Generative UX Research Process for Designing Professional Service Robotic Systems and Teleoperation Interfaces

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Abstract

The User Experience-driven Innovation (UXDI) framework emphasizes that successful product design, irrespective of organizational or personal systems, considers the user, context, and technology. In this paper, we outline a generative UX research process to study user needs for teleoperation robotics systems that can assist employees in specialized tasks under stressful conditions as there has been minimal work in documenting such processes. Grounded in the socio-technical systems (STS) theory we developed a tasks-first approach to studying employee needs for professional service robots. We designed worksheets for 1) identifying project tasks and their Key Performance Indicators (KPIs), 2) creating high-level and detailed task experience maps, and 3) developing personas for employees who complete the identified tasks. The experience maps and personas can then be used to generate insights for designing robotic systems that can assist employees with the identified tasks.

Keywords: Proto personas, teleoperation interface, human-robot interaction (HRI), socio-technical systems (STS), army

1. Introduction

According to the User Experience-driven Innovation (UXDI) framework, successful product design takes into consideration the user, context, and technology in the design innovation space (Djamasbi & Strong, 2019). Designing competitive user-centric products that not only meet existing expectations but exceed expectations requires a deep understanding of user needs within the context of use (Djamasbi & Strong, 2019). The UXDI framework is technology neutral; it can be applied to specialized systems that are designed for specific tasks (e.g., robotic-assisted surgery) to those that are used in personal everyday activities (e.g., web and smartphone applications).

Designing applications based on a careful study of user needs, goals, and challenges is necessary to increase user satisfaction and product acceptance, (Jain et al., 2019). Because users' needs evolve over time, the results of such a study can also help organizations assess the relevancy/accuracy of their assumptions about their target market needs (Djamasbi & Strong, 2019).

To design competitive user-centered products, the user-first approach to design must be applied regardless of whether products are developed for voluntary or mandatory use. When using a product is voluntary, customers have a choice of whether or not to use the system (e.g., personal fitness products). User experience (UX) has a significant and direct impact on whether or not the product is adopted (Jain et al., 2019).

When products are designed as organizational systems, employees may not have a choice in using them (e.g., systems for business and financial operations). However, mandatory use of a system that fails to deliver outstanding user experience hinders employees' creativity and empowerment, and thereby can negatively impact return on investment (ROI) and other organizational outcomes (Djamasbi & Strong, 2019).

While studying user needs (i.e., generative UX research) is essential in designing successful products, little work has been done to document such research processes (Sankar et al., 2023). Documenting research processes is essential for promoting transparency, accountability, collaboration, and the future reproducibility of work, while also serving as a valuable resource for scholars and practitioners and contributing to the growth of collective knowledge.

Motivated by the importance of generative UX research in developing mission-critical robotics products and the lack of sufficient documentation for such research, in this paper, we outline the process that we designed to study user needs for teleoperation robotics systems. The robotics products in our project must be able to assist employees in highly specialized tasks that 1) typically require a great deal of creativity and out-of-the-box thinking and 2) are often completed under stressful and/or hazardous conditions. While the process is designed for a system in a highly vertical

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organization (i.e., the army), we believe the process can be extended to other organizations that consider using robots at work under similar situations.

The subsequent sections of our paper delve deeper into the core tenets of the UXDI framework to explore how it can be applied to teleoperation robotics systems within organizational contexts using the Socio-Technical Systems (STS) theory. We start by providing background for the structured research process that we developed to uncover user needs. Next, we outline our research process and discuss the material that we developed to collect data. Finally, we discuss our findings from an initial data collection and explain the potential transformative impact that this approach to technology design can have on employee satisfaction, product adoption, and overall organizational outcomes.

2. Background

The design of organizational systems is akin to that of socio-technical systems (STS). STS in an organizational context implies that "*the organization is made up of social systems (hierarchies, communication networks, etc.) and technical systems, which are usually defined as technological artifacts*" such as the "*enterprise resources planning system*" (Barley, 1990; Griffith & Dougherty, 2001 in Leonardi et al., 2012, p.38). STS comprises actors, institutions, and infrastructure (van Rijnsoever & Leendertse, 2020). The STS theory has at its core the idea that the design and performance of any organizational system can be improved if both the social and technical aspects are brought together and treated as interdependent parts of a complex system (Walker et al., 2008). Hence, it is important to consider the STS theory when studying employees' needs for designing organizational systems.

