An Iterative Information System Design Process for Sustainability

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Abstract
Bridging business and computer science into an improved alignment using the theoretical foundations of information and computation is one of the aims of information science (IS). Improved design knowledge from other interdisciplinary research fields, like human-computer interaction (HCI), could advance different design thinking and processes for IS. While structuring an IS design process for a sustainable result is challenging, an HCI-focused viewpoint on IS design could be beneficial in this matter. In this paper, an iterative design process for sustainable information system design conceptualized from HCI is proposed. The resulting design process highlights the different roles of HCI towards building knowledge in IS by influencing different design choices on user behavior and contributing towards generating reusable designs in different phases of the design process.

Author Keywords
Sustainability; information system design; sustainable HCI; iterative design process.

ACM Classification Keywords
K.4.0 [Computers and society]: General.

Introduction
Sustainability and its associated design and development problems are omnipresent in our society. Information

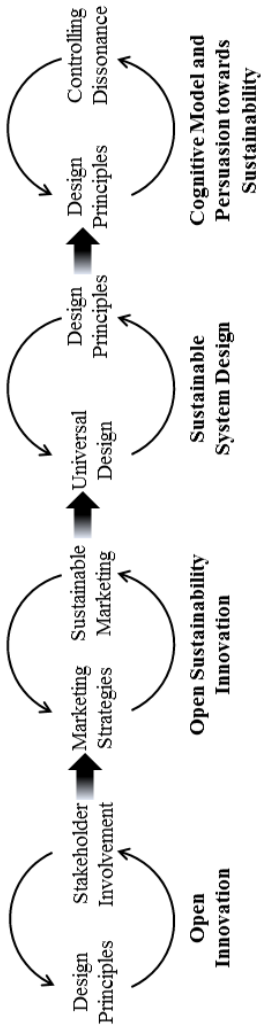

Figure 1: An iterative information system design process for sustainability.

systems (IS) can contribute to sustainable development in different ways. Nevertheless, the success of IS would typically depend on its design. Identifying sustainability boundaries in an absolute way is impossible, which makes it more challenging for sustainability in a system design scenario [4]. The complexity of sustainability and its associated indicators therefore bring new design challenges for the IS designers. This furthermore introduces the challenge of defining an appropriate IS design process for sustainability, because IS cannot be conceptualized within the limit of a software system and also the embedded concept of design is growing fast. Thus it becomes a new IS design challenge to bridge and align business and computer science using theoretical foundations from information and computation, and a disciplinary gap in the research of IS design is thereby noticeable. This problem could be handled by knowledge contribution from other interdisciplinary research domains, for example HCI. Since the pioneering research paper by Blevis [1], the importance of sustainable HCI has been shown in the increase of research in this domain [2, 10, 11]. In this paper we show how knowledge tailored from HCI could be used to fill an identified disciplinary gap (a design process for sustainable system design) in IS research. The research question here is therefore: “how to structure and support the design process of an information system for sustainability?”. As an answer this paper provides a design process in the form of a theoretical framework.

Sustainability and IS Design

Information systems are considered as a designed sociotechnical artifact. One of humans largest perils and challenges at present is how we can reach sustainability. IS are pervasive in our daily life and it becomes essential to include sustainability in the design if we are to reach sustainability. It is noted from previous research that a lack of acknowledging this in the current sustainable HCI research is apparent. What is missing is a holistic view and not simply to look at, for example, the energy use of a certain artifact and limiting the scope to an often delimited system [10]. Since for different research fields the term ‘design’ has different meanings, the understanding of ‘design process’ is thus also contextual. Generally a design process should reflect a set of processes in the form of a flow, where the target is to produce a desired goal by following the involved set of processes. But designing the right process itself is one very important challenge. Thus, if we want to support an IS through some specific factors, then the overall design process of that system should be tailored accordingly for the end system to act as a cause towards those factors. The need for an IS for sustainability thus takes us back to the initial requirement of developing a proper design process, which justifies the rationale of this research.

