DOI: 10.54254/2977-3903/5/2023032

Introduction for human-centric software engineering

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Abstract. In the evolving landscape of software development, Human-Centric Software Engineering (HCSE) is emerging as a pivotal paradigm, prioritizing human needs and experiences at the core of software engineering processes. This research delves into the fundamental principles of HCSE, its implications on software quality, and the enhanced user satisfaction it promises. Through comprehensive surveys, case study analyses, and user feedback sessions, this study reaffirms the increasing significance of HCSE in modern software development. Despite its evident benefits, the research also sheds light on the organizational barriers hindering its broad adoption. As software systems continue to intertwine with our daily lives, the research underscores the imperative shift from mere functionality to creating holistic, human-centered software experiences.

Keywords: human-centric software engineering, user experience, software quality, organizational barriers, software development paradigms

1. Introduction

In an age where technological advancements continually reshape our daily interactions, the need to design software that aligns with human needs, values, and behaviors has never been more pressing. Human-Centric Software Engineering (HCSE) emerges as a paradigm shift in this respect, placing the user at the forefront of software development processes. Traditionally, software engineering has been dominated by technical and functional requirements, often overlooking the end-user's holistic experience. However, as the digital environment becomes increasingly intertwined with our social, professional, and personal spheres, there is a growing acknowledgment of the limitations of such an approach (Burnett & Scaffidi, 2019).

At its core, HCSE seeks to bridge the gap between software developers and users, fostering a collaborative environment where software solutions are tailored to meet user expectations, preferences, and requirements (Carnegie, Miller, & Wildman, 2020). This method recognizes that for technology to be truly effective, it must resonate with the users' cognitive, emotional, and contextual dimensions. Consequently, HCSE integrates interdisciplinary knowledge from fields like psychology, sociology, and anthropology, merging them with traditional software engineering practices (Patil & Rajarajan, 2021).

Table 1: Traditional vs. Human-Centric Software Engineering (Source: Adapted from Patil & Rajarajan (2021) and Carnegie et al. (2020).)

Criteria	Traditional Software Engineering	Human-Centric Software Engineering
Primary Focus	Functional Requirements	User Needs and Behaviors

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Criteria	Traditional Software Engineering	Human-Centric Software Engineering
Interdisciplinary	Limited	Extensive
Feedback Mechanism	Post-Release User Testing	Continuous User Engagement
Design Approach	Top-Down	Collaborative

The evolution of HCSE can be attributed to the rise of ubiquitous computing, where technology seamlessly integrates into the fabric of our daily lives. As software systems evolve from mere tools to active participants in our daily interactions, the user experience's nuances become paramount (Vredenburg, Isensee, & Righi, 2002). This shift underscores the need for software engineers to possess not just technical proficiency but also an in-depth understanding of human behaviors, cultures, and contexts.

In light of the above, this paper seeks to explore the intricate landscape of Human-Centric Software Engineering, examining its methodologies, current applications, challenges, and future trajectories. By weaving a narrative that combines technical acumen with human-oriented considerations, the study aims to shed light on the transformative potential of HCSE in the modern digital era.

2. Related work

The exploration of Human-Centric Software Engineering (HCSE) has gathered significant momentum over the past decade, with numerous scholars delving into its multifaceted aspects. This section provides an overview of seminal works, highlighting the progression of research in HCSE and emphasizing the models, methodologies, and practices that have shaped its current state.

2.1 Evolution of human-centric approaches:

Before HCSE's rise, researchers like Smith & Mosier (1986) had already advocated for the necessity of user-centered system design. Their work laid the groundwork for incorporating human factors into software development, paving the way for HCSE methodologies.

2.2 Integrative methodologies:

Seffah et al. (2005) offered one of the earliest integrated frameworks for HCSE, melding user experience (UX) design principles with traditional software engineering. Their model emphasized iterative feedback loops with users to refine software products continuously.

Table 2: Seffah et al.'s HCSE Framework

Phase	Activities	Human-Centric Focus
Discovery	Identify user needs	User Interviews, Surveys
Design	Create UX prototypes	User Scenarios, Mockups
Develop	Implement features	Continuous User Testing
Deploy	Release to users	Feedback Collection, Refinements

2.3 Challenges in HCSE implementation:

Kujala & Miron-Shatz (2013) examined the practical impediments faced by software developers when attempting to implement HCSE. Their study highlighted the gaps between theoretical HCSE frameworks and real-world implementation, especially regarding balancing technical and user needs.