Organizations, at the atomic level, are defined by the type of tasks that are performed by employees on a daily basis. Therefore, designing a successful organizational system requires a solid understanding of the tasks for which the system is designed as well as employee needs and challenges when they perform those tasks (Goodhue & Thompson, 1995).

2.1. Understanding the task

Designing the UX for an organizational system requires a detailed understanding of how people go about completing their tasks. This can be done by developing a task experience map, i.e., a diagram visualizing the process through which a user completes a task or accomplishes a goal. Such a process often consists of multiple phases, each including several activities. In addition to phases and activities, such a map must include technologies that are currently used in the as-is task process (Figure 1).

Outlining the task process as phases, activities, and technologies used can help develop interview scripts to gather feedback from users about their challenges and needs at the more general level (e.g., phase level) as well as at the more detailed level (e.g., activities within a phase). By doing so, the map facilitates the identification of opportunities for creating value by designing positive user experiences.

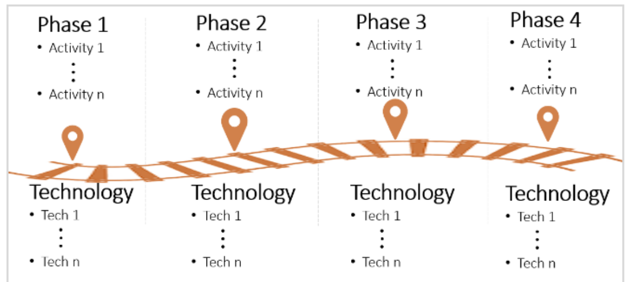

Figure 1. Task experience map.

2.1. Understanding user needs

Understanding user needs is often accomplished through developing personas, which refer to fictional yet realistic characters representing actual user groups. Persona development serves as the cornerstone of the user-first approach to technology design. The process of developing personas helps project stakeholders (e.g., business managers, system designers, developers, etc.) develop a shared understanding of user needs and a common language for communicating these needs. Establishing a shared understanding of user needs and developing a shared language for communicating ideas about users is crucial in making effective business and design decisions (Jain et al., 2019; Sankar et al., 2022). To develop personas, researchers must identify a set of user attributes that can impact the design of the system under consideration. These attributes, which are often visualized on a low-to-high scale, are often used to consolidate information that is gathered via generative UX research (e.g., through observation, workshops, focus groups, and interviews) into a small set of personas (Jain et al., 2019; Varzgani et al., 2023).

3. Our Generative UX Research Process

Generative UX Research is a qualitative research methodology focused on uncovering insights, ideas, and user needs in the early stages of the design process. Unlike evaluative research which assesses existing designs, generative research aims to generate fresh perspectives and innovative concepts by engaging users in discussions, activities, or exploratory tasks. It involves methods such as interviews and brainstorming sessions to gather rich qualitative data that informs the creation of user-centered solutions. By understanding what users need to accomplish their tasks and discovering what motivates or frustrates them, generative UX research provides a foundation for designing products and experiences that align closely with users' real-world needs and thus contributes to the development of effective and impactful solutions. Figure 2 provides an overview of the process that we used to develop study materials for our generative UX research process.

