AIS Transactions on Human-Computer Interaction

Volume 3 | Issue 2 Article 1

6-29-2011

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Recommended Citation
Hevner, A., & Zhang, P. (2011). Introduction to the AIS THCI Special Issue on Design Research in Human-Computer Interaction. *AIS Transactions on Human-Computer Interaction, 3*(2), 56-61. Retrieved from https://aisel.aisnet.org/thci/vol3/iss2/1
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Editorial

Introduction to the AIS THCI Special Issue on Design Research in Human-Computer Interaction

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THE IMPORTANCE OF DESIGN RESEARCH IN HCI

Design Research (DR) creates, builds, and evaluates innovative artifacts such as constructs, models, methods, and instantiations as well as operational information systems. It also investigates approaches, methods, behaviors, and processes related to design. Although the design research paradigm as an engineering approach in Information Systems (IS) research has been actively discussed in recent years (Hevner et al., 2004), comparatively little design related research has made its way into the IS community by means of widely recognized and outstanding publications. Human-Computer Interaction (HCI) Research is concerned with the ways humans interact with information, technologies, and tasks; especially in business, managerial, organizational, and cultural contexts (Zhang et al., 2002). Despite the realization that it is important for HCI research to focus on all issues that occur along the lifecycles of any information and communication technology (ICT) artifacts, IS scholars have traditionally put less effort into the design and development stage and more effort into the use and impact stage (Zhang and Li, 2005; Zhang et al., 2009).

We contend that the Design Research stream and the HCI research stream are inherently related and highly overlapping, representing different perspectives and approaches toward similar objects: ICT artifacts that humans interact with for various purposes. It is important to encourage active research efforts to make progress and research contributions at the intersection of these two streams. The goal of this special issue is to focus scholars' attention on this intersection and to provide an opportunity for active researchers in both DR and HCI to showcase their current work using the DR paradigm to address broad HCI issues.

We see design research as a particular perspective within IS research, focusing on the development of artifacts related to ICT. DR involves the analysis of the use and performance of designed artifacts to understand, explain, and, very frequently, improve on the behavior of the social system that the artifacts become a part of. Such artifacts include - but certainly are not limited to - algorithms (e.g. for information retrieval), human-computer interfaces, system design methods, management policies, and full system instantiations. In this way, DR has a clear applied and creative orientation.

Hevner, A. and P. Zhang (2011) "Introduction to the AIS THCI Special Issue on Design Research in Human-Computer Interaction (HCI)," *AIS Transactions on Human-Computer Interaction* (3) 2, pp. 56-61.

The application of design research to human-computer interaction represents a unique set of challenges due to the multidisciplinary nature of the HCI field. HCI research draws from a large number of existing disciplines including cognitive science, computer science, education, engineering, graphic design, human factors, information systems, library and information sciences, management, psychology, and sociology. A key tension in HCI is the perception that there is a divide between the 'hard' and 'soft' sciences that ground HCI research (Carroll, 2006). The seminal works of Herbert Simon with his *Sciences of the Artificial* (Simon, 1996) and Allen Newell with his theoretical characterization of HCI (Newell and Card, 1985) clearly establish the central role of design in HCI practice and research. Over the years, however, many researchers, including Newell himself, became concerned that an overemphasis on engineering design in HCI would diminish the importance of the softer sciences of human factors, cognitive psychology, and societal impacts. In contrast, Carroll (2006) argues that the sometimes conflicting objectives of the hard and soft sciences provide an 'essential tension' in HCI research that makes the field a vital and extraordinary science.

The HCI community in IS has historically focused its efforts on analyzing the impacts of HCI artifacts in business, managerial, organizational, and cultural contexts; less effort has been put into innovative design contributions (Zhang and Li, 2005; Zhang et al., 2009). Recent essays on the future of HCI research by Benbasat (2010) and Lyytinen (2010) particularly call for a greater design focus in research to increase the practical relevance of the HCI contribution. This special issue, the very first special issue of *AIS Transactions on Human-Computer Interaction*, is an answer to the call.

In this editorial introduction, we briefly position design research in the context of HCI research with a focus on the design and development stage of HCI artifacts' lifecycles. This is followed by an introduction of the four papers contained in this special issue.

THE ROLE OF DESIGN IN HCI RESEARCH

The activities of design research can be viewed as three cycles as seen in Figure 1 (Hevner 2007). The completeness and reach of a design research project can be assessed by describing the activities and results of these cycles.

