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Abstract:

In this editorial, we introduce the special issue on design science research in human-computer interaction with four papers extended from the 2020 European Conference on Information Systems and propose a conceptual model for such research projects. Research in the interdisciplinary human-computer interaction (HCI) discipline advances knowledge of how humans interact with technologies, systems, information, and work structures. Design science research (DSR) methods support three distinct modes in HCI projects. In the interior mode, researchers build and evaluate novel technical solutions with a focus on improved system interfaces to support effective human use. Next, in the exterior mode, researchers build and evaluate novel behavioral solutions with a process focus on interactions that increase human capabilities. Lastly, in the gestalt mode, researchers build and evaluate novel composite solutions that improve synergies between technologies and human behaviors. We pose a comprehensive model for identifying the DSR modes of HCI research with related artifacts, evaluation techniques, design theories, and research impacts.

Keywords: Gamification, Collaboration Processes, Collaborative Writing, Motivation, Engagement.

Fiona Nah was the accepting senior editor for this paper.

1 Design Science Research in Human-Computer Interaction Projects

Human interaction with information technology (IT) has become a pervasive element in private, organizational, and societal contexts. In an increasingly digitized and rapidly transforming world, humans constantly need to adjust their daily routines and work practices to the latest technological developments such as artificial intelligence's increasing capabilities (e.g., conversational agents enabled by natural language processing (Diederich, Janßen-Müller, Brendel, & Morana, 2019)) and emerging sensor technologies (e.g., smart homes enabled by inertial sensors (Heydarian, Adam, Burrows, Collins, & Rollo, 2019)). Similarly, system engineers need to consider the design, implementation, and evaluation of novel artifacts in highly competitive and dynamic environments. Against this backdrop, profoundly understanding how humans interact with technology constitutes an increasingly critical factor for the adoption and success of IT artifacts and application systems.

The interdisciplinary research human-computer interaction (HCI) discipline focuses on advancing the knowledge base concerning how "humans interact with information, technologies, and tasks" (Hevner & Zhang, 2011, p. 56). This knowledge base includes 1) descriptive knowledge that explains human cognition, affect, and behavior in their interactions with technology and 2) prescriptive knowledge in the form of design theories and/or design entities for creating IT systems and human process artifacts for interacting with them (vom Brocke, Winter, Hevner, & Maedche, 2020).

As an introduction to this special issue, we present a conceptual model that poses three design science research (DSR)[1] modes in human-computer interaction (HCI) projects. Understanding a project's DSR mode allows researchers to position their projects vis-à-vis relevant IT artifact contributions, rigorous evaluation methods and evidence, and growing design theories.

This paper proceeds as follows: in Section 2, we present the conceptual model and describe the three DSR models of HCI research. In Section 3, we briefly summarize the papers in the special issue and analyze their DSR modes. Finally, in Section 4, we conclude the paper with a summary and opportunities for future research directions.

2 Modes of DSR in HCI

Drawing on a framework for design theorizing (Baskerville, Baiyere, Gregor, Hevener, & Rossi, 2018; Gregor 2009), we argue that design science research in HCI can focus on the interior mode of an IT system design and/or on the exterior mode of an IT system usage design. The interior mode focuses on how to construct a HCI artifact for a given problem space. Here, primary HCI artifacts constitute computing interface constructs, models, methods, and their instantiations. In contrast, the exterior mode focuses on how individuals use the artifact in its environment (Simon, 1996). Human interaction constructs, models, methods, and their instantiations constitute primary HCI artifacts in the exterior mode. Based on this distinction, we posit that DSR can focus on generating both prescriptive knowledge and descriptive knowledge about constructing and using HCI artifacts. Maedche, Parsons, and Gregor's (forthcoming) design research activity framework addresses the interior-exterior distinction as one dimension; the other dimension pertains to whether one generates prescriptive or descriptive knowledge. In this paper, we focus primarily on the first dimension due to our concern with HCI design science research. This framework distinguishes between whether the researcher participates in constructing the artifact "first hand" (the interior mode) or whether the researcher(s) constructs and studies interaction artifacts to support other actors in effectively using the IT artifacts as deployed in the field (the exterior mode).