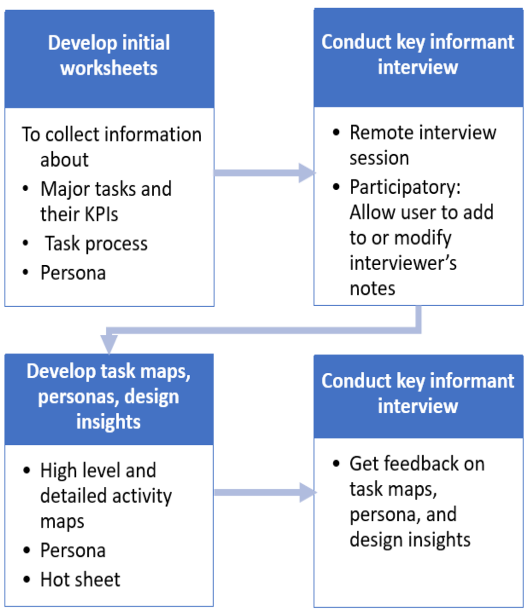

Figure 2. Our process for developing study materials.

3.1. Developing worksheets

The objective of our project was to gather information about army employee needs that could potentially be addressed with teleoperated robots. To accomplish this goal, we first had to identify pertinent tasks, develop brief descriptions for each, and outline metrics that defined their success, i.e., their key performance indicators (KPIs). We developed the worksheet displayed in Figure 3 to collect this information for up to 3 tasks during an interview with our project sponsor.

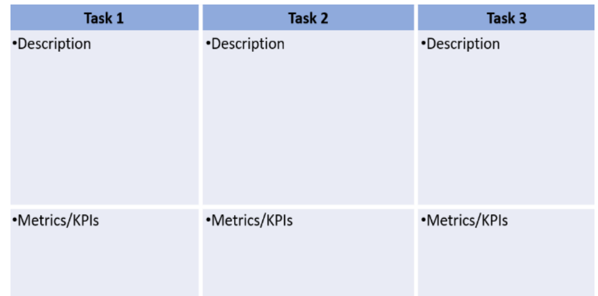

Figure 3. Worksheet for collecting information for project tasks.

Next, we needed to collect information that could be used to create experience maps, one for each task. This included knowing why the task is performed and under what conditions (e.g., in what situations, the constraints under which the task is performed), technologies used to achieve task success, collaboration, or communication with peers as well as supervisory support required to be successful, and pain points. We created the worksheet displayed in Figure 4 to collect information for creating task experience maps. The worksheet defines three major phases for each task: pre-task, during-task, and post-task.

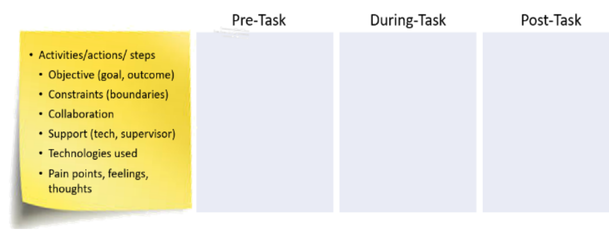

Figure 4. Worksheet for collecting information for creating experience maps.

Then, we needed to develop personas for those who completed the identified tasks. Creating these personas was necessary to provide insight into design decisions. We modified a persona development worksheet that was used in a recent study (Varzgani et al., 2023) to fit our study objectives (see Figure 5). This worksheet organized data collection in four major areas: demographics, typical workday, goals and needs, and challenges and delights. Next, grounded in the STS theory, we needed to refine the information that was collected via the worksheet (Jain et al., 2019; Varzgani et al., 2023). To do this, we conducted a thorough literature review for subjective factors that could impact the adoption and/or effective usage of technologies at work. Based on the results of our literature review, we decided that *social influence,* which refers to employees' tendency to be influenced by important others in their network on whether or not use a system at work (Chor et al., 2014), would serve as an appropriate user attribute in our project to capture social aspects of STS. For capturing technical aspects of STS that could impact the adoption and/or effective usage of organizational systems, we selected *motivation*, *self-efficacy*, *innovativeness, optimism, insecurity, and discomfort* toward technology (Chang & Kannan, 2006). The *motivation* to use an organizational system could be extrinsic or intrinsic. Extrinsic motivation in this context means that an employee engages in an activity because the activity is instrumental in achieving valued outcomes that are distinct from the activity itself, such as improved job performance, pay, or promotions (Ryan & Deci, 2000). Intrinsic motivation, on the other hand, means that an employee engages in an activity because performing the activity drives enjoyment and satisfaction, for example, the employee likes to use the system because he/she enjoys solving problems (Ryan & Deci, 2000).

