Toward Ontology of Designer-User Interaction in the Design Process: A Knowledge Management Foundation

In this study, we explore an ontology of designer-user interaction with a knowledge management foundation, because previous interdisciplinary design studies have not formalized the types of designer-user interaction. To address this research gap, we ask the following research question--What types of knowledge on designer-user interactions are associated with design function and approach in creating effective design outcomes in a collaborative design process? Based on ontology on a knowledge management foundation and ninety-nine design projects, we conceptualized the ontology of designer-user interaction, which considers design role, function, approach, and outcome as a knowledge of designer-user interaction in the design process. Based on this ontology, this study presents a case study of how this ontology could be applied into the actual projects.

Keywords **-** ontology, designer-user interaction, knowledge management, design process

Introduction

Web 2.0 philosophy has opened theoretical and practical directions of sharing knowledge, and the current ICT-enabled design innovations have facilitated actual business models and successful business design applications leading to the creation of a ‘sharing economy’ (Dowell, 2015; Rifkin, 2014; Stephany, 2015). Sharing economy companies such as Uber, Airbnb, and Freelancer represent the successful business models of how individuals could generate revenue from sharing their own knowledge, performance, and belongings with other people in our everyday life. Yet, these business-design innovations are still in the nascent stage, and business-design managers continue to face challenges in developing new design features and functions that have business impact in the market.

The current business-design paradigm has evolved from being industry-oriented to a customer (user)-centered one in the knowledge society. The design environments for identifying reliable design and business opportunities have been complicated, because radically changing technologies and users’ invisible behaviors and knowledge have been challenges in creating new social design and innovations (Redstrom, 2006). In this knowledge era, design enhanced the meanings from visible functionalities of products and systems to users’ invisible interaction patterns, and experience of services. While companies have made progress in developing features and functions of existing products, they do not yet have enough knowledge of their customers and their behaviors. To decrease gaps about customers’ knowledge between designers and users, new product designers need to pay more attention to understand users and their knowledge in the process of new product and innovation development (Park, 2012, 2013; Redstrom, 2008). Therefore, understanding users and their knowledge has been highlighted as the critical factor in creating better business-design outcomes in the design process.

User-centered design (UCD) community has sought to theorize the importance in capturing the knowledge on users and highlights interactions between ‘designers and users’ directly and indirectly in their design approach. On the other hand, participatory design (PD) research community has considered multiple stakeholders’ participation, and they advocate the design knowledge of ‘users as designers’ in creating new design ideas and opportunities during a design process. With radically changing design environments, these two design communities support incorporating users’ knowledge into the design process and have developed theoretical and practical design views, methods, and methodologies effectively. Doblin (1987) recognized the developing business-design industries called for more systematic knowledge and approaches in the design process, and he put forward two design dimensions of the changing design environment. First, design as a process consisting of analysis, genesis, and synthesis. Second, design as state, with three levels of complexity. With these two dimensions, he proposed a design knowledge matrix, dealing with six types of effective design methods. The matrix expanded the meaning of design and focused on the importance of system approaches in the contemporary design contexts. Although this design knowledge matrix suggested methodological improvement for adapting complex design

environment, it did not consider users' knowledge environment directly. On the other hand, a few UCD and PD researchers have argued the importance of interactions between designers and users (Cross, 2001; Ehn, 1993; Kyng, 1991). In their studies, these scholars suggested methods for designers to effectively interact with users in UCD and practical intervention methods for multiple stakeholders to collaborate and co-create with each other for deeper engagement. Yet, these studies, in general, have not formalized a theoretical knowledge of designer-user interaction for developing new design outcomes in the design process. Our study addresses this research gap and highlights 1) design function and 2) design approach as two design components for identifying knowledge of designer-user interaction in the design process.

