about the workplace, the characteristics of the organizations, the characteristics of the user and the established interactions. This process is what we consider the first contact with the work analysis in/between people and technology (Figure 3).

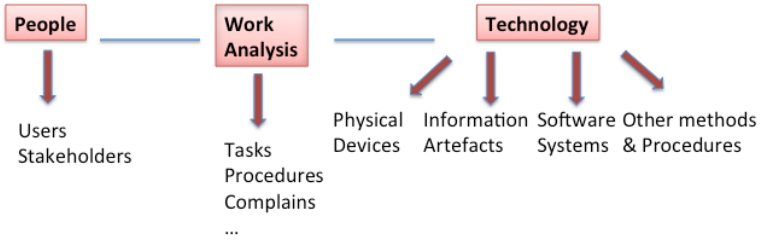

Figure 3 – Data Analysis Framework

We define people as the whole persons involved in the process. The work analysis are tasks, subtasks, activities, procedures, complains, needs, etc. The technology is the tangible or intangible output as the result of the interaction design process: it can be physical devices, information artifacts, software systems and other methods and procedures. Then, we tried to understand the different perspectives and aspects of the enterprise, the workplace. The approaches to gather information about situations, users, customers, collaborators and other stakeholders were institutional documents, attitudes from the community (nursing houses and institutions of social solidarity) and software applications in use.

The data was, initially, collected to fill the designed table (table 1), which served as a guideline support to organize the gathered information about the known and unknown situations. This table allowed ensuring a complete and holistic understanding of the enterprise architecture.

Table 1 – Data Collection Table

	What	How	Where	Who	When	Why
Scope						
Business						
Information Systems for Elderly Care						
Technology						

Table 1 is a four by six classification schema. The four rows represent different perspectives of the institution: its scope (vision, mission and objectives); the business characteristics and services; the main information systems and technologies used for elderly care and their features. The questions helped to organize and objectivize the data gathered and analysis. The output gave us some information about the workplace environment.

Firstly, we prepared the text for the interviews and we selected the staff members of each institution according a defined profile. After each set of interviews with people from the same profile (technical and/or services director) in each of the five institutions, we analyzed the data and started to design first sketches of our prototype. Then, we interviewed the information systems technician of each institution. Another phase of interviews with the previous members of staff was made to consolidate and correct the gathered information. Finally, we interviewed the administrative people that will be in charge of the application's use.

Sixteen questions were designed to gather information from the interviewees, either to understand the procedures and interactions in and out the institutions or to know the type of complains about the work situations experienced. We were interested, namely, to identify the kind of information that was necessary for users' management; the compulsory information to be exchanged between the institution and the social security system; the access points to consult information; people that should be involved in the process and the output documents that should be created.

The goal was to understand the difficulties that staff, in nursing homes, had when dealing with the whole amount of information that is spread all over the institution.

5.2 The Prototype

Our solution was a prototype of an interactive application, which integrates the whole information to be shared among institutions and users.

The information about each person's process, namely, the medical information, nursing information, social services information, physiotherapy, accounting, among others is organized and different users, those with permission, can consult it in an efficient way (Figure 4). The integration of services was highly complicated and controversial. The changes were progressively made with the collaboration of the staff. The information concerning the social area (social security services) was also included. Each month the system will deliver information maps about the different institutions interaction (waiting lists, client's allocation without institution place, etc.) Presently, the problems of mixed forms of communication, was sorted. The difficulties we had with the communication from institutions and the social area were settled.

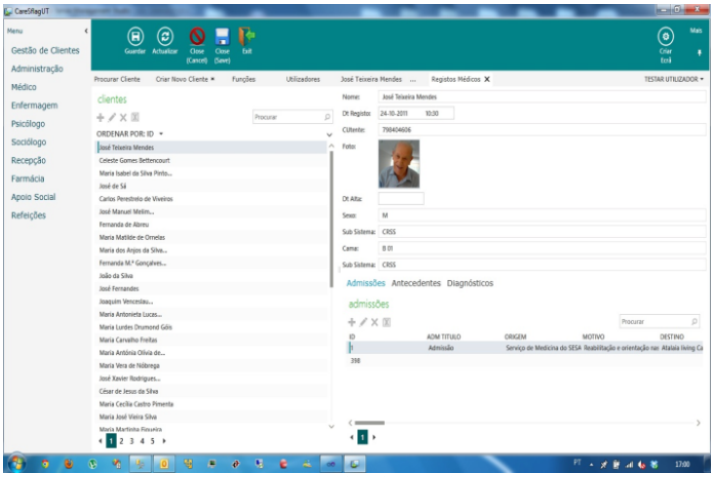

Figure 4 – Application Design

6. Discussion

According our research we concluded that, in general, information was spread by different means of communication in a mixed of digital and paper forms. Social solidarity institutions do not interact, efficiently and effectively with the social centres for elderly due to the disaggregation of information systems and technologies. The human resources were scared for the amount of activities that social security demands. The employees of these institutions had different backgrounds and experiences and, in general, they were not motivated to use technology.

6.1 Information systems and technologies

Concretely, in the SCLF centre, there were two software programs: one responsible for the accounting management and the other for user management. The former could only be functional for an accountant with some experience. The software had specific features, which do not permit a person who was not familiarized with accounting concepts, to use it properly. The software was divided into several areas; each one had its particular characteristics. Several features needed constant updates according the new law decrees; and conversely, the compatibility issues with the supervisory bodies were not easy to make. In parallel with the difficulties of operating the software, users dealt with information exchange in paper format, which was not aligned with those in the software. The latter, the management software was extremely complex due to its virtual use. Through this software users could create and record all parameters of the

institution receipts and they could make the calculations about what each customer spends. A list with all the people on the waiting list could be drawn.

The main problems encountered with the information systems use were based on the absence of customization hypothesis, the lower experience and background of the institution's workers, and conversely, on the frequent legislation changes.

6.2 Pursuing agility

The proposed approach contributed to introduce innovation on the social center through the alternative pathways of thinking and acting. The achieved changes permitted the organization to be agile. Every organization needs agility. An agile organization is one that senses change in the environment and responds efficiently and effectively to those changes in a timely manner. But, to be agile is not straightforward, new systems, new business processes; even ways of working must be designed and implemented.

This study provided some design guidelines for building and applying interventions to increase agility in the described institutions. Many practices that promote agility already existed in the organization, but they needed to be deeply identified, improved where necessary and then aligned within an overall capacity-building strategy. Change-management practices were designed to promote agility, which were concentrated on creating an openness to change and assuring immediate execution of strategy by ending structural or cultural barriers that impeded the flow of work, people, resources and ideas.

The prototype solution was implemented on the SCLF centre and then replicated on three other centres, until the moment. Information technology could generally be a barrier to business agility [27], and information technology may inhibit or allow agility [4]. We consider that these social centres are satisfied with the prototype proposal since they validate it. However, some improvements will be considered for the final application development. Agility was achieved through the organizational and technical solutions suggested.

7. Conclusions

One of the major insights we have reached within this study was that innovation methodologies were implemented across the social centres in interaction with the social security system. Human efforts engaged in the innovation process, tools, and technologies. The requirements, processes and outcomes were clearly defined and staff and employees were involved and motivated to this investment. The communication channels were identified and the structure of the innovation interventions process was defined.

Innovation introduced the social centres in study to alternative pathways of thinking and acting; the majority never previously explored. Changes like involving employees, staff and other stakeholders to discussion the information flow were made. The prototype of an interactive application for the centres management was implemented. We attained a final product development phase. As a result, a set of good practices was recognized and is, presently, followed by the whole intervenient in these institu-

tions. Furthermore, the proposed solution acted as an enabler of organizational agility maximizing the gaps of communication in and out the institutions involved. Our results indicate that agility do promote organizational performance, though in somewhat different ways.

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A Grounded Theory Study of Perspectives on Automation Amongst Aviation Industry Stakeholders

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Abstract. Using Ground Theory (GT), this study will interpret workshop data to elicit industry professionals' views on automation. Analysis of the interactive processes within human factors in the aviation industry will contribute to the theoretical and practical body of reference material and be used by researchers and industry specialists. The overall aim of the study is to understand human issues and interactive processes involving automation systems in the aviation industry, specifically the role of automation in the socio-technical system.
Keywords. Automation; regulation; systems-oriented design; human-automation interaction; complacency; communication.

1 Introduction

In 1996, the Federal Aviation Administration (FAA) Human Factors Team Report on the interfaces between flight crews and modern flight deck systems (FAA, 1996) was published. Although the report described the current aviation system as very safe, a review of the data identified vulnerabilities in flight crew management of automation and situation awareness. To address these concerns, the Performance-based Aviation Regulatory Committee (PARC) and the Commercial Aviation Safety Team (CAST) established a joint working group of authorities, industry and researchers to update the 1996 report. This included looking at the aviation system through the combination of actions and interactions, equipment design and flight operations in global airspace.

The working group identified several factors that are projected to impact future operations in order to provide a context in which to consider the findings and recommendations:

- Growth in the number of aircraft operations
- Continuing changes in the demographics of the aviation workforce
- Evolution in the knowledge and skills needed by pilot and air traffic personnel

- Historically low commercial aviation accident rates that make the cost/benefit case challenging for additional safety and regulatory changes fit case challenging for additional safety and regulatory changes
- Future airspace operations that exploit new technology and operational concepts for navigation, communication, surveillance and air traffic management.

The above can be summarised in two main recommendations:

Recommendation 2. Autoflight mode awareness. Emphasise and encourage improved training and flight crew procedures to improve autoflight mode awareness as part of an emphasis on flight path management. For the longer term, equipment design should emphasise reducing the number and complexity of autoflight modes from the pilot's perspective and improve the feedback to pilots (eg on mode autoflight modes from pilot's perspective and improve the feedback to pilots) while ensuring that the design of the mode logic assists with pilots' intuitive interpretation of failures and reversions.