Figure 1 presents the three modes we describe in this editorial. Researchers move through the three modes as their research moves from IT system creation (interior mode) to IT system interaction with human behaviors (exterior mode) with a gestalt mode that integrates components from both the other modes.

[1] We use the term "design science research" in a broad sense to encompass what researchers elsewhere might term "design research". That is, we use DSR not to refer to engineering or building activities alone but to a wider view that builds both descriptive and prescriptive knowledge bases around constructed artifacts (see Maedche et al., forthcoming).

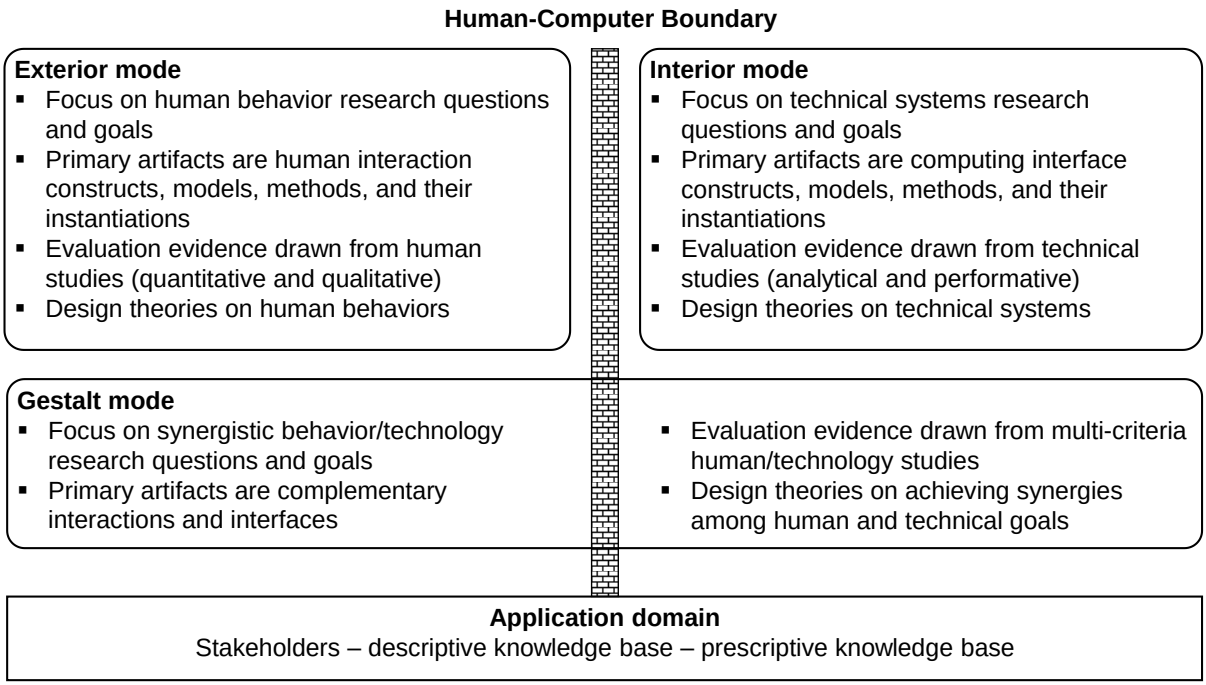

Figure 1. DSR Modes in HCI Projects

As Figure 1 shows, the designed primary artifacts, the applied evaluation methods, the produced improvement evidence, and the addressed design theories distinguish the three modes. Table 1 summarizes these research contributions across the three DSR modes. In Sections 2.1 to 2.3, we briefly describe the three modes and offer exemplar HCI projects from the IS literature.