Demographics	**Typical Workday**
• Age/gender • Educational background • Key characteristics	• What are persona's typical activities in a workday? Which activities take up most of persona's time? • What types of technologies does the persona use at work? Does the persona prefer to work remotely or in-person? In a group or alone?
Goals and Needs	**Challenges and Delights**
• What are the goals that the persona tries to achieve? • What does the persona need to do to achieve his/her goals?	• What are typical (yet specific) issues, pain points that challenges/frustrates/annoys the persona? • What are delightful work experiences for the persona?

Figure 5. Worksheet for collecting information for creating personas.

Self-efficacy refers to users' confidence in their abilities to use work-related technology (McDonald & Siegall, 1992). *Innovativeness* refers to users' tendency to be innovative and captures the degree to which users are among the first group of people to try out new technologies at work. *Optimism* refers to the users' positive view of technology. *Insecurity* refers to users' distrust and skepticism toward technology while *discomfort* refers to the perception of a lack of control and being overwhelmed by technology (Chang & Kannan, 2006). Innovativeness, optimism, insecurity, and discomfort toward technology are often used to measure technology readiness. Hence, these user attributes are likely to help understand the degree to which employees are ready to work with teleoperated robots at work. To collect information about these user attributes for each persona we developed the worksheet that is displayed in Figure 6.

	Low			Med			High
• **Social Influence** – Is influenced by important others in his/her network (i.e., co-workers) whether to use a new system at work.	1	2	3	4	5	6	7
• **Extrinsic Motivation** – Engages in an activity because the activity is instrumental in achieving valued outcomes that are distinct from the activity itself, such as improved job performance, pay, or promotions.	1	2	3	4	5	6	7
• **Intrinsic Motivation**. Engages in an activity because performing the activity drives enjoyment and satisfaction.	1	2	3	4	5	6	7
• **Self-efficacy** – has confidence in his/her ability to use work-related technology.	1	2	3	4	5	6	7
• **Innovativeness** : Has the tendency to be a technology pioneer and thought leader. Is among the first group of people to try out new technologies.	1	2	3	4	5	6	7
• **Tech. Optimism**: Has a positive view of technology and believes that technology offers people increased control, flexibility, and efficiency.	1	2	3	4	5	6	7
• **Tech. Insecurity**: Distrusts technology and is skeptic about technology's ability to work properly.	1	2	3	4	5	6	7
• **Tech. Discomfort**: Perceives a lack of control over technology and has a feeling of being overwhelmed by it.	1	2	3	4	5	6	7

Figure 6. Worksheet for collecting information for socio-technical user attributes.

3.2. Generating initial task experience maps and personas

To develop the initial task experience maps and personas, we conducted a 90-minute interview with a key informant who sponsors our project. Using the worksheet in Figure 3, two top-priority tasks were selected for the project by the project sponsor: explosive ordinance disposal (EOD) and repair and maintenance (R&M). Then using the worksheet in Figure 4 we collected data for task experience maps. Finally, using worksheets in Figures 5 and 6, we collected information for personas. After the interview data was collected, we used secondary data from published sources such as the Defense Technical Information Center (DTIC) and Military Operational Specialties (MOS) career lists to refine the interview data.

A thorough analysis of this primary data from the stakeholder interview and secondary data from published sources resulted in the creation of high-level experience maps for each of the two identified tasks. For example, the combined interview data and information gathered through published sources showed that the repair and maintenance task, which requires a great deal of out-of-the-box thinking, is performed during or after an army operation. This task involves conducting repairs or performing maintenance checks on equipment such as radio and other communication equipment, Apache copters, Bradley Fighting Vehicle Systems, etc. Depending on what kind of repair or maintenance is needed, the task as such is characterized by varied technical expertise, ranging from those that require fine motor movements to those that would require welding or assembling or disassembling heavy equipment. Therefore, the tools and technology used to perform these repairs are also specific to the types of repairs being carried out. KPIs that determine task success include task completion time and repair accuracy. Major pain points that were identified include extremely long hours at work and the hazardous nature of work. Figure 7 displays the high-level experience map for this task.