Recommendation 4. FMS documentation, design, training and procedures for operational use, operational policies, flight crew procedures and flight crew qualification and training for pilots flying automatically-operated aircraft. This historically had a somewhat outdate human-centric approach, where automation revolved around the human; future debate should no longer place humans at the centre.

A number of workshops were subsequently held to keep up to date with the continuous changes taking place within the industry. These allowed individuals within the industry to keep each other up to date with perspectives on automation. The intended aim of workshops held by the Civil Aviation Authority (CAA) and National Air Traffic Services (NATS) is to contribute to the theoretical and practical body of reference material that can be used by industry specialists (ie regulators) to understand safety attitudes at an organisational and managerial level.

The CAA and NATS are also testing whether any further requirements are needed both nationally and on a global scale. Using these findings, current regulations will be tested for their suitability in future operating environments. It will also test whether any further requirements are needed both nationally and on a global scale. In one such workshop held by the CAA/NATS in February 2014, 66 industry professionals (including pilots, engineers, regulators and air traffic controllers who had two tables comprising eight or nine participants each) were asked a series of questions, each designed to explore the present and future implementation designs that use advanced human-system integration i.e. automation and the need for further regulation. The questions asked to participants included: What could make the current situation worse? And what could happen as a result? What do you need to provide you with assurance to make it better? Questions and answers were written in bullet point form and placed within a matrix.

2 Study objective

This work follows a study reporting on an effort led by NATS, the UK Air Navigation Service provider for air traffic management to elicit critical views from all parties involved in the design, implementation regulation and use of the existing or planned automated systems (Amaldi & Smoker, 2012). In line with this, the aim of the current study is to analyse a number of salient claims elicited from major stakeholders in civil aviation/air traffic management milieu about the current status of automation and role that each stakeholder group can play in laying ahead a pathway where concerns are expressed and way forward suggested.

This study will lay the foundations for an automation survey to gauge measure stakeholder attitudes at an *organisational* level. This will differ from previous automation surveys which historically have mostly been limited to the level of human-machine interaction at an individual (operator) level. The study uses Grounded Theory (GT) to interpret the characteristics of critical reflections that emerged from this workshop by describing, categorising and applying theoretical foundations to them (creating themes and sub-categories with dimensions).

The study comprises three key stages:

a) Carrying out a thematic analysis of the statements issued during the workshop.
b) Elaborating on workshop statements through interviews with stakeholders in order to gain a thorough understanding of issues; checking that study themes and sub-categories constitute an accurate synthesis of individual stakeholder views.
c) Testing the relevance and significance of statements at an organisational level by asking the group to score the relevance of statements on a scale – thus capturing the group view.

Results from stage a) will be reported in what follows.

3 Thematic analysis

Using GT, 16 categories/ themes of workshop discussions have been identified:

1. Communication: Improve feedback loops/ communication within human agents/stakeholders of a system. Eg. “We need to communicate assumptions and dependencies to operators and users”.
2. Inadequate Methodology for Regulations: The methodological processes regulators use to consolidate stakeholder views in order to set regulations give rise to risks only being partially understood by regulators. A reason for this is because of the lack of regulators’ expertise in all domains across industry. Regulators do not conduct actual operations and have different educational background from engineers, pilots and ATCs and they need to rely on external sources/ stakeholders for decision leading to possible bias; Eg. “Lack of expertise in regulator/ inappropriate regulation & requirements” or “Lack of Champions regulatory structure to approve systems”

3. Designers Not Embracing a Systems-Oriented Design: Designers cannot foresee all possible scenarios of System's failure and are thus, not able to provide automatic safety devices for every contingency. Systems' designs are therefore seen as "non-intuitive" or with "poor ergonomics" Eg. "Designing really complex, difficult to understand systems".
4. Slack Resources (Time/ Workload Management): resilience and safety boundaries can be better applied when a reduced workload means people have time to react. Eg "Reduction of workload".
5. Risk Measurement: Risk Measurement/ Metrics/ Management and Reliability of operational system through safety boundaries. Eg "Develop metrics of current operational system. What is current baseline?"
6. Standardisation: Standardised/proceduralised structure across industry. Eg. "Need for rules (develop plans) to drive towards an industry wide automation standard".
7. Flexibility: Divergence is "good" - flexibility/adaptability within the Systems Theory view/approach is industry's continuous need to "keep up" with transformational changes. . Eg. "Over-proceduralise the task so much competence falls and people are uncertain on how to behave when the technology fails".
8. Just Culture: Organisational "Just Culture" - "Good Practice" principles that reduce finger pointing and encourage individuals to report near-misses. Eg. "ATCO appreciation of "good practice" given increasing system support".
9. Training: training, learning and regular practice: a learning culture and knowledge-sharing. Eg "Operators need to be trained to avoid becoming overconfident, thereby increasing performance/ risk-taking behaviour (which becomes valued because of exceptional performance) and consequently getting closer to risk boundaries."
10. Confidence/ Trust: Confidence in the ability to control risks Eg "Design systems that provide too many false alerts that distract (undermine the confidence of) the user/ engineer."
11. Degree and Delegation of Control, Autonomy, Authority and Responsibility: Which stakeholders to give authority to which tasks? How are decisions taken to empower automation, and to what extent? Eg "Greater authority without a corresponding increase in responsibility".
12. Alarms/Alerts: Unanticipated problem of alarms/alerts when they impose unwarranted information to operators on a routine basis. This leads operators to "distrust" or "dis-use" or delay their response to true alerts/ alarms. Eg "Minimise the effects of false positive alarms of automation".
13. Over-Reliance on Automation: Complacency, over-reliance on automation in authority/ decision making. Eg. "Increasing reliance on automation (to gain the benefits) => what happens when it goes wrong? How are fall-back modes addressed?"
14. Adoption of New Technology. Operators need to adopt new technology consistently – little incentive to do this. Eg. "Provide no regulatory or economic incentives for operators to adopt new technology."
15. ETTO Principle: Acknowledging the Efficiency–Thoroughness Trade-Off principle (or ETTO principle). Eg. "Automating primarily for economic reasons without

due consideration for impact of the "improvements" on the big picture leading to unintended consequences for other stakeholders and knock-on impact of safety."

16. Global System: Global approach to international air traffic control. Eg "Not taking action on a global scale".

4 Integration with previous study

The web of connected themes in Figure 1 constitutes the articulated views and perspectives of the stakeholders interviewed in the February 2014 workshop. The outcome of this workshop is compared with that of two previous workshops (Amaldi & Smoker, 2012) to check for thematic overlap and consistency (or lack of such). Figure 2 shows a number of statements extracted from the previous workshops. Figure 3 shows where themes from previous workshops overlap with those from the 2014 workshop.

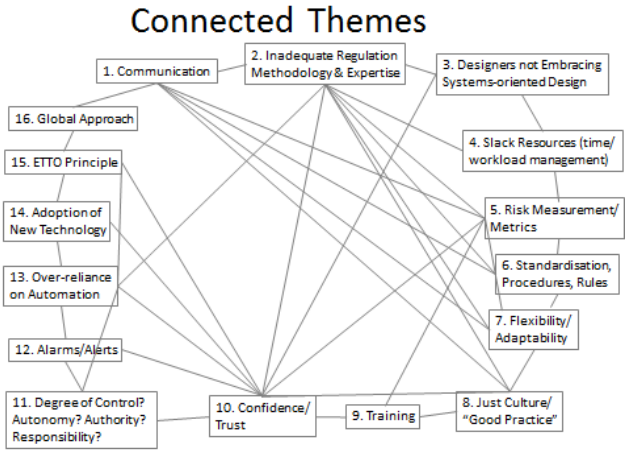

Fig. 1. The 'web' of connections and links between themes.

Main reflections about automation	
Lack of definition/vision	Lack of definition/vision Different expectations about what the automation will deliver. What 'levels' of automation
Responsibility and role allocation	No clear vision about responsibility for decision making. Define roles and appropriate training
Safety and effectiveness of automation	Safety relies on effective human- automation interaction. Manage the cost/benefit of automation. Automation needs to be focused upon removing key risks from the operation and exploiting the different strengths of the human and the machine.
Role/responsibility under unexpected circumstances	How tasks and roles will shift
New skills required	What skills need 'un-learning' and what the new are
Validation of effective co-operation and co-ordination	Automation as 'user friendly'

Fig 2. Main reflections about automation taken from December 2011 survey (Amaldi & Smoker, 2012).

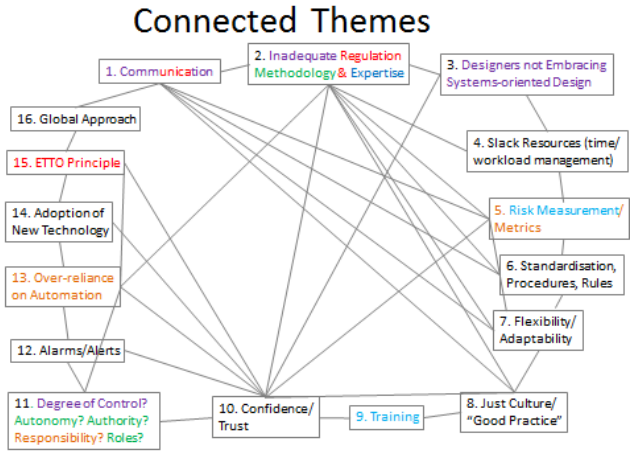

Fig 3. Themes from February 2014 workshop overlap with those from December 2011 survey (Amaldi & Smoker, 2012).

5 External Themes

Also under consideration are a number of themes which are external to the process of workshop discussions. These are the implicit factors of organisational cultures which are not articulated but, have an influence on organisational behaviour. For instance, features such as power, group interest, conflict or inequality feed into the cultural schema and interpretative mechanisms of stakeholders (Amaldi & Smoker, 2012) and thus effect behavior at an organisational level. Figure 4 demonstrates these implicit

factors which appear to be pervasive in the connected themes of the workshop discussions.