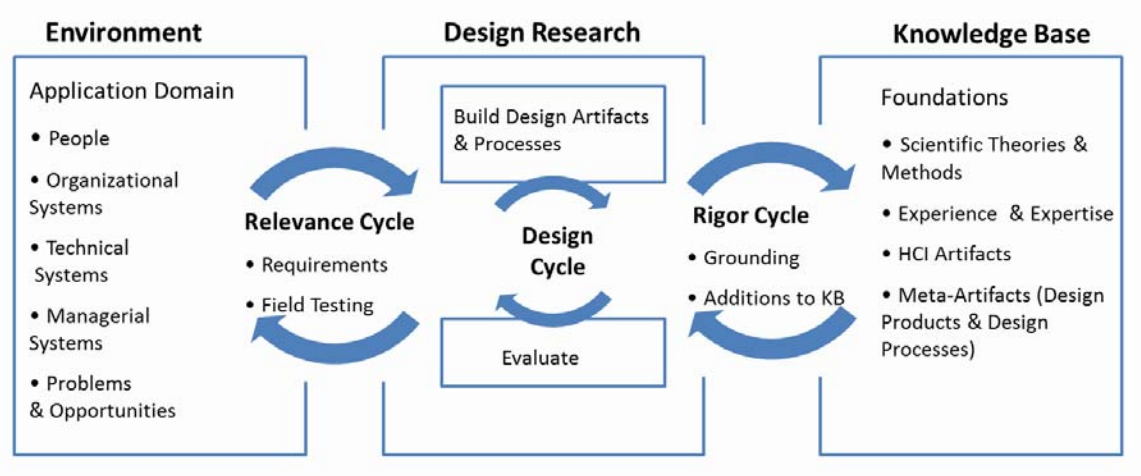

Figure 1: Three Cycles of Design Research (Adapted from Hevner, 2007)

- The *relevance cycle* initiates design research within an application context that not only provides the requirements for the research (e.g., the opportunities/problems to be addressed) as inputs but also defines acceptance criteria for the ultimate evaluation of the research results in the application context.

- The *rigor cycle* provides past knowledge to the research project to ensure its innovation. To guarantee that the designs produced are research contributions to the knowledge base and not routine designs based upon the application of well-known processes, this cycle is reliant on the researchers' thorough examination of the extant literature.

- The internal *design cycle* is the crux of any design research project. This cycle of research activities iterates rapidly between the building of an artifact, its evaluation, and the use of subsequent feedback to refine the design further. The requirements (opportunities and constraints) are input from the relevance cycle and the

theories and methods used to build and evaluate are drawn from the rigor cycle. It is important to understand the dependence of this design cycle on the other two cycles while also appreciating its relative independence during the actual execution of the research.

Design research in HCI must draw its relevance from a real-world application need and ground its build and evaluate activities via rigorous appropriation from the knowledge base of theories and methods. While HCI evaluation activities are well understood in the IS community (Cairns and Cox, 2008; Benbasat, 2010; Prestopnik, 2010), less is known on how to build innovative HCI artifacts.

A vitally important first step is to identify what constitutes an HCI artifact in design research. March and Smith (1995) define an IT artifact as a construct, model, method, or instantiation. Table 1 presents some examples of HCI artifacts in each of these categories. We draw these examples from well-known resources in the HCI community (e.g., Shneiderman and Plaisant, 2010; Te'eni et al., 2007; Tidwell, 2006).

Table 1: HCI Artifacts

Category	Definition	Examples of HCI Artifacts
Constructs	Vocabulary and symbols used to define design problems and solutions that provide a means to represent design ideas	• Metaphors (desktops, dashboard, folders, shopping carts) • Interaction Constructs (forms, dialog boxes, wizards) • Visualization Constructs (colors, fonts, icons) • Organization Constructs (ribbons, menus)
Models	Cognitive and sensual (e.g., visual) representations of designs; sense-making arrangements of constructs that allow exploration of abstract design	• Graphical Models • Card Stacks • 3D Models • Lists • Cognitive Maps
Methods	Processes that provide guidance on how to solve problems and exploit opportunities; algorithms; solution approaches	• Participatory Design • Collaboration Processes • Human-Centered Design • Sensory Stimulus-Response • Value Sensitive Design • The Task-Semantic-Syntactic-Lexical (TSSL) Method
Instantiations	Implementation of an artifact in a working system; demonstrates feasibility and value; provides ability to study uses and impacts on embedded system	• Web Sites • User Interfaces • Mobile Devices • Peripherals • Input/ Output Devices • Avatars

The design of HCI artifacts is essentially a search process to discover an effective solution to an HCI problem. Problem solving can be viewed as utilizing available means to reach desired ends while satisfying laws existing in the environment (Simon, 1996). Abstraction and representation of appropriate means, ends, and laws are crucial components of design research. These factors are problem and environment dependent and invariably involve creativity and innovation. Means are the set of actions and resources available to construct a solution. Ends represent goals and constraints on the solution. Laws are uncontrollable forces in the environment. Effective HCI design requires knowledge of both the application domain (e.g., requirements and constraints) and the solution domain (e.g., technical and organizational aspects).