Towards this end, in this paper, we synthesize an ontology of designer-user interaction and ask a research question as follows: *What types of knowledge on designer-user interactions are associated with design function and approach in creating effective design outcomes in a collaborative design process?*

To address this research question, we adopted ontology on knowledge management (Alavi & Leidner, 2001; Davenport, De Long, & Beers, 1998; Nonaka & Takeuchi, 1995) as a theoretical foundation to understand the designers' approach to the different types of interaction with actual users in the design function in creating design outcomes. As an empirical approach, this study analyzed ninety-nine project stories and extracted constructs in order to conceptualize an ontology of designer-user interaction with a knowledge management foundation. As a result, we conceptualize the ontology of designer-user interaction as having five components: (1) participant, (2) role, (3) design function, (4) design approach, and (5) design outcome. Each dimension is articulated as a taxonomy, and the ontology consists of 504 paths of designer-user interaction. To demonstrate the ontology of designer-user interaction, this study presents a case study of how designer-user interaction could approach the design function in creating a design outcome in a design process.

This study makes three contributions. First, it theorizes the ontology of designer-user interaction systemically with a view of knowledge management. Second, it provides a practical guideline of how designers could interact with users in the real design project contexts. Third, it highlights a design vocabulary for explicating the knowledge of how current user-centered design and participatory design practitioners could invite, interact, or co-create with actual users in the design process.

Literature Review

In previous studies, most design theorists and methodologists have highlighted designers' effective and efficient knowledge and practice, while participatory design (PD) and user-centered design (UCD) communities have considered the importance of designer-user interaction in their research disciplines. In this literature review, we summarize the previous PD and UCD researchers' endeavors in Table 1 and elucidated lessons about designer-user interaction from previous studies in

PD and UCD.

Table 1. Designer-user interaction in PD and UCD

Designer-User Interaction Process		***Description (Major Authors)***
Design Function in PD	Organizing Complex Design Environment	**Proposition 1:** organizing complex design environment and managing multiple participants 'conflicting interests in order to provide suitable design environment for multiple participants (Mumford & Ward, 1968).
	Context-centered Design Approach	**Proposition 2:** providing a context-centered design approach in order to promote multiple stakeholders' positive participation (Kyng, 1996; Suchman, 1998)
	Systems for Participation	**Proposition 3:** synthesizing information systems for multiple stakeholders' participation (Bansler, 1989; Dahlbom & Mathiassen, 1993; Hirschheim & Klein, 1989; Suchman, 1998)
	Collaborative Innovation	**Proposition 4:** leading collaborative innovations by dynamic actions and activities among multiple stakeholders (Buur et al. 2000; Buur & Bødker 2000; Burr et al. 2004; Buur & Matthews 2008)
Design Approach in UCD	Design Language	**Proposition 5:** design language as a structured design process to identify design inquiry (Luck 2003; Poggenpohl et al. 2004; Newton 2004)
	Design Prototypes	**Proposition 6:** design prototype as tangible outcomes from design actions (Suwa et al. 2000; Dorst & Cross 2001; Bucciarelli 2002; Luck & McDonnell 2006)
	Design Methods	**Proposition 7:** a variety of UCD methods for identifying users' needs and information environments (Gero 1990; Lloyd 2000; Owen 2001;Cross 2006)

Designer-User Interaction in Participatory Design (PD)

In prior participatory design (PD) studies, scholars have focused on multi-stakeholders' participation, and Table 1 presents how they have considered the designer-user interaction in the design process. In general, PD researchers have dealt with complex design issues in order to identify suitable design requirements among different people, organizations, and technologies in the design process. In their studies, they have highlighted types of design function (design actions and activities) like inviting multiple participants, interacting with them effectively, and developing their design activities efficiently in the design process. Their research can be summarized with the following four propositions (proposition 1~4): 1) organizing a complex design environment; 2) context-centered design approach; 3) systems for participation; and 4) collaboration for participatory innovation.

First, the primary question of PD literature asks how multiple stakeholders could be involved in the process of design development. Previous studies have proposed organizing a complex design environment that facilitates collaboration among multiple stakeholders. To do so, the following were considered essential: 1) space for participant to put forth their own design contexts with

reference to the design outcome (Schuler & Namioka, 1993); 2) management of multiple participants' conflicting interests (Mumford & Ward, 1968); and 3) participatory design fundamentals and theoretical underpinnings, concerning social theories (Andersen, Danholt, Halskov, Hansen, & Lauritsen, 2015; Halskov & Hansen, 2015). In PD, organizing complex design environment give a space to all stakeholders who represent their various design voices and contexts in the design process.