External themes:

- Non Linear Systems Thinking: The scope of regulation is often limited to what is at hand (Dekker, 2011). Systems thinking is about non-linearity and dynamics, not about linear cause-effect-cause sequences. It is about understanding how accidents can happen even when all the rules and policies are followed correctly. In ultra-safe industries, "accidents come from relationships, not broken parts (rules)" (Dekker, 2011). These "relationships" comprise of "soft" difficult to define issues that can lead regulators into safety traps. The dynamics in relationships mean it is not possible to anticipate all the rules and guidelines on a check list. Regulators have to accept the rules and policies are "good enough". However, "good enough" can still lead to accidents over time. It may be possible to ensure compliance, but, will not necessarily ensure safety (Dekker, 2011)
- Politics and Regulation: An example of these soft issues is politics within the regulatory environment. Groups with conflicting interests may have an influence on regulators and how they regulate. Regulators are dependent on the views of industry experts. Ideally, such views should prioritise "public safety"; in practice, they can be politically motivated or influenced (Dekker, 2011), meaning that regulators' decisions on how to set or amend regulations can be subject to bias.
- Corporate Governance: In an ideal world, we will be able to rely on corporate governance and accurate external assessment of companies' management practices. But the truth is that the people governing the airlines usually have only a limited term management contract and no ownership share. By definition, excessive cost-cutting on safety will have an immediate positive effect on the financial side, while the negative safety effect will only be visible in the future. Moreover, in a complex system like airline operations, the negative safety effect will be difficult to trace back to a certain bad decision. Therefore, when leaders are under pressure to be productive/ competitive/ efficient, they may be all the more likely to favour productivity over safety.
- Strength of human capabilities: The strengths of automation and weaknesses of humans are often highlighted. What is not emphasised enough is the strength of human capabilities.
- A human-centric approach has been developed where humans have a need to control automation. However, can this continue? Are humans afraid to be left out of the loop?
- Poor understanding of automation: Do flight crews now fly or merely monitor? If they monitor, humans are notoriously bad at monitoring. Are we therefore doing the right thing in tasking humans with monitoring systems? Knowing when to take manual control of automated systems and when to leave the automation to run itself is key. Eg. Doing nothing can be good but only if you know *when* to do nothing (thus giving you better control of the process) (Amalberti, 2013).

The single over-arching theme that appears to emerge from internal and external factors is that of safety culture.

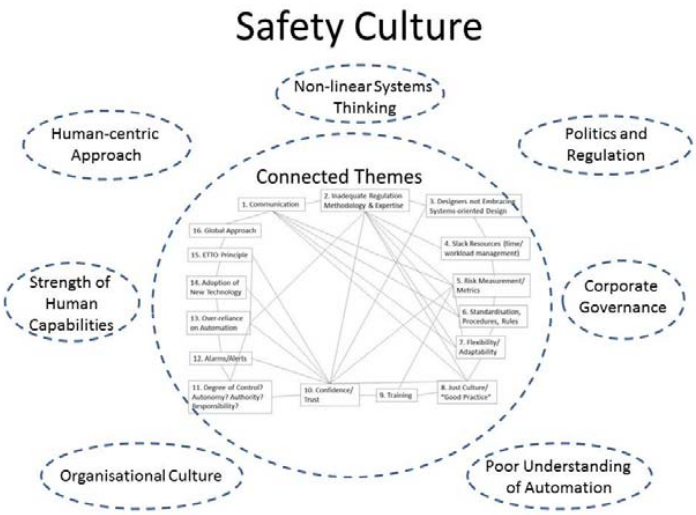

Fig 4. Connected themes appear to be influenced by pervasive external themes within the organisational environment; the over-arching theme seems to be safety culture.

6 Conclusion

The aim of this study is to provide a critical reflection of the findings that emerged from the CAA/NATS workshop conducted in February 2014. The study uses Grounded Theory (GT) to interpret the characteristics of the data gathered at the workshop by describing, categorising and applying theoretical foundations to it (creating themes and sub-categories with dimensions).

The web of connected themes in Figure 1 constitutes the articulated views and perspectives of the stakeholders interviewed in the February 2014 workshop. These themes are compared with those gathered from previous workshops (Amaldi & Smoker, 2012). As in shown in Figures 2 and 3, these themes overlap with those from the 2014 workshop. The study also considers a number of themes which are not articulated in the workshop discussions but which pervade organisational culture and behaviour. Safety culture appears to be the over-arching connection linking all these themes.

It is intended that the findings of the study will contribute to the theoretical and practical body of reference material that can be used by industry specialists (ie regulators) to understand safety attitudes at an organisational/ managerial level. Using these findings, current regulations will be tested for their suitability in future operating en-

vironments. It will also test whether any further requirements are needed both nationally and on a global scale.

Furthermore, this study aims to lay the foundations for an automation survey to assess measure stakeholder attitudes at an *organisational* level - automation surveys have historically mostly been limited to the level of human-machine interaction at an individual (operator) level. The study will seek to provide guidance material to help create, design and deploy systems for safe and effective operation, while recognising business drivers for the industry as a whole. The focus of the study is ultimately on the interactive processes between technology and humans within and across domains.

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Systems Design of a Virtual Learning Environment to Teach Space Syntax: Seeing from the User's Perspective

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Abstract. Space syntax is an important knowledge domain and focus of study for students of Architecture. It centers on the understanding of spaces, tectonics and volumes for the informed design of buildings or outdoor spaces. Space syntax is considered to be a threshold concept in Architecture, in that understanding and interpreting this knowledge domain is something that the learner needs to acquire in order to progress as a professional in this field. The concept of "line of sight" is a specific example of a concept in the space syntax domain. This research investigates a case of systems design of a virtual learning environment to support teaching a concept of space syntax to students of Architecture. The applications of virtual worlds as virtual learning environments are increasingly applied in workplace learning. Virtual worlds can engage, immerse and guide learners in ways not yet undertaken and may find application in workplace learning. This research explores the systems design requirements through the design a demonstrator that is tested by a small pilot group. One case scenario to teach the concept of "line of sight" was selected for the target design. Based on the expert feedback we designed a learning module demonstrated at the University College London CAVE-hybrid facility. This "demonstrator" was trailed in 16 timed trials. Several conclusions for workplace learning on the systems design choices are drawn.

Keywords: virtual learning environments, space syntax, threshold concepts, systems design, experiential learning, virtual worlds.

1 Introduction

Information Systems (IS) designers have often made analogies between the design of information systems and the design of buildings, saying that IS design is like building design in that, "Architecture, design, construction, furnishings, inhabitants, and location all play major roles in shaping the overall experience" [1]. It is not surprising

then that "consideration of the end users first person perspective" would be an important approach to teaching of concepts in Architecture. And we as systems designers of Virtual Learning Environments (VLE) would seek to discover and include these requirements in the design of VLE learning module for students of Architecture. In this paper, we describe our approach of systems design of a VLE "demonstrator". We report on the trials of the demonstrator and discuss the implications that such tools support reflective learning approaches and can be suitable for students at different stages of their careers. This paper explores: What are the systems design requirements for the design of VLEs to support learning of the threshold concept of "line of sight" in the knowledge domain of space syntax?

The remaining paper is presented as follows. In the next section, we clarify meaning of threshold concepts and the role of virtual technologies in practical experiential learning, and we present prior research in these domains. In Section 3, we give a description of our methodology for this project describing the systems design approach for the demonstrator. In Section 4, we describe our trials and observations. Section 5 discusses implications for VLE design. Section 6 gives concluding remarks.

2 Literature Review

In recent years, virtual reality (VR) technologies have been applied in teaching and learning. The main motivations for their use have been that VLE based on VR technologies are engaging as media [2] and that use of 3D media facilitates comprehension by means of situating learning materials in a context and exploiting the natural capabilities of humans to interact in 3D space [3]. In particular they investigated user interaction in immersive VR environments and found that the use of virtual content successfully changed the users' conceptual understanding of the content [3]. A key characteristic that motivates the use of VR in training is that participants behave in a way that is similar to their behavior in comparably similar real situations [4, 5]. These studies distinguish immersive 3D VR from desktop VR in that in the immersive 3D VLE the participant acts, to a great extent, as they would in the real physical world. In desktop VR, this level of immersion is limited by the form and structure of the interface. General studies of the capabilities of immersive 3D VR systems on comprehension have shown that these systems are preferred for tasks that are exploratory and interactive [6-8]. One study identifies that for constrained tasks that features of immersive VR are contributing to performance differences [9]. However, these studies are limited in that they have not provided requirements analysis that can predict tasks for which immersive VR environments are superior over desktop approaches.

Recent pedagogic approaches have emphasized the importance of real life experience such as in the workplace, for transforming learning objectives into knowledge that can be applied in practice. Approaches, such as experiential learning and problem-based learning in classrooms, while having correct objectives, often fall short of supports for the transformative process necessary for the learner to capture core concepts within the targeted discipline. This problem with traditional textbook based 2D exercises was noted by Architecture teachers, and is discussed in the next section.

The core concepts referred to here are identified as "threshold concepts". Erik Meyer and Ray Land state, “A threshold concept can be considered as akin to a portal, opening up a new and previously inaccessible way of thinking about something. It represents a transformed way of understanding, interpreting, or viewing something without which the learner cannot progress” [10]. They state further that threshold concepts are central "core" concepts within a discipline that are essential in the acquisition of creative thinking, learning and communication of understanding within a discipline [10-13]. There is a documented lack of support for threshold experiences in higher education [14]. However, recent research has explored and identified conceptual requirements for systems design for teaching threshold concepts with the support of VR technologies [15]. This study extends the research of [15] in that it designs and pilot tests a demonstrator of a VLE that aims to support an exploratory and interactive learning task for Architecture students. The demonstrator is designed with use of immersive VR technologies that are described in the next section on methodology.