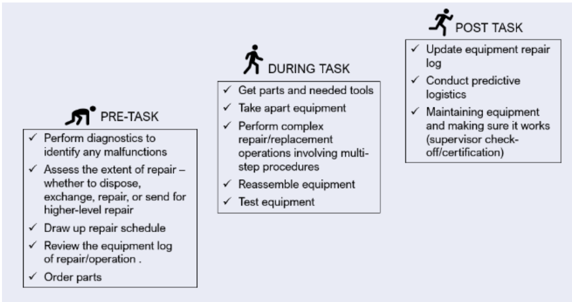

Figure 7. High-level experience map for the repair and maintenance task

The high-level experience maps were further refined into activity maps for each of their phases to allow exploring possibilities for creating value with robotics technology. Figure 8 displays an example of such an activity map for developing repair schedules for the repair and maintenance task. Figure 8 also shows two possible opportunities for value creation with robotics technology that were identified by developing and exploring the map for this pre-task activity.

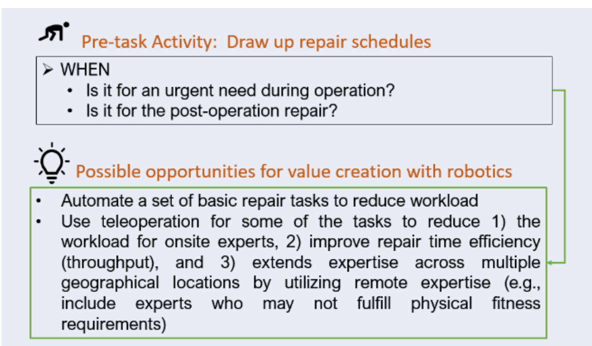

Figure 8. Example of activity map for the repair and maintenance task to explore opportunities for creating value with robotics technology.

In addition to these experience maps, based on collected information from the interview and secondary data sources, we created 4 personas for those army soldiers who complete the above-mentioned tasks, one for the explosive ordinance disposal task and 3 for the repair and maintenance task. Figure 9 displays one of the personas for the repair and maintenance task collected information from the interview and secondary data sources, we created 4 personas for those army soldiers who complete the above-mentioned tasks, one for the explosive ordinance disposal task and 3 for the repair and maintenance task. Figure 9 displays one of the personas for the repair and maintenance task.

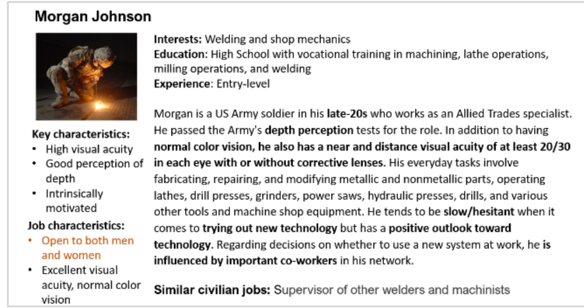

Figure 9. Example of the developed personas for the repair and maintenance task.

Next, using the developed task experience maps we identified several opportunities for improving the task outcomes with robotics technology (e.g., reducing risk both to human life and assets, reducing experts' cognitive load and/or physical burden, improving task accuracy and completion time). We then summarized these findings into a single hot sheet to provide an overall overview of the findings (Figure 10). This hot sheet had three major sections each summarizing its related findings: task characteristics, user characteristics, and design insights. The latter were divided into design insights for the robot and its teleoperation interface. For example, by considering factors like physical abilities, task load demand, situational awareness, and communication needs, the information in the hot sheet provides design insights for tailoring robotic systems to best support different user groups for the identified tasks. Teleoperation interfaces enable soldiers to remotely control robotic systems from a safe location, reducing their exposure to danger. These interfaces must be intuitive, efficient, and user-friendly, given the high-stress environments and time-sensitive situations in which they will be used. Personas aid in designing interfaces that cater to the ergonomic and cognitive requirements of specific user groups, ensuring effective control and minimizing human error. They foster empathy among designers by humanizing the end-users. By doing so the developed personas are more likely to enable the creation of intuitive and usable interfaces that enhance mission success and soldier safety.