Table 1. Research Contributions in DSR Modes for HCI

DSR mode in HCI	Design artifacts	Evaluation methods and evidence	Design theories
Exterior mode	Work systems and human behavior design with focus on human-computer interactions	Observational studies (qualitative and quantitative) that examine human behaviors with evidence of human behavior goal improvements	Design theories on human behavior (prescriptive and descriptive)
Gestalt Mode	Synergistic balance between IT systems and human behavior/work systems design	Combination of technical and observational studies with focus on iterative synergies of technical design and human behavior design	Design theories on achieving synergies among human and technical goals (prescriptive and descriptive)
Interior Mode	IT systems design with a focus on human-computer interfaces	Technical studies (creative and analytical) that examine application systems performance with evidence of technical improvements	Design theories on IT systems (prescriptive and descriptive)

2.1 Interior Mode

The interior mode of HCI research focuses on technically designing IT systems and their interfaces to enhance human performance and to solve an important research question. Construction activities occur with "how to build" questions, such as how can one design an interface to allow users to experience social presence in online shopping (Lu, Fan, & Zhou, 2016). In most cases, evaluation criteria surround issues that concern system performance, interface usability, and effective integration of the new technology into existing work systems. The HCI project will create new ways to understand prescriptive design theories on how to create, evaluate, instantiate, and deploy the new IT systems. We discuss two exemplar interior HCI projects next.

New forms of artificial intelligence that involve machine learning from large amounts of data can suffer from transparency problems as they can have limited means to explain the reasons behind their decisions to the

decision makers. Martens and Provost (2014) develop a new type of explanation (a new construct) for document classification that relies on showing the minimal set of words to distinguish the document class of interest (e.g., web pages with objectionable content). They show the algorithms (the instantiation) that will provide such explanations and devote much effort to presenting the algorithms. The authors analytically evaluate the algorithm's performance and discuss their observations of how the algorithm performed with test data. They discuss the study's contributions in terms of the algorithm performance and mention the need for concise and comprehensible explanations. Thus, the study exemplifies the interior mode in that it focuses on the inner workings of an HCI artifact in the form of an algorithmic instantiation rather than the human behavior associated with its use.

Nunamaker, Derrick, Elkins, Burgoon, and Patton (2011) provide another interesting exemplar with their research on conversational agent-based kiosks for automated interviewing. They propose a detailed system architecture of an embodied intelligent agent that interviews individuals while employing sensors to detect changes in arousal, behavior, and cognitive effects. The system uses feedback mechanisms to influence human behaviors while measuring stress and deception. Three evaluative studies analyze the system's effectiveness with changes in interviewee gender, appearance, demeanor, and vocal pitch. While the researchers ground the project in descriptive theories of human stress and deception, prescriptive design theories that address how one can use sensors and algorithms to capture, measure, and analyze human psycho-physiological behaviors in novel IT system methods and instantiations constitute their research's novel research contribution.

2.2 Exterior Mode

In the exterior mode of HCI research, researchers derive new design knowledge from observing and analyzing existing IT systems in real-world applications outside their original development environments. In this mode, researchers primarily evaluate HCI artifacts based on observations with qualitative and/or quantitative evidence to support how effectively humans interact with the IT system interfaces. Projects in this mode show limitations in HCI artifacts and systems as deployed and possibly suggest the need for improvements. They focus on designing human processes and work systems in order to generate both prescriptive and descriptive knowledge around human behaviors. For example, studies that examine machine learning systems show that systems that cannot adequately provide reasons for their recommendations can lead to unexpected and harmful outcomes (Knight, 2017).

Komiak and Benbasat (2006) provide an interesting exemplar of an HCI study in the exterior mode in investigating the effect that personalization and familiarity have on whether individuals trust and adopt recommendation agents (RAs). The experimental material for this study uses two commercial RAs from the same company; that is, the artifacts already exist. While the two RAs resembled each other, one could offer more "personalized" advice than the other. In the high-personalization case, the customer could click on a "get advice" hyperlink to answer need-based questions and the RA would consider their needs when recommending products. The study used several behavioral theories as grounding and the theoretical contribution included the importance of including an "emotional trust" concept in IT system adoption models in e-commerce. The study reflects on different ways in which one could engender emotional trust through interface design, but the theoretical contribution focuses on descriptive behavioral theory. The IT artifact is the RA interface (an instantiation) with varying personalization features.