3 Methodology

This research applies the general steps of Design Science Research (DSR) as an approach to design the "demonstrator" artifact that is a learning module implemented in a VLE. We selected DSR as recent studies for developing user innovation in virtual worlds shows that DSR can be used as problem solving process to develop IS artifacts [16-18]. Through a cyclical process of design of the learning module, a better understanding of the users experience and design requirements are obtained. The general steps of DSR are: problem awareness, suggestion, development, evaluation and conclusion. At each stage of development, evaluation and conclusion, knowledge is gained and fed back into problem awareness, thus influencing suggestions for further improvements. The DSR approach was useful in that it allowed us the designers of the VLE, to study how a trial group learned. We conducted the following steps:

1. *Problem Awareness*: Through interviews with experts in the selected field of learning, Architecture, we recognize difficulties with traditional learning methods.
2. *Suggestion*: The knowledge gained from the interviews and designers knowledge of VLE technologies influence the initial development of the learning module.
3. *Development*: The learning modules are implemented using two software implementations to allow control for the influence of the software interfaces on the trials.
4. *Evaluation*: The demonstrators are evaluated by general users in timed trials.
5. *Conclusion*: The designers draw conclusions based on the observations of the trials
6. *Cycle-2*: Further cycles are suggested with use of several trial groups of Architecture students at different points in their progression of study.

3.1 Problem Awareness and Suggestion

In September 2013, the researchers conducted interviews with Architecture experts Dr. Sean Hanna (SH, Space and Adaptive Architectures, UCL) and Dr. Sam Griffiths

(SG, Urban Morphology and Theory, UCL). The information from these interviews was used to inform the learning module that would be implemented in the VLE. Some of the statements of the interviews are summarized as follows:

- SH: "Space syntax" is a long threshold concept. This is a very broad theme, and the knowledge domain for a master's level program. SH says that students that have mastered the concepts of space syntax make different assessments and decisions as applied to architectural designs. This has been tested in students' responses to school assignments and even in master's thesis.
- SH: Issues such as "lines of sight", "where people are likely to move, gather around objects, meet others", are related to understanding of space syntax.
- SH: The way that students think about "spaces, tectonics, and volumes" are part of a long threshold in Architecture. Students that know about design space syntax are more likely to use those concepts in design decisions.
- SG: Points out that there are some students who you can see that "get it" and that these are distinguishable from those who may struggle with the tools and models. While understanding the tools and models, these can give very delineated responses to questions. However, the questions are sometimes complex and do not have simple responses.
- SG: Most of the tools and visual presentations of their work are done in 2D. The use of 3D tools in itself offers another perspective that can be helpful in learning.

We concluded at this stage to develop a module that would function in a CAVE, as described in the next section. A simulation in the CAVE that provides a real-time feedback would help in the student's integrated analysis.

3.2 Development Components of the Immersive 3D VLE

The platform applied in this research made use of Cave Automatic Virtual Environment (CAVE) an immersive projection technology [19]. A CAVE is typically a cube-shaped display that the user stands inside. The CAVE surrounds the user, thus excluding other distractions and allowing the participant to move about un-constrained by the need to face a specific desktop display. The wide field of view allows natural peripheral observation and gaze control.

More specifically, this research was conducted as part of a visiting scholar research project (see acknowledgements) in cooperation with the Virtual Environments and Computer Group (VECG) of the CS Dept. at University College London. The project applied VECG group computers and immersive visualization facilities. The VECG group of the Department of Computer Science (UCL-CS) has excellent visualization facilities including a four-sided CAVE-hybrid driven by a PC cluster (four client nodes with GeForce Quadro 5600 graphics), a six-camera Vicon motion-tracking system, an eight camera Optitrak system, an Intersense wireless tracking system, head-mounted VR and augmented reality displays, a GRAB haptic interface and various other tracking systems and input devices including bio-signal amplifiers.

This research applied two virtual world technologies that are normally accessed through desktop interfaces. However, the learning modules were instantiated (brought

up) in the CAVE. These VW technologies were vAcademia™ (vA), a virtual world software that was created especially for educational purposes [20], and Second Life™ (SL) a general purpose virtual world software that has been widely adopted also for non-educational purposes. The implications for this study were that the researchers had access to more server side hooks for vA when bringing up simulations in the CAVE. With use of two VW technologies we also control for some behavior differences that can be due to perspectives afforded by the different interfaces.

3.3 Demonstrator Design

In the next phase of the project, we developed a learning module that is based on a prior design of Kalff et al. [21]. The demonstrator activity is shopping for items in a food store. In our scenario, the participant is to look for and identify three items on the shelves in a food store. Our model has eight shelves. There are two perspectives of the shelves and in the VLE models and both perspectives are replicated in SL and vA. That is we have made two separate builds for each perspective. The perspectives are with shelves pointing towards the participant ("plus" or A) and with shelves pointing away from the participant ("minus", B).

The 2D overhead view of the learning scenario is depicted below (Fig. 1, left). A person would stand at point A or B. In general, the perspective of B should result in faster times for participants to locate and identify items in the food store. This would be a typical "line of sight" exercise for a new student in Architecture.

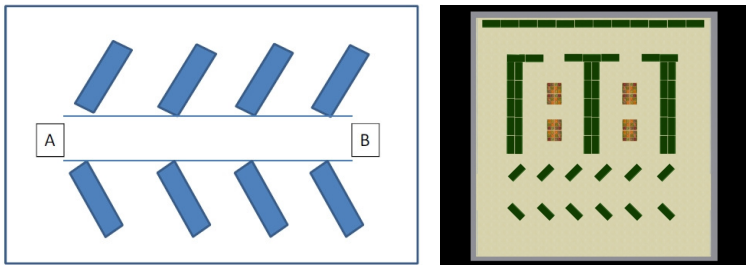

Fig. 1. The Learning Scenario in a VLE (left) and a 2D layout of a food store (right)

For a participant to look at the 2D representation above, it can be difficult to visualize which perspective is more effective. With the help of a 3D representation the "better" design could be more easily identified. Applying the 3D representation would be seeing from the end user's perspective, that is, the shopper's perspective. A more experienced Architecture student might be given more delineated tasks. For example, they might be asked to determine the best angle of the shelves. This was not asked in these trials.

4 Trials and Observations

We conducted trials of the learning module with five volunteer participants, using a Think-aloud protocol [22] to gather data. Participants were asked to talk about what they were doing while active in the trials. The trials were video recorded to not interfere with the participants while they completed their tasks. All had prior experience with virtual environments. They gave verbal consent for use of video recording of their trials. We first showed them a 2D diagram of a food store (Fig. 1, right) and asked which perspective would be their preferred starting point (A or B). Although everyone did choose B, most of the responders were hesitant and unsure. We then had the participants try out the module in SL (Fig. 2) and in vA (Fig. 3).

Fig. 2. Trials in SL: Plus perspective – A point (left) and Minus perspective – B point (right)

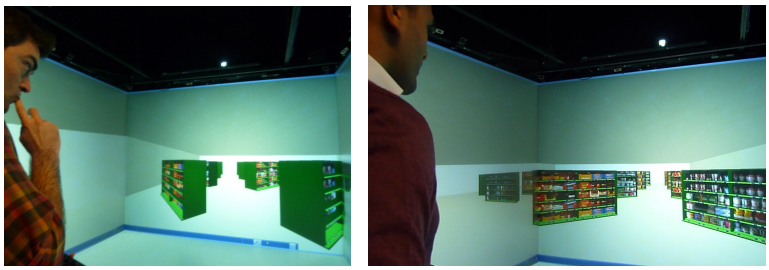

Fig. 3. Trials in vA: Plus perspective – A point (left) and Minus perspective – B point (right)

Of the five participants, all five trialed the module in vA and three in SL (Table 1). In all trials the "identification" times, used as an objective metric of the users' effort for location of three items in the food store, were faster for perspective B, even when the items sought after were made different across trials. This trend was consistent across both VLE platforms.

As an affective measure of participants' feelings of the learning experience we asked after the trials if they had any comments about the two perspectives. All responded that it was immediately obvious that B was "easier" or "better" that "I can see

everything in B, but in the other (A) my view is blocked". Some noted that it was also a more pleasant shopping experience with B, as it was so hard to move around in the VLE and with B they did not have to move the avatar so much. Many commented that in real life grocery stores, that store owners want you to walk around, and maybe wanted customers to not find items so quickly. Some participants of the exercise noted that items were easier to see/identify items in vA than in SL. We attribute this to the fact that first person perspective functioned in the vA trials, giving better level of view. And, only third person perspective functioned in SL in the CAVE. However, some commented that it was easier to move around in SL. In both VLE the user controlled the movement of the avatar using a keyboard. The model in vA had shelves inside a four-walled store; while alternatively, the model in SL had shelves on an open plane. So the reason for some longer times in vA may have been the presence of the walls, as sometimes the users' camera view was obstructed when standing too close to the walls. While the number of trials is too few to make performance comparisons of the 2 VLEs, future designs could be created in open spaces to avoid confusions caused by misaligned camera views.