We presented the results to the expert who sponsors the project for discussion and feedback in another one-hour interview session. The positive feedback suggested that this initial study material (task experience maps and personas) as well as design insights were ready to be used in the next step of our project which consists of a set of interviews with experts from each of the developed personas. The objective of interviews with a set of soldiers that complete the identified task in our project is to refine the initial task experience maps and personas. This will then help us to identify new opportunities for creating value with technology design or refine/modify the ones that we identified in the initial study material.

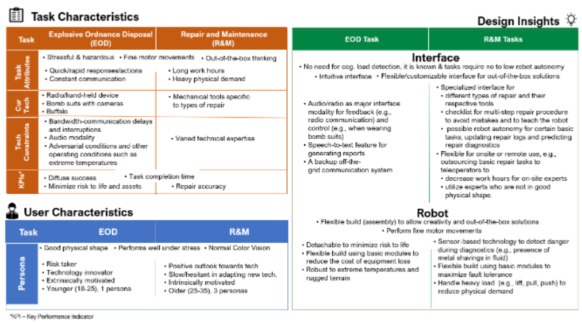

Figure 10. Hot sheet that provides an overview of our findings

4. Discussion

The paucity of documentation for the generative UX research process in developing robotics systems for the workplace calls for developing and testing such scientific processes (Sankar et al., 2023). In this paper, we outline the process by which we prepared an initial set of study materials to help us gather user needs for two highly specialized army tasks. Both tasks demand creativity often under highly stressful conditions. While the process was designed for studying army soldiers' needs, the discussed process which is grounded in the STS theory can be extended to other organizations as well. Such a process not only ensures developing systems that are used effectively in organizations but also helps to generate employee buy-in.

Our process started by focusing on identifying project tasks. Taking a task-first approach to designing organizational systems is necessary to improve employee satisfaction and empowerment. Task identification was followed by task experience mapping and persona development which gave us an idea of who can do these tasks and what their characteristics are that make them successful at these tasks. These findings in turn helped us generate design insights for the robot and the teleoperation interface.

This basic understanding of task and user characteristics, which are highly intertwined, assists in identifying the pain points and further refining and developing personas that complete the defined tasks. Gaining a deep understanding of task nuances and employees' needs and challenges when completing those tasks is crucial for generating insight for designing successful organizational systems.

Our initial findings suggest that for teleoperated robots in the workplace, especially those that are used for highly specialized tasks that require creative solutions, the use of these systems should remain voluntary to a large extent as this would foster flexibility and out-of-the-box thinking. Thus, for employees to choose to use such systems to be able to carry out their tasks successfully would require their buy-in in addition to increased satisfaction and a positive user experience. Generative UX research, which involves employees in the design of systems, could help with employee buy-in. Leveraging factors such as social influence can also impact employees' adoption and effective usage of such systems. Developing interfaces that provide an acknowledgment of task success is also likely to motivate employees to use the system (Liu et al., 2017).

5. Limitations & Future Research

Our initial set of personas and task experience maps were generated via interviews with a key informant and based on secondary publicly available data. The next step in our research project will focus on conducting user interviews with those experts who complete the identified tasks. This process will help to validate and refine our current findings, which will further aid in generating insight for the design of teleoperated robotic systems for our project. By refining task experience maps and personas, we can generate design insight for enhancing performance, safety, and success of using robotic systems at work.

6. Conclusion

The lack of sufficient documentation for the generative UX research process, particularly in creating workplace robotics systems, highlights the need to develop, test, and document these scientific methods. Our paper addresses this need by reporting the process that we used to create study materials for uncovering user needs in the domain of teleoperation robotics. By doing so our paper fills an important gap in research that is essential for obtaining design insights in the early stages of developing robotics products, particularly those that are mission-critical.