Foundations and Structures of the Proposed Design Process

Our proposed design process in the form of a theoretical framework (see Figure 1) is based on the underlying concepts that originate from the five previous research works referred to in [5–8, 10]. Under the economical, ecological and social dimensions of sustainability, Fiksel [4] exemplified several conventional sustainability indicators. We considered these indicators and showed how they would fit within the context of our theoretical framework. The four triggers of the proposed framework that are concluded from previous researches are shown in Table 2. The principle underlying selection rationale of these four triggers is focused on the concept of user-centered design. Table 1 shows different sustainability indicators with their corresponding triggers from our theoretical framework. Seven design principles for designing an information system

Indicators	Design Triggers
Customer retention. Business interruption. Direct and contingent costs. Revenues.	Open innovation
	Open sustainability innovation
Material consumption. Energy consumption. Local and Regional impacts. Global impacts.	Open sustainablity innovation
	Sustainable system design
Quality of life. Peace of mind. Safety improvement. Health, welleness and disease reduction.	Cognitive model and persuasion towards sustainaibility
	Sustainable system design

Table 1: Sustainability indicators and associated triggers.

for sustainability were then formulated. Each design phase from the process is now described here. Both open innovation and open sustainability innovation consider stakeholders to build new knowledge in design for organizations, where the latter specifically focuses on sustainable creation. Due to the stakeholder's involvement, their relationships with different business interruptions could be taken care of by an open innovation policy. Several direct costs associated with product design and development reaching the hands of end users could be controlled by advancing the marketing policy in an organization, where open sustainability innovation can play new key roles. Similarly, for different types of tangible and intangible revenues, it would be possible to make stakeholders understand different potentials through open sustainability innovation. Development and policy alternation as required could occur by following the proposed sustainable system design life cycle. Different impacts at local and regional levels could be handled using open sustainability innovation principles by looking at design from the perspective of a specific cause. Complex ecologically associated issues, like material and energy intakes, together with broader global impact realization, could be handled by policy alternation in the development phase. System development life cycles aimed specifically for sustainable system design (e.g. [10]) would allow this to happen. For the operational level of a design process, proper actions should be taken to achieve a goal and thus new problems could be identified. Complex social issues, like improving the quality of the life, trusting the community, different safety improvement and health related issues, are societal sustainability indicators that are not achievable in a short time. These issues could be reflected in design by the action and practice of an improved design cognitive model (e.g. [7]). Selection of the right design principles (e.g. [7]) would help in achieving these goals.

Design Triggers	Research Source	Results
Open innovation	[5]	Design principles
Open sustainability innovation	[8]	Design principles & marketing knowledge
Sustainable system design	[6, 10]	Life cycle & design principles
Cognitive model persuasion	[7]	Design principles & cognitive model

Table 2: Four triggers as design phases in the framework.

Discussions

The emphases on this unique proposed design process are highly focused on designing the process itself. Existing design processes or system development life cycles found in the literature are very abstract and do not actually clearly specify what actions need to be taken for a particular design challenge. The use of our proposed framework can thus be crucial for looking into the issues of process related sustainability. Fiksel [4] argued that the success of a system's design with an explicit thought to sustainability would depend highly on the proper consideration of the associated subsystems. By following this argument the proposed design process in this paper can be seen as an applicable one. The belief that HCI can be important when searching for solutions to complex and imminent problems challenging our society can be traced back to Douglas Engelbart, who in 1962 wrote about bootstrapping human intelligence [3]. Achieving sustainability through IS design is thus a critical task that could benefit from an approach based on sound HCI theorizing. The fundamental of this paper's theoretical framework is thus a good example of this argument. Nevertheless, this paper is theoretically

Seven Design Principles

- Use open innovation for a better control over tackling business interruptions and customer retentions.
- Practice open innovation at the small scale system level for improved control of different associated costs and revenues.
- Alter policies on strategic marketing by involving stakeholders in the knowledge gathering process by using open sustainability innovation.
- Use universal design and its extended concept for designing systems to enable ecological actions for sustainability.
- Follow a sustainable system development life cycle for designing complex systems to manipulate on global sustainability triggers.
- Use contextual cognitive models for persuading the involved stakeholders towards social sustainability.
- Design persuasive systems for stakeholders to change their dissonance on complex social phenomena like community, health and wellness.

positioned with a large connection to practice and has practical design implications to sustainable IS. It is thus not focused on problems with new technology, which Norman [9] described as the predominant research topic in HCI initiating a research-practice gap.

Conclusions

In this paper we have clarified the scope of sustainable information system design by introducing an iterative design process. Based on the previous researches our theoretical framework proposes an iterative design process. This paper complements the accumulated sustainable HCI knowledge and brings new perspectives on how to reach sustainability by using HCI. Placing a strong emphasis on describing different HCI designs would thus build cumulative reusable design knowledge for information system design, as presented here.

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