Table 1. Trial Times according to VLE and Perspective

VLE	Perspective	Items to Find	User (U); Trial (T)=Time to locate the item
SL	**A**	• Orange Juice, Tooth paste, Milk • Pasta, Tooth paste, Olives • Tomatoes, Tomato sauce, Yoghurt	U3;T365=1min 42sec U4;T384=0min 50sec U5;T387=1min 15sec
SL	**B**	• Yoghurt, Pasta, Olives • Milk, Cabbage, Lunch Meat • Milk, Cabbage, Pasta	U3;T366=0min 30sec U4;T383=0min 35sec U5;T388=0min 33sec
vA	**A**	• Orange Juice, Tooth paste, Crisps	U1;T351=1min 50sec U2;T354=2min 30sec U3;T369=1min 20sec U4;T374=2min 15sec U5;T378=1min 00sec
vA	**B**	• Yoghurt, Pasta, Olives	U1;T353=0min 30sec U2;T357=0min 50sec U3;T373=0min 26sec U4;T375=0min 42sec U5;T379=0min 35sec

5 Implications for VLE Systems Design

This study gives evidence that VLE hold potential to support of learning of threshold concepts through experiential learning approach. A demonstrator of one threshold learning scenario was implemented and trialed in the CAVE using two VLE platforms. We conclude that several design factors can contribute to better workplace learning environments that support experiential reflective learning. These are:

1. First person view is important for achieving realistic lines of vision/sight (Fig. 1). The use of third person view in SL places the user above the scene (Fig. 3). In addition, as one user pointed out, it is harder to get closer (next to) the shelves in third person view, and so it is more difficult to see and identify the items.
2. Choices of interface tools are important. Several commented a joystick would have enabled easier movement as opposed to the application of keyboard for movement. The choice of "easier movement" would represent more accurately the real life ease of walking around in a food store.
3. The food items on the shelves in the store models were placed with no specific logic next to each other. For example, refrigerated items (e.g., orange juice) could be on shelf next to dry storage items (e.g., toothpaste). In addition, the color of the shelves were green, indicating dry storage space, and this did not make sense to one participant that was looking for orange juice in a cold refrigeration unit that should be white. Obliviously, the placement of items in the model is not how the items would be located in stores in real life.
4. The model should be built to the right scale. The same task is performed differently using the VLEs in the CAVE and through PC desktop interface. For example, the shelves might appear too large or the avatar might be higher than the participant.

In brief, during trials the participants could not rely on internalized experience models of normal layouts of food stores. While done purposely for this exercise, course designers and VLE designers might consider multiple layouts when testing learning outcomes. When using a PC desktop interface, the user often uses a third person view to find items. As such, the scales of objects (items and shelves) are often made larger in respect to the avatar than they would be in real life. This is because the designer of the module that is to be viewed on the desktop would like objects to fill more screen space. However, in design for the learning module for the immersive 3D CAVE environment, if the participant is using first person view, the size of the objects should be on a 1:1 scale with the avatar. That is the shelf height should be designed as in real life, 2–2.5 meters for a 1.6–2 meter tall person. The reason for doing this is, if a shelf height of a three meters is used, the top of the shelf could not be viewed in first person view mode in the CAVE, unless the avatar would take a step away from the object.

6 Concluding Remarks

In summary, this paper explored the systems design requirements for the design of VLE for teaching an architectural threshold concept of "line of sight" within the knowledge domain of space syntax. Our research used a DSR approach to design a demonstrator that contributes to a proof-of-concept that that VLE can be applied to support learning of a threshold concept. This was demonstrated in two different VLE. We described the implementation and analysis of a demonstrator of a threshold learning scenario in the CAVE and assessed the system elements that would support that environment. We identified some basic factors about the software and hardware components that need to be considered in VLE design to be more supportive of a workplace learning environment. Last, we created a testing environment that can be repli-

cated, modified and applied in future research projects. For further DSR cycles of the VLE design, we recommend testing of the modules with Architect students at various stages of their career including those with workplace experience. Educators could also change tasks and apply different assessment methods. Future changes to this design should explore the question: can the VLE be a learning aid for those who already "get it". That is, more experienced professionals may already comprehend the threshold concept, but may struggle with it in different contexts.

Finally, we think the DSR approach may be applied to the design of other VLE scenarios for workplace training and for teaching threshold concepts in other knowledge domains. For example, possible scenarios could include re-training for new equipment or settings in industry, continuous training in medicine, and threat detection in emergency management. In such a case, VLEs can be used as tools for vocational training. Creating more learning scenarios and trialing these with expanded target groups is a natural next step.

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Co-Design of a Cloud of Services for Archaeological Practice

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Abstract. This paper presents an overview of the results of a multidisciplinary collaboration between several domain experts in the frame of archaeological projects. Since 2001, different independent interactive systems have been co-designed, developed, and tested on the field. The adoption of a semiotic approach to a participatory action design research process with the involvement of domain experts led us to a better understanding of the main characteristics but also the challenges of the archaeological practice and helped us to apply technology in a better and efficient way. The currently undergoing work is focused on the co-design of a cloud of services able at integrating all the tools into a bigger framework to support the archaeological practice in a more pervasive way.

Keywords: Digital humanities, archaeology, cloud of services, domain experts, co-design, interdisciplinary teams, HWID, participatory action design research.

1 Introduction

Nowadays, the reconstruction of a historical and cultural context in Archaeology is a very complex activity where the collaboration among several scientists from different domains (e.g. geography, geology, architecture, chemistry, anthropology) is needed. Current interdisciplinary researches in Archaeology aim at designing innovative solutions supporting the study and reconstruction of the historical and cultural context of excavation sites. In this field, many technologies have been developed to collect information from an archaeological site or to generate very precise stratigraphic representa-

tions, 3D models, GIS, orthophotos, Digital Terrain Models of any archaeological context. Even if, the use of these technologies is widely adopted in different excavation contexts, one of the main time-consuming activity is the constantly look up for relationships among the archaeological evidences, geographical, architectonic, and anthropological data found in excavation sites. Archaeologists find themselves overwhelmed by different documentation representing the archaeological context from different points of view: landscapes, stratigraphic layers, and artefacts - e.g. mobile findings (organic and inorganic) and architectonic structures.

To build a comprehensive knowledge on such mole of data and to integrate the information that stems from it is nearly impossible without the support of technology.

Another important issue is that contents and structure of domain experts' knowledge is highly dependent on professional or individual practice and this makes the collaboration among the stakeholders even harder and critical.

In the last 14 years, the two departments of Computer Science and Cultural Heritage and Environment of Università degli Studi di Milano (in particular with Giovanna Bagnasco Gianni, Director of the excavation site of Tarquinia) and the Department of Architecture and Urban Studies of Politecnico di Milano actively collaborated to develop tools and methods for supporting the archaeological practice in a very pervasive way: on the field (excavation site), in warehouse for data storage and catalog operations, and during the study and collaborative analysis time (back at the University). This collaboration has led all the participants to developer higher awareness of the potentials and challenges that such an interdisciplinary research field may encounter.

The sites of the Etruscan cities of Tarquinia and Cetamura are the benchmark of an all-comprehensive investigation upon which multiple disciplinary areas applied to archaeology are converging, such as geology and natural science, archaeometry, architecture and computer science. Thanks to this cooperation, the data capture about the history of Tarquinia and Cetamura, in the field of Etruscan study in general, is significant and recognized at an international level. Through a long lasting cooperation with Computer Science experts, in the frame of the "Tarquinia Project" and the "IESP Project", a "free" approach meant to put scholars involved in the research team in the condition to handle data according to their own procedures within the same environment arises. So far, such an approach has been fruitfully applied to the relationship among structures, stratigraphic units, and mobile findings, but the entire topographic and large scale documentation has not been integrated yet. In Section 2 we present the semiotic approach adopted for the co-design that involved the domain experts in choosing the right interaction style and visual language for their interactive tools. Section 3 gives an overview of the archaeological practice and how technology is used for its activity. The tools developed so far in these years are briefly presented in Section 4, while Section 5 presents the currently ongoing work focused on the creation of a cloud of services for integrating all the interactive tools that the research team has co-designed so far.

2 Semiotic Approach to Co-Design with Domain Experts

The complexity and the expanding scale of most collaborative projects that take place in these years require more comprehensive knowledge than any single domain expert can possess. Experts in different disciplines have to share their specialized knowledge, skills and practices in order to work collaboratively and reach common goals. The design of a common knowledge management system to support such collaboration needs to balance different requirements. On the one hand, the information and data need to be organized according to common, generic schemes or ontologies in order to allow the sharing of data and results. On the other hand, different domain experts need to have access to content structured in a way that fit their specific interest and professional practice and expectations. It is however challenging to be able to catch the right way to structure the content has to be organized. However, these structures are often not explicated, since they are tacit knowledge, which users possess and use to perform tasks and to solve problems, yet they are unable to express verbally and might even be unaware of. The domain experts perform their activities, take their decisions, read and create documents using implicit information, articulatory skills and tacit understanding, which derive from their individual and professional experience and practice. These factors result in determining what Nardi and Engeström [21] called invisible work. Implicit information -- e.g., information embedded in spatial displacement, physical appearance of the text, and graphical elements in a document -- is often significant only to users who possess the right knowledge to interpret it. Practitioners are often more able to act in a specific way rather than to explain how and why they act so [28]. Therefore, experts or domain experts from different technical and scientific communities, often face cultural clashes and communication gaps [30, 32] due to their different perspectives and different ways of reasoning and working. Our research work contributes to resolving these contradictory requirements. It addresses the question of how to conceptualize and design knowledge management systems supporting collaboration across multiple heterogeneous domains and at the same time providing each domain with specific tools and structures. The interfaces to the shared knowledge base are designed as flexible so that they can be tailored to fit into different domain experts' practices. To this end, processes of representation, storage, access and transfer of knowledge are explored through a semiotic approach. A knowledge management design strategy for mapping and translating domain experts' understanding into domain specific interfaces is presented. Since our approach is framed in computer semiotics [31], user interfaces are studied as compositions of graphic elements that are related by their users to their expertise, their reasoning pattern and their work practices [8, 7]. The same interface can trigger different semioses and processes that lead to meaning production. When using an interactive system, a significant portion of the information conveyed by the system is implicit information [5], i.e. embedded in the actual shape of the elements displayed and in the visual organization of the overall user interface. Knowledge management systems need to materialize their contents as well as their structures in the interface in line with the professional practices they are designed to support. Also the navigation through the interface needs to fit with users' background e.g., using proper vocabularies and suitable navigation structure.