Second, PD research highlighted a context-centered design approach that controls conflicting interests among multiple stakeholders and suggests a solution from the design process (Kyng, 1996; Suchman, 1998). The context design proposition deals with the elements that support the discovery of core design components of projects and promotes effective organizational techniques and tools among participants in the design process. Fischer & Scharff (2000) proposed 'meta-design', comprising activities, processes, and objectives to create new media and environments that allow users to act as designers and be creative using participatory design processes in the context of a particular system. Fischer (2003) argued that a fundamental objective of meta-design was to create socio-technical environments that empower users to engage in informed participation. The suggested model explains how designers could incorporate users in the three conceptual stages: seeding, evolutionary growth, reseeding. This model demonstrates how designer-user interactions could support meta-design in the design process. Fischer & Giaccard (2006) outlined the evolution of users from passive customer to meta-designer in collaboration with designers in the design development process. They demonstrated the ways in which designers could provide the opportunities for users to act as designers in addressing and overcoming the problems of closed systems. Robertson & Simonsen (2012) argued a variety of contexts and technologies that multiple stakeholders could engage in each other in developing more dynamic contextual environments for PD.

This context centered design approach involves seeing the designer-user interaction as a collaborative construction of mutual knowledge through which design problems are defined and solutions created. It shifts the focus from how users' current knowledge is revealed to designers to how the interaction expands designers' and users' knowledge. This approach works better for the actual design process where not only solutions but also problems evolve over time (Dorst & Cross, 2001a; Suwa, Gero, & Purcell, 2000). Botero & Hyysalo (2013) suggested evolutionary co-design for elderly in everyday practices. Based on this approach, designers and users are encouraged to think beyond the knowledge within a person, department, or problem domain by reframing the current design problem and finding solutions from various domains.

Third, the participatory design (PD) studies have developed a variety of systems for malleable participation that lead participants' collaborative actions and activities in the design process. These systems are a collective resource in system design (CRA) (Bjerknes, Ehn, & Kyng, 1989), information systems development (Bansler, 1989; Dahlbom & Mathiassen, 1993; Hirschheim & Klein, 1989; Suchman, 1998), and computer supported cooperative work (CSCW) (Bansler, 1989; Greenbaum & Kyng, 1991). Sanders & Stappers (2014) argued co-design methods and systems (e.g.

probs, tookits, and prototypes) between designers and users. Van Dijk et al. (2016) also highlighted the importance of methods and objects as co-design systems that empower people into the PD process and contexts.

Fourth, PD researchers have emphasized dynamic actions and activities among multiple stakeholders to lead collaborative innovation in the design process. Buur et al. (2000) pointed out the critical issue of utilizing video in the ethnographic data or fieldwork materials, because visual data and material are the core objects to reflect real interactions between users and participants in the design process. Especially, non-participating stakeholders (e.g. designers, managers, and IT developers) could reflect on the real moments of interactions in the fields based on the raw data. Buur & Bødker (2000) presented design collaboration as a design approach that uses open physical and organizational space, in which designers, engineers, users and usability professionals can collaborate. It illustrates the reframing of usability work and discusses new usability as a competence required in the collaborative design process such as event-driven ways of working in participatory design. Burr et al. (2004) posited the limitation of tangible user interaction in projects and service design processes could highlight a particular user's tasks and contexts. To address this, they suggested two tangible user interactions techniques: (1) Hands-Only Scenario and (2) Video Action Wall. The Hands-Only Scenario is the dramatized use scenario, while the Video Action Wall is a technique on a projected computer screen. Little snippets of action videos running simultaneously help designers understand user qualities by the actions they represent. Buur & Matthews (2008) overviewed three of the dominant approaches for engaging with users in co-innovation of products and services, in which they compared the three perspectives in terms of goals, methods and basic philosophy and discussed research directions. As a result, they proposed a fundamental framework for the development of user-driven innovation.

Designer-User Interaction in User-centered design (UCD)

As Table 1 shows, user-centered design (UCD) researchers have investigated effective methods for inviting users into a design process. UCD research scholars have focused on the methodological approaches of how designers could analyze users adequately to identify design problems, opportunities, and solutions with logical directions. These endeavors on designer-user interaction can be condensed with the following three research propositions (proposition 5~7): (1) design language, (2) design prototype, and (3) design method.