2.3 Gestalt Mode

In some projects, researchers can integrate both interior and exterior DSR modes, which we term the gestalt mode. Such HCI research focuses on the synergistically improving human behavior and IT system designs to enhance human performance. Iterative cycles of interior and exterior research activities continually refine the IT system interfaces and the human interaction artifacts. Such projects make new research contributions to both interior system interfaces and exterior human interactions. The evaluation methods researchers select would encompass both systems performance and human performance to evidence improvements in the overall HCI application. Such projects would advance prescriptive design theories for achieving synergies among human and technical components of socio-technical systems.

We found few studies that exemplify the gestalt mode in the IS literature. Individual published studies in HCI appear to concentrate on either constructing an IT system (interior mode) with some evaluation or on examining existing systems in use. Furthermore, they describe their inner workings (exterior mode) to a comparatively limited degree. A journal paper's confines possibly limit efforts to fully describe both an

artifact's construction and its unfolding usage; thus, one may likely find fuller treatments in a series of publications from a research program or in monographs (e.g., dissertations).

A longitudinal study in online deception detection that used neuroscience theories constitutes one recent example that illustrates the gestalt mode of HCI research (Hibbeln, Jenkins, Schneider, Valacich, & Weinmann, 2017; Jenkins, Proudfoot, Valacich, Grimes, & Nunamaker, 2019). This research stream presents the interior mode of DSR in designing, constructing, and evaluating the algorithms and systems for capturing mouse-cursor movements in online screening questionnaires. Neurophysiological evaluations provide evidence of deceptive behaviors that one can analyze and match with movement activities. The project also proposes prescriptive design theories for capturing and analyzing deceptive behaviors in automated systems (Jenkins et al., 2019). Further, the project performs exterior mode DSR by identifying and modeling human interaction behaviors and inferring emotions from these interaction models. Thus, the models constitute novel artifacts. Extensive studies provide evidence that negative emotions correlate with deceptive behaviors (Hibbeln et al., 2017). Research contributions include extensions to attentional control theory.

3 Special Issue Papers

Over the past 30 years, the European Conference on Information Systems (ECIS) has become a powerhouse for innovation and scientific discovery in information systems. At ECIS 2020, we organized a track on "Design research in Information Systems". It attracted 33 submissions with seven full papers and three short papers presented at the conference after peer review. Via consultation with Editor-in-Chief Fiona Nah, we invite the authors of four of these papers to submit them to a special issue on design science research in human-computer interaction in *the AIS Transactions on Human-Computer Interaction*. We required all the authors to expand their papers' content and length to match the requirements for standard research papers that the journal publishes. Subsequently, the papers proceeded through a fast-track peer review process. In this section, we summarize each paper and how one could position them in terms of the interior, exterior, and gestalt modes that we present in our conceptual model with respect to creating descriptive and prescriptive knowledge.

In their paper "CASSI: Designing a Simulation Environment for Vehicle Relocation in Carsharing", Prinz, Willnat, Brendel, Lichtenberg, and Kolbe (2021) design and evaluate a carsharing simulation tool. To do so, the authors engaged in three interrelated cycles (relevance, design, rigor) to iteratively create an IT system that enables researchers to develop and evaluate different carsharing relocation strategies. Hence, the work primarily focuses on creating prescriptive design knowledge. Given the focus on creating a technical system, this research exemplifies the interior mode of design research in HCI. The identified requirements primarily address aspects of the technical solution artifact, such as its accessibility, flexibility, programmability, and automation. Similarly, the design principles captured in the proposed design theory contribute to the prescriptive knowledge base for creating technical systems that consider human information processing and decision making (e.g., grid search, visualization, simplified programming).