The study of the archaeological practice has been carried on for several months and repeated over time to validate the results. We adopted several techniques: ethnography (shadowing), multidisciplinary workshops, focus groups, structured/unstructured interviews and questionnaires, collaborative design of paper prototypes (e.g. CARDS, PICTIVE [20]), and End-User Development (EUD) [9, 18] applications for interfaces and systems design. This long-lasting (and currently still ongoing) study of the practice on the excavation sites and in the warehouses, of face-to-face discussions with the involvement of experts in various domains, and of the analysis phase, we gained a better understanding of the main peculiarities of archaeological practice, and understood the role that technology plays and how it is used.

3 Archaeological Practice and Technology

The data collection activity that archaeologists perform in their practice mainly follows two families of methods: non-intrusive and intrusive. Non-intrusive methods include the analysis of aerial photography for landscape alterations, use of ground-penetrating radar to find buried anomalies, and the systematic, controlled collection of materials from surface contexts. Intrusive methods include shovel testing (units 40 cm on a side), test units (1 or 2 meters on a side) or excavation blocks (anything larger than 2 meters on a side). Archaeologists analyze these remains to determine their original purpose and effective role within the overall context of a given site. In turn, the archaeologist attempts to understand cultural processes and behaviors, with the primary goal to interpret how and why cultures evolved over time. Several technological approaches can be adopted in order to support archaeologists in their analysis and interpretations. For example, mobile or Web applications can be used for collecting information from an archaeological site, while 3D recording, processing, and visualization technology can be adopted for helping in generating very precise three-dimensional models of any archaeological context, perfect replicas of how the soil layer looked like the exact moment before its removal and the position of artefacts and structures. At the same time, technology such as laser scanners, high-precision survey strategies or systems for managing orthophotos, Digital Terrain Models (DTM), geo-spatial information, and LiDAR data, represent new solutions for studying landscape and monuments from an archaeological, geological and architectonic point of view in order to reconstruct the territorial conformation and related elements. Of course, it is nearly impossible to keep track of every category of documentation produced during the fieldwork without the support of technological solutions and without taking into account that the content and structure of domain experts' knowledge is highly dependent on professional or individual practice. Although there is a growing use and demand for advanced technologies in archaeological resources management, there is still an inherent lack of innovative solutions and methodologies for documenting, combining and managing the vast data sets generated by these technologies and for presenting them to domain experts in effective ways. At the same time, no platforms are available so far for integrating all these data, fostering their dissemination between scholars and researchers through a correct management of the cultural objects contained in the original sources.

To support the archaeological practice and especially the research in this domain there is the need of a cloud of tools and services able to integrate archaeological data, artefacts and architectural structures (subsoil and over-ground), cartographic and photographic documentation, and scientific contents - both achieved in the past and implemented during the field research.

In these years, we co-designed and developed tools for responding to the main needs that arise during all the phases of archaeological (interdisciplinary) work. All the tools are developed as perpetual-beta software products: continuously evolved and updated. So far, the services are not yet completely integrated and we are currently working on this, as will be explained in Section 5.

The semiotic approach we applied to the archaeological domain allowed us to follow a participatory action design research [34] addressing five main stages: the analysis of the domain with the open problems identifications; the detection of opportunities and open challenges to be addressed with a participatory approach; the actual design with the use of prototypes and recurrent usability evaluations; the measurement of impact evaluation with the active involvement of the archaeologists on the field and the generalization of the outcomes in a model that reflects the expertise we developed in this field [35].

The archaeological application domain is characterized by strong social and organizational factors and the successful introduction of interactive systems designed according to our semiotic model has proved that once more the validity of the Human Work Interaction Design framework [36] that considers the strong influence of environment and context. Collaboration in taking decisions on the design and in analyzing activities and tasks resulted fundamental for the good results we reached so far.

4 The Tools

The tools we co-designed and developed so far can be categorized according to the archaeological activity that they are meant to support. We identified several of these categories that are described in what follows.

4.1 Excavations' Data Archive Activity

In archeological knowledge creation and dissemination the information overload plays one of the most critical roles. The large quantity of digital material generated by each team (archaeologists, architects, geologists, chemists) is incomplete, inconsistent and often hard to access. Moreover, very often, the teams are geographically distributed and the communication among all the stakeholders becomes challenging. As a possible solution to these problems, we identified a strategy based on a holistic approach for knowledge representation, designed according to widely held community understanding.

We designed and developed an application called "Tarchna DB" (See Fig. 1) that is meant to collect the categories of evidences predetermined by the archaeologists in order to classify the multifaceted aspects of the findings that are almost always fragmen-

tary (e.g., architectural structures, layers of ground, pottery, different kinds of equipment) [10]. Several problems arise from the integration of different archives, and one of the most important issues is the need of establishing a common knowledge representation to be used to exchange data among all the stakeholders involved in the collaboration. Specifically, our model allows to organize archeological data in a way that is more natural for archaeologists to use. It relies on an ontology (i.e., "a description of the concepts and relationships that can exist for an agent or community of agents" [11, 12]) organized into two levels, and on specialized services for managing it. The top level of the ontology presents a view that is suitable for non-computer experts while the bottom level is suitable for interacting with the computing infrastructure. The top-level ontology exploits the concept of a standard ontology of cultural heritage (CIDOC-CRM [6]) for producing a representation of concepts and relationships suitable for archaeologists. The information core also supports the ability to perform information retrieval and to browse the existing knowledge. This approach uses the knowledge base as a semantic access point to the information that can then be retrieved from databases federated by means of the ontology schema. The knowledge representation model at the base of our framework uses an ontological schema, representing a specific cultural context, as a semantic access point to different types of data sources using suitable mapping strategies.

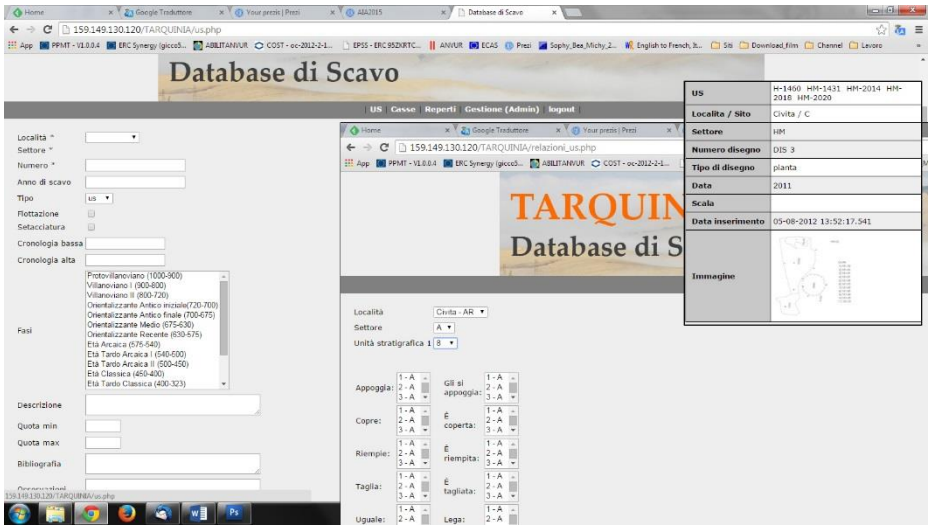

Fig. 1. Tarchna DB system is used for archiving all archaeological data resulting from the excavation campaigns in Tarquinia.

4.2 Stratigraphic analysis

Beyond archiving, managing and studying the findings collected during archaeological excavations there is a wide research area that is focused on information visualization.

The way in which the information is represented can deeply impact how it is understood and used [15].

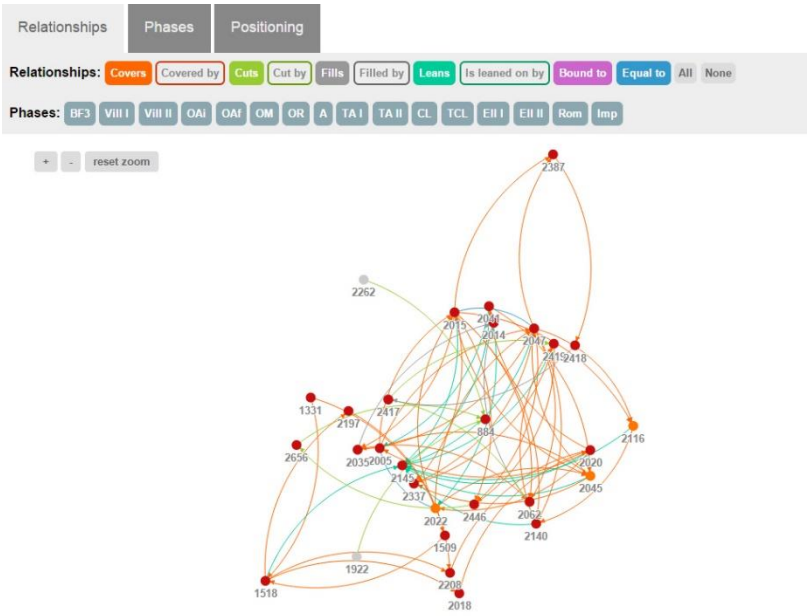

Fig. 2. A screenshot of ArchMatrix system. The nodes in the graph represent the stratigraphic units while the edges are the relationships that exist between the nodes. The color of an edge depends on the type of relationship that it represents.

In particular, in archaeology graph visualization systems can face the problem of facilitating the exploration and analysis of a vast amount of data by means of visual methods and tools able to support needs of a wide range of different research communities involved in the study of an excavation such as archaeologists, architects, geologists, chemists, and biologists. Information visualization strategies are applied for assisting domain experts in the examination and interpretation of the stratigraphy of excavation sites, and identifying both natural and cultural strata. The British archaeologist Edward Cecil Harris in 1973 invented the Harris Matrix that is used to provide a means to view stratigraphic sequences in diagram form [14]. Our work aims to define an innovative visualization tools named ArchMatrix [4, 33] able to efficiently store and manage excavation site knowledge so that the data may be visualized and queried in a graph-based environment, and to offer a visual representation of archaeological assets and their relationships in order to support intuitive and useful explorations. To support real-world knowledge construction and decision making by means of a Harris Matrix, the most important challenge was the design of a visualization system able to meet real needs of domain experts in handling contents and structures that fit their domain-specific interests and practices. In this context, the paradigm of the map as a support for knowledge organization has been used. This is based on the principle that maps can also be used

to spatially represent knowledge about systems and subjects. In fact, the Harris Matrix system uses a map-based representation to show the stratigraphic units, the relationships between them and other related information. ArchMatrix is implemented as a Web application which uses a graph visualization as tool for knowledge assessment. Through a Harris Matrix and its nodes, relationships and conceptual structure, ArchMatrix offers a solution for collaborative managing shared knowledge among experts of different domains. A screenshot of ArchMatrix is given in Fig. 2.