Fifth, a few UCD design researchers recommended a design language to identify design inquiry as the fundamental step in a structured design process. Luck (2003) highlighted the importance of design dialogue to reveal user preference which also represents users' tacit knowledge in the design process. Poggenpohl et al. (2004) maintained lack of formal design structures in the established design literatures and suggested language as an alternative way through which designers could use design dialogue as procedural evidence in the design process. Newton (2004) suggested a design narrative model, which deals with forms of semantics and grammatical structures of how designers could analyze users and design environment in the UCD process. Steen (2011) summarized six

user-centered design approaches in generating more suitable design knowledge for complex design environments. In management studies, a few scholars maintained the value of users and the importance of designer-user interaction in creating better digital innovations (e.g. projects, systems, and services) (Menguc, Auh, & Yannopoulos, 2014; Nishikawa, Schreier, & Ogawa, 2013; Park, 2012). In these studies, researchers invited the user-centered design as a new approach in reinforcing the established information system development (Hyysalo & Johnson, 2015) and business innovation by a designer-user interaction view (Schweisfurth & Raasch, 2015).

Sixth, design prototype accounts for the relationship between design actions and the resulting outcomes during a UCD process. Bucciarelli (2002) explored the importance of design sketches, which are malleable design prototypes to connect designers' ideas. Chayutsahakij (2001) demonstrated design prototypes with four sequential design prototypes: 1) conceptual; 2) behavior; 3) procedural; and 4) appearance prototypes. Suwa et al. (2000) investigated the co-evolution of unexpected design situations that arise between design problems and solution spaces in the conceptual design process. Dorst & Cross (2001b) suggested a co-evolution model to evaluate design problem and solution dimensions over time. Luck & McDonnell (2006) showed an example of designer-user interaction in design prototype research. In this study, they investigated collaborations between an architect and building users to create conceptual or behavior design prototypes in the early stages of the building design process. To do this, they ask how user-involved conversation can acquire the required level of design information in the early stages of design process. In this way, design prototype as a tool initiates interactions among designers in order to combine users and their information environments into the UCD approach.

Seventh, UCD researchers have improved a variety of design methods (Vredenburg, Isensee, Righi, & Design, 2001) that reveal users' unmet needs and address their information environments. Using diverse UCD methods, the UCD designers have incorporated users more effectively in a design process. Owen (2001) synthesized a system design methodology to analyze design environments and users. His structured planning method allows for systematic synthesis of design solutions based on the analysis of the user's activities, functions, and environmental information. Gero's Function, Behavior, and Structure (FBS) model (1990) captured only meaningful user behaviors and optimizes the design process around them. Howard et al. (2008) considered the creative process in the engineering design and suggest an integrated creative design process model based on Function, Behavior, and Structure (FBS) to generate dynamic design narratives. Crabtree (1998) and Lloyd (2000) highlighted the importance of ethnographic research techniques and they regard them as a set of scientific methods that utilize observation and the mechanism of storytelling during a UCD process. Lai (2006) suggested a design mechanism that includes idea, agent, and role-playing as design factors for a dynamic agent-role interplay system. Kruger & Cross (2006) identified four types of designers' cognitive strategies: solution-driven, problem-driven, information-driven and knowledge-driven strategies that increase solution quality and the creativity of design outcomes. Jiang, Jachna, & Dong (2017) practically explored the methods of designer-user interaction by a care-oriented perspective in the healthcare industry. To provide an analytical method, Sharma &

Patil (2017) analyzed the current six design methodologies and proposed twofold design objectives: 1) designer's effective interaction with actual users and 2) decision in design discourse and practice.

Lessons from Previous PD and UCD research on Designer-User Interaction

This literature review summarizes seven academic research propositions on designer-user interaction from the previous PD and UCD research in Table 1. Previous PD and UCD research has indirectly dealt with the designer-user interactions theoretically or empirically. The previous PD and UCD scholars have highlighted designer-user interaction with their design functions and approaches. In their studies, the PD researchers have considered the effective design actions and activities in order to promote multiple stakeholders' participation and qualified engagement in the design project (proposition 1~4). On the other hand, UCD researchers have argued for methodological betterment to interact with users in creating better design outcomes in the design process (proposition 5~7).