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8. References

Barley, S. R. (1990). The Alignment of Technology and Structure through Roles and Networks. Administrative Science Quarterly, 35(1), 61. https://doi.org/10.2307/2393551

Chang, A.-M., & Kannan, P. K. (2006). Employee Technology Readiness and Adoption of Wireless Technology and Services. *Proceedings of the 39th Annual Hawaii International Conference on System Sciences (HICSS'06).* https://www.semanticscholar.org/paper/Employee-Technology-Readiness-and-Adoption-of-and-Chang-Kannan/6f809a53e43c4607b1210a0b4cffcf3510f3660

Chor, K. H. B., Wisdom, J. P., Olin, S.-C. S., Hoagwood, K. E., & Horwitz, S. M. (2014). Measures for Predictors of Innovation Adoption. Administration and Policy in Mental Health and Mental Health Services Research, 42(5), 545–573. https://doi.org/10.1007/s10488-014-0551-7

Djamasbi, S., & Strong, D. (2019). User Experience-driven Innovation in Smart and Connected Worlds. AIS Transactions on Human-Computer Interaction, 215–231. https://doi.org/10.17705/1thci.00121

Goodhue, D. L., & Thompson, R. L. (1995). Task-Technology Fit and Individual Performance. MIS Quarterly, 19(2), 213. https://doi.org/10.2307/249689

Griffith, T. L., & Dougherty, D. (2001). Beyond socio-technical systems: introduction to the special issue. 18(3-4), 207–218. https://doi.org/10.1016/s0923-4748(01)00034-0

Jain, P., Djamasbi, S., & Wyatt, J. (2019). Creating Value with Proto-Research Persona Development. HCI in Business, Government, and Organizations. Information Systems and Analytics, 72–82. https://doi.org/10.1007/978-3-030-22338-0_6

Leonardi, P. M., Nardi, B. A., & Jannis Kallinikos. (2012). Materiality and organizing: social interaction in a technological world. Oxford University Press.

Liu, D., Santhanam, R., & Webster, J. (2017). Toward Meaningful Engagement: A Framework for Design and Research of Gamified Information Systems. MIS Quarterly, 41(4), 1011–1034. https://doi.org/10.25300/misq/2017/41.4.01

McDonald, T., & Siegall, M. (1992). The Effects of Technological Self-Efficacy and Job Focus on Job Performance, Attitudes, and Withdrawal Behaviors. The Journal of Psychology, 126(5), 465–475. https://doi.org/10.1080/00223980.1992.10543380

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. Contemporary Educational Psychology, 25(1), 54–67. https://doi.org/10.1006/ceps.1999.1020

Sankar, G., Djamasbi, S., Li, J., Xiao, J., & Buchler, N. (2023). Systematic Literature Review on the User Evaluation of Teleoperation Interfaces for Professional Service Robots. *Proceedings of the 25th International Conference on Human Computer Interaction (HCII forthcoming),* Copenhagen, Denmark.

Sankar, G., Djamasbi, S., Telliel, Y. D., Bajracharya, A. S., Amante, D. J., & Shi, Q. (2022). Developing Personas for Designing Health Interventions. HCI in Business, Government and Organizations. 325–336. https://doi.org/10.1007/978-3-031-05544-7_25

van Rijnsoever, F. J., & Leendertse, J. (2020). A practical tool for analyzing socio-technical transitions. Environmental Innovation and Societal Transitions, 37, 225–237. https://doi.org/10.1016/j.eist.2020.08.004

Varzgani, F., Djamasbi, S., & Tulu, B. (2023) Using Persona Development to Design a Smartphone Application for Older and Younger Diabetes Patients – A Methodological Approach for Persona Development. *Proceedings of the 25th International Conference on Human Computer Interaction (HCII forthcoming),* Copenhagen, Denmark.

Walker, G. H., Stanton, N. A., Salmon, P. M., & Jenkins, D. P. (2008). A review of sociotechnical systems theory: a classic concept for new command and control paradigms. Theoretical Issues in Ergonomics Science, 9(6), 479–499. https://doi.org/10.1080/14639220701635470