4.3 3D Reconstruction of Tombs

A virtual reality simulation of the Etruscan Necropolis of Tarquinia (UNESCO site since 2004) has been designed and realized to support archaeological analysis [24]. The site is an outstanding testimonial of the Etruscan culture, in which so far more than 6200 tombs carved in the rock were discovered. Among them, around 140 are extraordinarily painted, and many hundreds more present traces of paintings [19]. The earliest tomb dates from the 7th century B.C.. Most of them are constituted by a room only, while others are more articulated. Currently, 64 tombs are accessible: some of them are protected by glass and always visible, some others are open for visits in rotation, whereas many others are kept closed. Most of the painted tombs were discovered in the second half of 19th century. Across the centuries, many paintings were detached from the walls and then lost or destroyed, while others are currently not visible due to the fading of the original colors. In these cases, our knowledge of those paintings is mainly based on descriptions and paintings made by artists and scholars in 17th, 18th, and 19th centuries. Cultural Heritage experts rely in a relevant way on digital images acquired inside the tombs: natural light is not present (or it is limited to some parts of a small number of tombs whose entrances are adequately oriented), while artificial light is often not adequate to achieve a full and detailed observation of the full painted walls. Therefore, many samples of each area that compose the inner parts of the tombs are collected through several accurate sessions of photographic acquisition. The images are then processed to enhance details, merged using adequate techniques in order to allow an ensemble analysis of the painted walls, and eventually stored in a multimedia database for supplemental studies and for dissemination.

3D models allow to investigate the morphology of the architecture in its completeness and to analyze all the parts of the architecture in detail and as a whole. The VR reconstruction of the Necropolis is based on a modular approach, in order to handle a site composed by a large number of independent tombs. The 3D visualization of the tombs is based on a first-person point of view approach, and the users can rotate their view and eventually move inside the environments. Moreover, we have introduced the possibility to visualize the already mentioned drawings and paintings as superimposed on the original walls (See Fig. 3).

Fig. 3. A screenshot of the reconstruction of a tumb with a painting superimposed on the original wall.

4.4 Geographic Analysis

A LiDAR [26] (Light Detection and Ranging) survey, by means of an aerial recognition, has been carried out in the area of the Civita of Tarquinia in 2010 (see Fig. 4). The application of laser scanning and LiDAR technology in an archaeological environment has rapidly established abroad and recently in Italy.

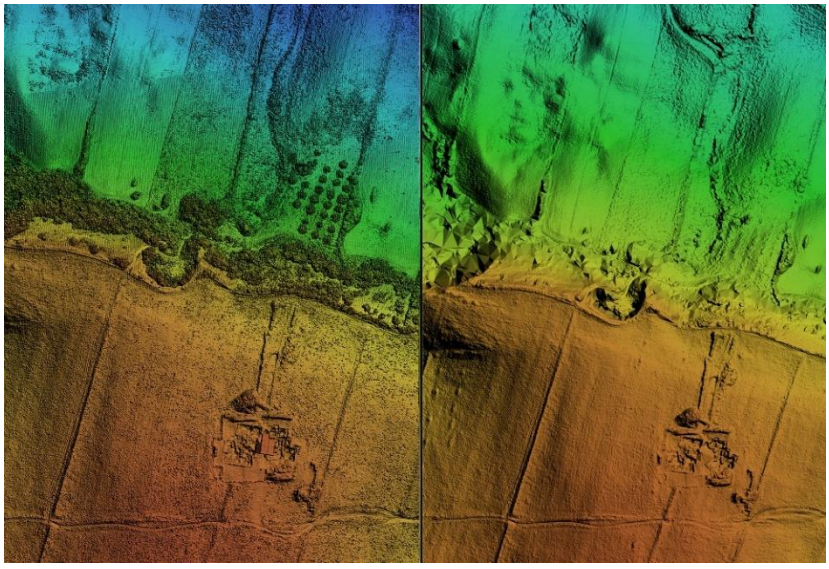

Fig. 4. A LIDAR 3D reconstruction example.

The first output of the aerial survey appears as a dense cloud of points (defined by planimetric coordinates, elevations, intensity, number of returns and other parameters) arranged along the scanning pattern of the instrument. From such raw data it is possible to reconstruct the territorial conformation and the related elements (vegetation, ground,

structures, etc…). Subsequent digital processing produces different elaborations: Digital Elevation Model (DEM), Digital Terrain Model (DTM), high-resolution orthophotos, and elaborations on the basis of intensity and number of returns. These elaborations are inserted in a Geographical Information System to catalog and to systematize the existing documentation about historical cartography and scientific and literary information, in order to grasp persistence and consistence of meaningful traces of the ancient territorial occupation. Therefore an exhaustive georeferenced documentation, gathered in a diachronic and synchronic atlas endowed with each punctual or areal data, is available in order to compare and contrast the palimpsest of settlement. After the analysis, through the use of metric models previously created, a 2D-3D cartographic archive is improved to permit the geo-referenced localization of every data set on the territory, giving the possibility to interface information through a shared platform. Such work results useful tools to identify and analyze settlements and to assess cause-effect relationship between their architectural and urbanistic features and the terrain morphology. The GIS cartographic database, with all its interfaces (geological, historical, archaeological), makes it possible to read permanent signs and assess the land use in historical cartography.

4.5 Non-Verbal Markings Collaborative Decipherment

In the frame of IESP (International Etruscan Sigla) Project, we co-designed and developed a system aimed at supporting the collaborative decipherment of Etruscan sigla (non-verbal markings) found on objects discovered in different digging sites distributed in the Mediterranean area. The project involved archaeologists from Università degli Studi di Milano and Florida State University, giving us the possibility of studying the two different approaches to archaeological practice, both in terms of methodology and terminology used. A screenshot of IESP system is given in Fig. 5.

Unlike what happens in deciphering verbal languages, in the case of non-verbal signs it is possible to study their elements from a graphical point of view and to apply similarity techniques to support the human interpretation activity. As to Etruscan language, thousands of examples of non-verbal markings exist. Typically, they are referred to as graffiti, a term that is found to be inadequate. Instead, the Latin word siglum (pl. sigla) – corresponding to the Greek one sema (pl. semata) – should be used. Etruscan sigla, composed by one or more symbols, numbers or letters, are dated from around 700 BCE to the first century BCE. They are incised, painted or stamped on different types of objects; e.g., pottery weights, spindle whorls, sarcophagi, burial urns, roof tiles, architectural terracotta, boundary stones, stone walls, and a wide variety of artefacts in bronze (axes, fibulas, helmets, knives, razors, sickles). The contexts in which the objects have been found include cemeteries, sanctuaries, ports, artisans' quarters and habitations – all spheres of Etruscan life and afterlife. The study of Etruscan sigla is aimed at assessing the real consistency of archaeological indicators according to a deductive method that takes into account a dialectic comparison between the ideas of function and role [13, 2]. The function of an object could be in fact be deduced by its shape. On the other hand, the role of the same kind of object can be determined differently on the

basis of the conditions of their discovery and from the comparison of iconographic sources. This means that the meaning of sigla can change widely according to the context in which they have been discovered. An example is the case of V-shape siglum that can be interpreted as a number 5 or letter U. The same uncertainty exists in interpreting a siglum formed by a cross inscribed in a circle: it could mean the Greek letter theta or could be the graphic representation of a sacred space [1]. The experience we developed in the frame of IESP Project led to the design and development of an approach and its software implementation for:

- Analyzing cases of recurrent sigla as cultural indicators of non-verbal communication within their different archaeological contexts.
- Supporting questions about function and role in the field of sigla and according to a multifaceted perspective that takes into account archaeological data to a larger extent.

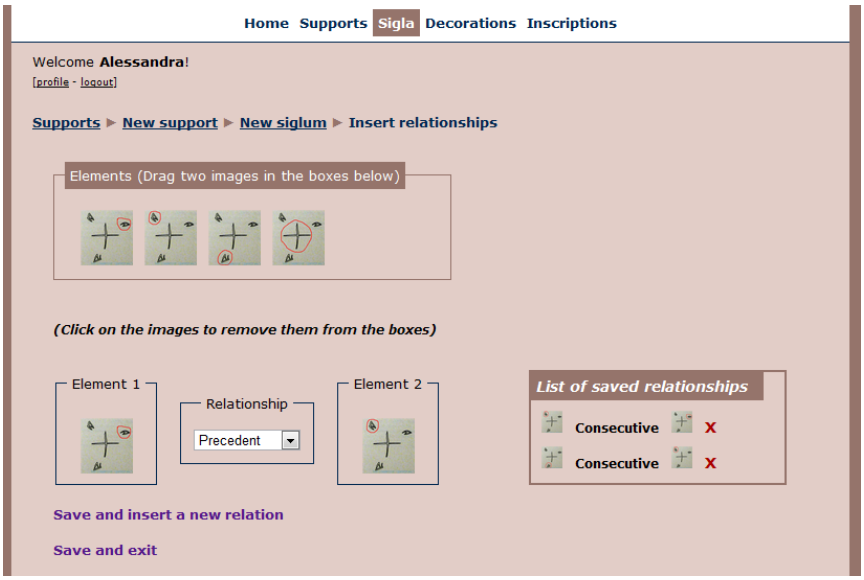

Fig. 5. The IESP System. The archaeologists, using the visual notation they usually adopt on paper, are able to identify relationships between different elements in the same siglum.