We summarize that the prior PD scholars focused on *design function*, initiating better design attitude and manner (design actions and activities) for promoting multiple stakeholders' participation, while UCD studies highlighted *design approach*, dealing with effective design methods and methodologies in the design process.

Yet, previous UCD and PD studies did not document a comprehensive system that comprises theories, models, and frameworks to deal with the whole design process, demonstrating the roles of designer-user interaction, latent forms of designer-user interaction and their interaction sequence, and their design outcomes in the design process. Therefore, in this study, we address this research gap.

Theoretical Foundation

To address the research question, we use Knowledge management (Alavi & Leidner, 2001; Davenport et al., 1998; Nonaka & Takeuchi, 1995) as a theoretical foundation to support the designer-user interaction with a view of ontology. An ontology is a way of structuring and deconstructing the combinatorial complexity of designer-user co-creation. It represents the conceptualization of the domain (Gruber, 2008). It is an "explicit specification of a conceptualization" and can be used to systematize the description of a complex system (Cimino, 2006). "Our acceptance of an ontology is… similar in principle to our acceptance of a scientific theory, say a system of physics; we adopt, at least insofar as we are reasonable, the simplest conceptual scheme into which the disordered fragments of raw experience can be fitted and arranged" (Quine, 1961, p. 16). An ontology, therefore, is multi-dimensional; each dimension being represented by a taxonomy of elements on the dimension (Ramaprasad & Syn, 2015).

As a view of knowledge management, we adopt an ontological perspective in knowledge management (Fensel, 2002; Holsapple & Joshi, 2004; Sure, Staab, & Studer, 2002) to support the causal relationships of designer-user interaction in the design process. To explore roles, latent forms, a set of sequential interactions, and the resulting design outcomes from designer-user interaction,

we propose a designer-user interaction model in Figure1.

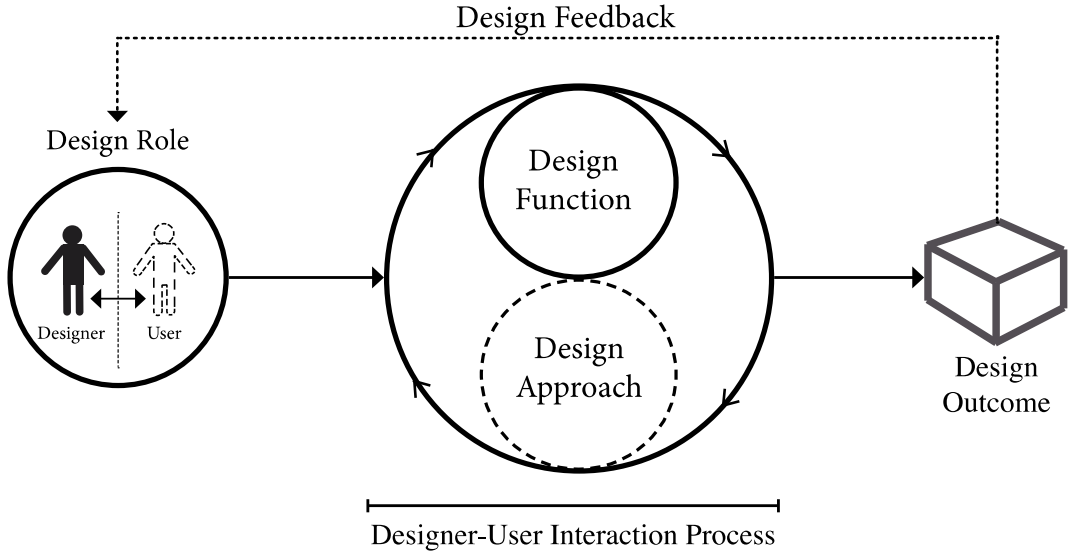

Figure 1. A proposed ontology of designer-user interaction model by a knowledge management foundation

The proposed ontology of designer-user interaction model is made up of five components as design parts: 1) participants (designer, user), 2) roles, 3) functions, 4) approaches, and 5) outcomes. To elaborate, the design participants are designers and users as major stakeholders, and the design roles could be characterized by their original roles (designer as designer and user as user) and role reversals (designer as user and user as designer). The design functions could specify designer-user interaction characteristics such as participation, interaction and co-creation. The design approaches classify design orientations such as design innovation, refinement, or reflexivity. The design outcomes determine kinds of design such as product, systems, or service design.