DESIGN RESEARCH IN HCI: SPECIAL ISSUE PAPERS

In response to the call for the special issue, a total of 15 papers were submitted, including nine original research papers, three theory & review papers, one research note, one issues & opinions paper, and one research commentary. These submissions came from a total of 36 authors in all three regions affiliated with schools such as

business, information science and technology, informatics, design, communication and media studies, industrial engineering, computer information systems, computer engineering, computer science, and industry. Together, the articles cover a wide range of important topics for design contributions in HCI. After an initial screening followed by two to three rounds of rigorous review and revisions, this special issue includes a total of four exemplary papers. Together, these four research projects advance our understanding of how rigorous design research methods can be applied to important and relevant HCI problems. Brief overviews of the accepted papers are given here.

- Derrick, Jenkins, and Nunamaker design a novel and unique class of intelligent agents known as *Special Purpose Embodied Conversational Intelligence with Environmental Sensors* (SPECIES) agents. As information systems increase their ability to gather and analyze data from the natural environment, and as computational power increases, the next generation of human-computer interfaces will be able to facilitate more lifelike and natural interactions with humans. This can be accomplished through using sensors to non-invasively gather information from the user, employing artificial intelligence which interprets this information to perceive users' emotional and cognitive states, and responding to the user with customized interfaces and responses based on embodied-conversational-agent (avatar) technology. The authors build on interpersonal communication theory to specify four essential design principles of all SPECIES agents. They present initial findings that demonstrate how SPECIES agents can be deployed to augment human tasks.

- Zheng and Vaishnavi design a visual exploration method for prioritizing projects based on multi-dimensional perceptual maps. When prioritizing projects for funding, managers usually evaluate multiple dimensions of project data. Such data are typically condensed into one or two aggregated indicators. However, aggregated scores may only offer a limited view of project importance. This often leads decision makers to ignore the possible differences masked by aggregation. Following the design science research paradigm, the authors present a visual exploration method based on multi-dimensional perceptual maps. The method incorporates human intuition in the process, and maintains the multidimensionality of project data as a decision basis for project prioritization and selection. A prototype system is developed and qualitatively evaluated by a group of project managers. The qualitative analysis of the data supports the utility and usability of the system.

- Luse, Mennecke, Triplett, Karstens, and Jacobson propose a method for the design of security visualization products. Research surrounding visualization for computer and network security has produced several accepted methods for developing security visualization products. This paper melds the research of the three competing frameworks. A group of corporate network administrators develop, use, and evaluate a security product which incorporates the proposed design method. Findings show that users of the system believe the improved system has increased their respective performance at completing network security tasks and are likely to use such a system in the future.

- Yetim discusses Value Sensitive Design (VSD) as a framework for producing and evaluating a design outcome by taking into account human values. Drawing on discourse ethics, the author analyzes the current state of VSD and identifies gaps such as the lack of explicit methods for supporting a deliberative process of decision making with respect to concerns including the identification of stakeholders, the justification of trade-offs in the case of competing or incommensurate values, and the selection of design goals and means. The author proposes improvements to VSD based on the standards of discourse ethics by drawing on the knowledge base of critical research in IS. The applicability of the ideas in this paper is explored in a case study.

CONCLUSIONS

This special issue of the AIS Transactions on Human-Computer Interaction has drawn scholars' attention to design research in HCI. In particular, it has provided an opportunity to advance the goals of the design research community with the publication of four interesting exemplar papers and to further the discussion on what constitutes good design research in HCI. To achieve the latter, we presented a brief discussion of the build activity in HCI projects, which highlighted appropriate HCI artifacts and outlined the search process for finding good HCI designs. It is our hope that continued research efforts and on-going discussions among the thought leaders and scholars in the HCI and design research communities will lead to an improved understanding and more effective use of the design research paradigm to solve relevant HCI problems.

ACKNOWLEDGEMENTS

The Guest Editors wish to thank the following researchers who willingly provided timely and constructive reviews for this special issue: Ofer Arazy, Hock Chuan Chan, Bojan Cukic, Soussan Djamasbi, Xiaowen Fang, Batya Friedman, Traci Hess, Shuk Ying Ho, Paul Jen-Hwa Hu, Netta Iivari, Zhenhui Jiang, Sherrie Komiak, Na Li, Eleanor Loiacono, Ji-Ye Mao, Salvatore March, Hong Sheng, Heshan Sun, Sherry Sun, Jason Thatcher, Ozgur Turetken, Kathikeyan Umapathy, Debra VanderMeer, Heinz Roland Weistroffer, and Dongsong Zhang.

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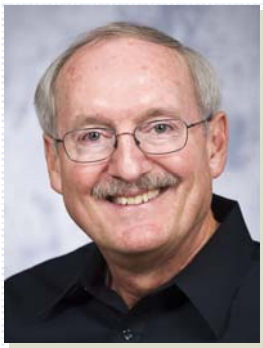

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ISSN: 1944-3900

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