The main goal of the approach and the final system is to assess sigla with reference to their geographical range and chronology, to the nature of the objects and contexts to which they belong and to the layout of the graphic design. The enormous amount of data, the variety of the cultural background of archaeological experts involved the wide span of different hypotheses about the interpretation of each siglum type and their relationships led to the design of a tool that supports collaborative activities and dialectic comparisons. With 'collaborative' we mean that the involved people decide to work

together to reach a shared goal. In our case the goal is to interpret the meaning of non-verbal markings by means of the comparison of images, the sharing of descriptions, and the collaborative contribution by whole archaeologists' community.

5 Innovative SOA architecture for supporting archaeological research

The set of tools previously described have been developed thanks to the collaboration among computer scientists with archaeologists, architects and other domain experts of the Università degli Studi and Politecnico di Milano. Moreover, these tools have been tested in the archaeological sites of Tarquinia and Cetamura. Although we developed several tools, there is a growing demand for a comprehensive solution in archaeological resources management able to offer a multifaceted and flexible environment for supporting archaeologists' work during all phases of their activities of study.

Starting from these considerations, the our current activities aim at setting up a cloud platform on top of current public and private repositories (owned by University, cultural intuitions, museums or archaeological parks either open source, private or subjected to fee). The platform is conceived for extracting and integrating contents according to the researchers and scholars' needs, the specific quality criteria, and the sharing policies. Domain experts (archaeologists but also architects, chemists, geologists, anthropologists or others users) are the target of this cloud of service. They are put in the condition to search contents to be employed either for their personal studies or for supporting their interpretations and ideas in comparison with other colleagues. The idea is to exploit the metaphor of the "Cloud of Services" in order to provide a vision inspired from the Service Oriented Architecture paradigm where services are fully connected to the network and integrated with the cloud. Cloud computing can offer virtually unrestricted capabilities (e.g. storage and processing) to implement services and application that can exploit data and visualization strategies provided by the cloud of services in different archaeological contexts. The cloud essentially acts as a transparent layer between the services and applications providing flexibility, scalability and hiding the complexities between the two layers (services and applications). The final result is the development of an innovative authoring Web platform able to put together and combine part or all described services characterizing archaeological studies according to their heterogeneous expertise – geological, historical, anthropological, chemical, human and many others. Using an ontology-based discovery and integration mechanism, the challenge of this environment is to enable the combination of a cloud of services that can support analytical reasoning facilitated by interactive visual interfaces. The design of this ontology is based on our previous researches carried in the context of the T.Arc.H.N.A. Project. It will provide a global ontology specifically tailored for the archaeological context able to map concepts and contents available in each considered data source in order to establish a kind of "lingua franca" among the different services. The aim of this ontology is to offer a way for mapping services in an integrated manner with well-defined semantics. Through the use of this ontology, the platform will build on a Web-

mashups strategy able to integrate interactive components (widgets/gadgets), to represent the services coming from the cloud, to create new coherent and value-adding composite applications. In order to do it, this platform aims at developing a paradigm of End-User Development [3] that does not require programming skills, being the final users domain experts. Under this perspective, the platform is designed for supporting the domain experts in detecting, combining, visualizing and analysing data coming from different services and transforming the data into information, information into knowledge, and knowledge into wisdom. The basic idea aims at enabling domain experts for unwittingly developing personalized mashups according to specific needs.

5.1 Integrated Services for Archaeologists

This section aims at presenting our current efforts for providing archaeologists or cultural heritage experts with services able to support their studies and interpretations. These services are based on the tools described in Section 4 and are meant to address the following issues.

Wrapping service for many original data sources. This service is devoted to identify the kind and format of archaeological contents (but also other related data coming from architectonic, geographic, geological, historical archives) available in each repository. This service aims to provide data at three layers. The first layer offers an access to the (physical) objects held by the contributing organizations. These can be archaeological artefacts, archival documents, cartography, chemical/geological analysis or any other type of objects that are held by a cultural heritage or scientific organization. The second layer contains digital objects representing these physical objects. These can be photographs, scans, transcriptions, 3D models, videos, audio recordings or any other type of digital file that represents a physical object. There can be multiple digital objects relating to one physical object. In the third layer, the service provides descriptive metadata about the digital objects from its providers. This descriptive metadata contains only information about the digital and physical object and includes factual information such as titles, authors and dates as well as descriptions and relationships to other objects. The final output of this service will be a semantic representation of the data coming from the repository defined according to the ontology concepts created for effectively expressing the intrinsic characteristics of our specific archaeological context.

Map-based Spatio-Temporal Queries and Data-mining Strategies. This service, taking in input a set of data wrapping services combined by using the ontology-based integration mechanism, provides data-mining functionality for searching hidden patterns in collection of heterogeneous data and spatio-temporal queries. This service is designed around a set of classical data mining techniques such as: anomaly detection (outlier/change/deviation detection); association rule learning (dependency modelling); clustering; classification; regression and summarization. If one or more input services are devoted to provide cartographic data, this service will also offer map-based data visualization functionalities in order to exploit the temporal and spatial nature of the integrated data. Several studies and projects [23, 27] aim at studying some aspects of the design and implementation of map-based applications for managing, querying and

visualizing changing locations of moving objects. By exploiting these studies, this service aims at providing a map-based visualization through which carried out analysis and monitoring of trajectories of objects discovered in an excavation site. These trajectories can concern both documented movements that brought an object towards the place in which it was found, and later movements that brought it from the place was discovered to the place where it is preserved. This service will offer capabilities for specifying typical continuous queries (such as range, distance and nearest neighbour search) and visual display of objects' trajectories and collection of movement statistics. This service will be endowed with a location intelligence visualization strategy to identify patterns and trends by seeing and analysing data in a map view with spatial analysis tools such as thematic maps and spatial statistics. This location intelligence service will help to find data by using spatial relationships to filter relevant data. A temporal condition of this location intelligence service will be applied for providing spatio-temporal clusters, simulation and visualization, map animation and movement tracking.

Social Networks Service. The service aim at offering a set of functionalities for creating a social network of domain experts, scholars, students and researchers that will promote the creation of communities around the knowledge areas and will sup-port the peers in all the phases of the creation, revision, audit and publication of hypothesis, interpretations about how and why cultures evolved over time. Several roles will be established in the social network that will dynamically change, according to the level of participation to the network. This involvement will be stimulate through a set of serious game solutions in order to acquire points and obtain gifts and rewards of user's activities. Moreover, this social network service will be endowed with social computing techniques in order to study social network dynamics and to promote crowd-sourcing analysis that can lead to new and meaningful uses of data. Exploiting models such as: The pure probabilistic models [22], Exponential Random Graph Models [22, 2524, 29], and the Latent Space Models [17], the idea is to study social networking analysis techniques to capture social relationships among users in order to provide a user with suggestions based on preferences of other users according to their role in each community, their competencies, and their level of participation. In this way, in accessing the archaeological information, users will be guided by suggestions coming from other users taking into account that well-regarded members of the social network will have a higher influence in the whole process.

Analysis Support Service. By exploiting data wrapping services that contain stratigraphic information of excavation sites, this service is devised for supporting the domain experts in analyzing stratigraphy from a temporal and spatial point of view, by exploiting the ArchMatrix previously described. The service aims at providing researchers with a visual representation of the stratigraphic units highlighting geometric, topological and temporal relationships. Stratigraphic units are necessary to detect the relative chronological sequence of the entire excavation site but they also produce a number of supplemental data that are not included in the classic tool used for stratigraphic visualization. If one or more services able to retrieve data about landscapes, cartography, mobile findings and architectonic structures, are provided in input to this service, it can be used for exploiting the graph for defining queries and algorithms able

to explore stratigraphic units and combine them with the knowledge retrievable from the other excavation databases. Therefore, to support the complex and interdisciplinary decision-making activity at the base of the archaeologists' work, this service will allow archaeologists to develop new opportunities for their investigation (both individual and collaborative), to increase their knowledge, to improve their traditional working practices and to develop new ones.

6 Conclusions and Future Developments

To sum up, the aim of the presented services is to enable interdisciplinary researches able to support archaeological documentation, analysis and dissemination and able to provide an environment for supporting collaborative works. These researches aim at finding ways to push forward the boundaries of what semantic and social technologies and Archaeology can do together in order to define original means of communication for practitioners across this field.

In the archaeological literature, the concept of context as an association of objects which can be physical, spatial and/or temporal is specific to a long archaeological tradition. However, for the renowned French schools of anthropology as well as for Anglo-Saxon scholars [16], the concept of pure archaeological context has been supported by the importance of the cultural environment and social structures. Of course it is nearly impossible to follow such procedures for every category of documentation yielded by an archaeological project without the support of technological solutions and to carry out comparisons with other situations and contexts. Such procedures could be positively supported by adequate graphical environment in which combining different services that aim at helping the archaeologist to verify the validity of their interpretations and studies through sophisticated simulations of the archaeological evidence and data at different scale. The use of a cloud of services and the idea to combine them by using an ontology-based discovery and integration mechanism could be a useful solution. For example, data coming from distributed and heterogeneous databases, 3D reconstructions of archaeological materials and data-mining service could be integrated with landscapes and stratigraphic layers models allowing to combine the aforementioned activities in a unique context of analysis. In such a context, all experts involved in the process of analysis of the results and data from an archaeological project can effectively collaborate to define innovative interpretations and hypotheses. Therefore, the final aim of our current studies and development activities is addressed to explore new strategies for studying multidisciplinary knowledge by means of innovative authoring Web platform able to put together and combine part or all described services characterizing archaeological studies according to their heterogeneous expertise – geological, historical, anthropological, chemical, human, and many others. The platform will build on cutting-edge Rich Internet Application (RIA) and semantic technologies for providing domain experts with a user-centered Web application mashup platform.

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