To understand the ontology of designer-user interaction, we consider cybernetics (Von Bertalanffy, 1973; Wiener, 1948) and devised three design systems. The design input system deals with design role by design participants (designer and user). The design process system comprises of two designer-user interaction sub-systems: design function and design approach. The design function accounts for actual designer-user interaction such as design action and activities (e.g. dialogues, prototyping), while the design approach comprises invisible design methods and methodologies (e.g. design strategy, orientation, and directions) in the design process. The design output system involves design outcomes such as products, systems, and services as the result of design system. Also, a feedback system would work to continually evolve the designer-user interaction system.

Based on this, we seek to conceptualize an ontology of designer-user interaction that demonstrates how a design inquiry system could be created with the five design parts in order to identify a wholeness of system based on Churchman's system approach (C West Churchman, 1971; Charles West Churchman, 1979; Charles West Churchman & Schainblatt, 1965). Considering Churchman's system approach, in this research, we conceptualized the designer-user interaction systems as the whole design inquiry systems with the following three sub-systems, consisting of five design

components: 1) design role, 2) designer-user interaction process, working with two design components--design function and design approach, and 3) design outcome.

Methodology

In this study, we conducted semi-structured interviews with thirty-five designers who have direct interactions with actual users in their design projects. From the interviews, we collected ninety-nine project stories that reflect our proposed ontology of designer-user interaction model (Figure 1).

The collected ninety-nine deal with ICT-enabled innovation project stories (e.g. products, systems, and services), in which designers are knowledgeable in participatory design (PD) and user-centered design (UCD) methodologies and methods. Working in the new product development (NPD), user experience (UX), and service design & advanced marketing departments, the designers shared their direct designer-user interactions or co-creations in the design process.

The objective of analysis is to elucidate the characteristics of the identified three design systems with five design components, as described in our proposed model. To do this, we followed a grounded theory approach (Charmaz, 2006; Strauss & Corbin, 1990) to analyze the collected data with the following three steps of analysis.

First, in the open coding step, we reviewed every single line of the design project narratives, using Atlas.ti qualitative research software, to identify codes, to highlight themes, and to compose memos about the transcribed project stories. In the second axial coding process, we compared the applied design actions and activities and categorized the characteristics of their designer-user interactions from the ninety-nine projects stories. We then performed a theoretical coding process to incorporate themes, codes, and memos and synthesize the characteristics of design – participant, role, function, approach, outcomes, and design feedback by designer-user interaction in the design process. As a result, we extracted themes from the ninety-nine projects stories, which represent the characteristics of designer-user interactions and the types of design outcomes from their interactions Based on this, we incorporated these codes into our ontology of designer-user interaction in Figure 2.

Ontology of Designer-User Interaction

The challenge in constructing an ontology is to transform the core logic encapsulated in the linear natural language representation of a domain into a structured natural language representation as a text-matrix. It is to transform the voluminous description of the logic of the domain into a parsimonious visualization of the same, while being true to its combinatorial complexity. A second part of the challenge is that the fragments of the core logic may be formalized to different degrees in the various locations. The logic may be implicit in the latter and need to be made explicit. A third part of the challenge is that the logic encapsulated in the research may be incomplete. The ontology has to make it complete. Fourth, and last, there is the challenge of defining the domain itself. Defined too broadly, the ontology may become too complex and unwieldy. Defined too narrowly, the ontology may become simple but also simplistic. The method of constructing the ontology is

iterative, with the objective of making the core logic of the domain and the ontology isomorphic. The logic of the linear natural language text has to be represented in the structured natural language of the ontology. And, the derivations from the ontology have to be semantically meaningful when represented in the linear natural language as text.

Based on this analysis we theorize an ontology of designer-user interactions as shown in Figure 2. The ontology has five dimensions: (1) Participant, (2) Role, (3) Function, (4) Design Approach, and (5) Design Outcome. Each dimension is articulated as a taxonomy.