In their paper "Designing and Evaluating a Collaborative Writing Process with Gamification Elements: Toward a Framework for Gamifying Collaboration Processes", Wiethof, Tavanapour, and Bittner (2021) report on the results of an action design research project. The authors followed a four-stage approach to create and evaluate a collaborative writing process that builds on gamification elements (e.g., countdown, group competition). In the project, the authors implemented a Web application to instantiate the process and allow for its evaluation. They carefully designed the process to yield human behavioral outcomes of higher hedonic motivation, meaningful engagement, and enhanced continuance intention to use the system. The authors note that they built on the mechanics, dynamics, aesthetics (MDA) framework, which advocates games "as systems that build behavior via interaction" (Hunicke, LeBlanc, and Zubek, 2004, p. 2). Hence, the authors inherently focus on how the interaction with the system shapes human behavior in order to balance how they design specific gamification elements in the user interface with how they design a process framework that facilitates collaborative writing in groups. Due to this duality, one can see the project as exemplifying the gestalt mode of design research in HCI.

In their paper "Gamification: Explaining Brand Loyalty in Mobile Applications", Mattke and Maier (2021) investigate a different aspect of gamification. Rather than focusing on specific gamification features, they examine an aggregated level by considering the frequency with which users use three different categories of gamification features (immersion-related, achievement-related, social-related features). Based on surveying individuals who use the mobile language application Duolingo, the authors theorize and find

evidence for a link between the frequency with which users use these different gamification feature categories and their brand loyalty. Overall, the study focuses on how users use an existing technical system (exterior mode) with a clear goal to generate descriptive knowledge on how the frequency with which users use gamification features links to brand loyalty. Mobile application providers could build on the generated knowledge to reduce churn rates by considering additional incentives for users likely to churn based on their usage data. At the same time, the study links to the prescriptive knowledge base in that it contributes to better explaining "what categories of gamification elements…mobile application providers should implement" (p. 5).

Finally, in their paper "Understanding the Impact that Response Failure has on How Users Perceive Anthropomorphic Conversational Service Agents: Insights from an Online Experiment", Diederich, Lembcke, Brendel, and Kolbe (2021) investigate the impact that specific design features of text-based conversational agents (or chatbots) have on user perceptions. Based on an online experimental survey, the authors show that a chatbot's failure to provide a meaningful response (e.g., due to limited conversational capabilities) reduces its perceived humanness (i.e., the degree to which users attribute human properties to it) while at the same time increasing its perceived uncanniness (i.e., its degree of strangeness due to its inhuman qualities). Taken together, the decreased humanness and increased uncanniness detrimentally impact users' service satisfaction. The paper focuses on how users perceive the system's user interface aspects (interior mode). It does not focus on extending the prescriptive knowledge base but rather the descriptive knowledge base in terms of understanding the relationship between chatbot design and human perception. However, it is a straightforward matter to draw implications for the prescriptive knowledge base of chatbot design in that system designers should avoid response failure. The authors conclude that chatbots need to be equipped "with sufficient conversational capabilities to mitigate and adequately handle response failures" (p. 14).

4 Summary

In this brief editorial, we propose three distinct DSR modes in HCI projects. In the interior mode, researchers build and evaluate novel IT system solutions with a focus on improved interfaces to support effective human use. In the exterior mode, researchers build and evaluate novel behavioral solutions with a process focus on interactions that increase human capabilities. In the gestalt mode, researchers build and evaluate novel composite solutions that improve synergies between technologies and human behaviors. We pose a comprehensive model for identifying the DSR modes of HCI research with related artifacts, evaluation techniques, design theories, and research impacts. We provide studies that exemplify the three modes from the IS literature and discuss the four special issue papers.

In this editorial, we provide HCI researchers with a simple and illuminating model for positioning HCI project goals and design research contributions. The three modes help one understand the different contributions of HCI projects, which range from interior IT system design, the design of exterior human interactions with the IT system, and the synergistic design of IT systems and interactions in the gestalt mode. One can track design knowledge's growth in terms of artifacts, evaluative evidence, and both prescriptive and descriptive theories through the project trajectory of published results (vom Brocke et al., 2020).

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