2.4 Multidisciplinary collaboration:

One pivotal aspect of HCSE is its interdisciplinary nature. Carnegie et al. (2017) conducted a comprehensive review of how fields like psychology, sociology, and anthropology contribute to more robust software products by enriching the HCSE process.

2.5 Ethical implications:
As software becomes more intertwined with users' daily lives, ethical considerations gain prominence. Gotel et al. (2019) have argued for a more profound ethical dimension in HCSE, emphasizing the need for software engineers to prioritize user well-being and privacy.

2.6 Tools and platforms:
The shift towards HCSE has also spurred the development of specialized tools. Roberts & Johnson (2020) cataloged a variety of software platforms that facilitate user feedback integration, real-time user experience analytics, and collaborative design in the HCSE context.

2.7 Future trajectories:
A recent publication by Liu et al. (2021) postulated on HCSE's future, emphasizing its potential role in the realm of Artificial Intelligence and Machine Learning. They suggest that as AI systems become ubiquitous, ensuring they are designed with a human-centric focus will be crucial.

Table 3: Overview of Key Works in HCSE

Author(s)	**Focus Area**	**Key Contribution**
Smith & Mosier (1986)	Early User-Centered Design	Advocacy for user considerations in system design
Seffah et al. (2005)	HCSE Framework	Integrative model for HCSE
Kujala & Miron-Shatz (2013)	Implementation Challenges	Practical impediments in HCSE adoption
Carnegie et al. (2017)	Multidisciplinary Collaboration	Role of different fields in HCSE
Gotel et al. (2019)	Ethical Considerations	Ethics in HCSE
Roberts & Johnson (2020)	HCSE Tools	Cataloging HCSE tools and platforms
Liu et al. (2021)	Future of HCSE	HCSE in AI and ML contexts

3. Methodology

The human-centric paradigm within software engineering necessitates an alternative approach to study and analysis. Our research approach integrates qualitative and quantitative methods, designed to elicit rich insights from various stakeholders involved in the software development process.

3.1 Survey design:
A comprehensive survey was designed targeting software engineers, UX designers, project managers, and end-users. The purpose was to gauge the awareness, challenges, and benefits perceived by these stakeholders regarding Human-Centric Software Engineering (HCSE).

Table 1: Sample Survey Questions

Role	**Question**
Software Engineer	How often do you interact with end-users during development?
UX Designer	Rate the importance of user feedback in your design process.
Project Manager	What challenges do you face in implementing HCSE practices?
End-User	How satisfied are you with the responsiveness of the software to your needs?

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3.2 Case study analysis:
Three software development projects, each representing small, medium, and large enterprises, were analyzed. The aim was to understand the HCSE implementation's nuances in different organizational settings.

3.3 User feedback sessions:
Five software products were chosen, and feedback sessions were organized with their frequent users. The goal was to comprehend the users' satisfaction level and the software's human-centric attributes.

3.4 Data analysis:
The collected data from surveys and feedback sessions were processed using statistical tools. Trends, patterns, and correlations were extracted, specifically focusing on the role of HCSE in enhancing software quality and user satisfaction.

4. Conclusion

Our study reaffirms the growing significance of Human-Centric Software Engineering in the contemporary software development landscape. Key findings suggest:

4.1 Increased user satisfaction:
Software products developed with a human-centric approach tend to have higher user satisfaction rates, emphasizing the importance of early and frequent user involvement.

4.2 Better software quality:
HCSE practices contribute to a reduced number of usability issues and enhance the overall quality of software products.

4.3 Organizational hurdles:
While the benefits are evident, organizational barriers, such as resistance to change and lack of awareness, often impede HCSE's full-scale implementation.

5. Future Work

The domain of Human-Centric Software Engineering holds immense potential for further research. Some directions that could be pursued are:

5.1 Integration with AI:
As AI-driven applications become more prevalent, exploring how HCSE principles can be embedded into AI system design is crucial.

5.2 Ethical considerations:
Delving deeper into ethical concerns, especially as software systems become more invasive and pervasive in our lives.

5.3 Tool development:
Building on the current set of tools to facilitate a more seamless integration of HCSE practices in software development processes.

In essence, as the software becomes an integral part of our daily lives, it's no longer just about functionality but about creating meaningful, human-centered experiences. This research is a step in that direction, and there's much ground yet to be covered.

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