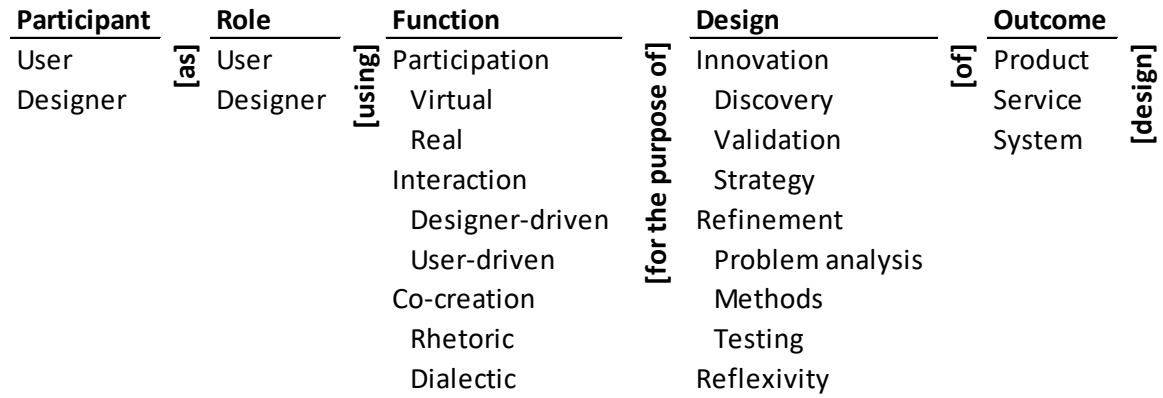

Figure 2. Ontology of designer-user interaction patterns

The left two dimensions capture the two key participants in the design process and their roles as themselves and the other.

Participant $\subset$ (User, Designer)

Role $\subset$ (User, Designer)

Thus, a User can play the role of a User or of a Designer, and the Designer can play the role of a Designer or a User. In combination, the four possibilities are (a) User as User, (b) User as Designer, (c) Designer as User, and (d) Designer as Designer. Other types of participants and roles can be added to the two taxonomies – for the present the dichotomies will suffice,

These above four combinations can be created in the context of the three functions (the third dimension) – Participation, Interaction, or Co-creation for design. The user and the designer may play the role of themselves or the other while participating in, interacting during, or co-creating the design. Thus:

Function $\subset$ (Participation, Interaction, Co-creation)

Further, Participation may be Virtual or Real; Interaction may be Designer or User-driven, and Co-creation may be Rhetorical or Dialectic – they are shown as subcategories of the taxonomy of Function. Thus:

Participation $\subset$ (Virtual, Real)

Interaction $\subset$ (Designer-driven, User-driven)

Co-creation ⊂ (Rhetoric, Dialectic)

The taxonomy of Function can be extended by adding more categories, and refined by adding sub-categories if necessary. The combination of Participant + Role + Function may be with reference to Innovation in design, Refinement of design, or Reflexivity in design – the three are shown as the taxonomy of Design Approach.

Design Approach ⊂ (Innovation, Refinement, Reflexivity)

Within Innovation the focus may be on Discovery, Validation, or Strategy; and within Refinement on Problem analysis, Methods, or Testing. These are shown as subcategories in the Design Approach taxonomy. Thus:

Innovation ⊂ (Discovery, Validation, Strategy)

Refinement ⊂ (Problem analysis, Methods, Testing)

As with the Function the Design Approach taxonomy can be extended and refined. Last, the final outcome may be a Product, Service, or a System. These are the three broad outcomes of design which can be extended and refined as necessary. The three are shown as the taxonomy of Outcome.

Outcome ⊂ (Product, Service, System)

(Note: Terms from the ontology are capitalized in the text when used individually. They are not capitalized when used in a concatenated component as in the illustrations below.)

Concatenating an element from each of the dimensions, left to right, with the connecting words and phrases generates a natural English sentence which can be a component of the designer-user interaction pattern in the design process. There are 504 (2*2*6*7*3) components encapsulated in the ontology. Four illustrative components are:

1. User as user using virtual participation for the purpose of validation of innovation of service design. For example: Users participating via Skype in validating an innovation to improve service in a hotel.

2. User as designer using designer-driven interaction for the purpose of testing design refinement of product design. For example: Users playing the role of designers and interacting with the designers to test and refine a product innovation.

3. Designer as designer using dialectic co-creation for the purpose of reflexivity of system design. For example: Designers engaging in reflexive debate in designing a system.

4. Designer as user using dialectic co-creation for the purpose of discovery innovation of product design. For example: Designers wearing the users' hat and debating potential discoveries for a product innovation.

The 504 components can be said to define the system of designer-user interaction. Each component may be instantiated in many ways. We have given an example of each above. A select set of components can be used to define the pattern of a design process systematically. We illustrate the

application of the ontology in the following case study.

Case Study

In this section, as one of ninety-nine projects, we demonstrate a case study of how the components of designer-user interaction ontology could be interplayed with each other in an actual design project (Yin, 2009). Thus, this design project case presents how the participants (e.g. designer and user) could take their design roles (e.g. designer as design as an original role versus designer as user as a reversed role), in conducting a design function (e.g. participation, interaction, and co-creation) with a certain design approach (e.g. innovation, refinement, reflexivity) in order to identify design outcomes (e.g. products, systems, services) in the design process.

Designer-User Interaction in SAP Inc.

SAP. Inc. is the biggest ERP company as the first the market leader in the Enterprise Systems Business. This project story demonstrates how the company could interact with actual users in their new product development (NPD), and it presents how SAP could develop the knowledge of designer-user interaction for their business-design innovation. To develop or release new products, the Alpha Company developed a set of co-creation workshops with their actual users for sharing company's business-design knowledge and acquiring users' knowledge such as feedback and user-driven innovation ideas (Von Hippel, 2005). .

Ontology of Designer-User Interaction in SAP

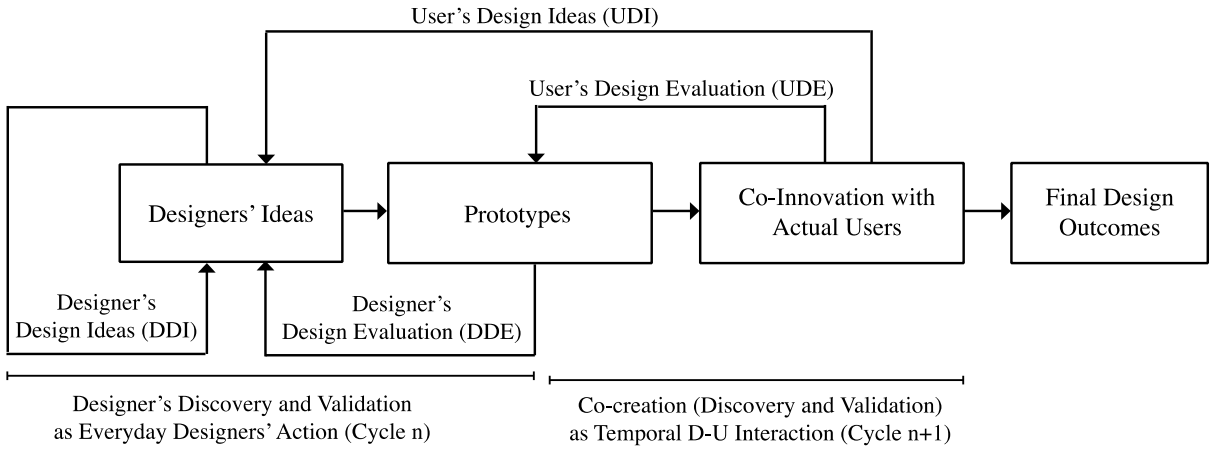

Figure 3. SAP's project story on designer-user interaction

As Figure 3 presents, the designer-user interaction of SAP has two different designer-user interaction cycles. The first cycle deals with designers' discovery and validation as everyday design interactions among designers (cycle n), while the second cycle accounts for co-creation for discovery and validation with actual users as infrequent designer-user interaction (cycle n+1).

Considering the ontology of designer-user interaction (see Figure 1), we could apply it to this design project in order to elucidate the meanings of how the designers and users as design participants could interplay with each other in generating design outcomes, concerning design roles,

design functions, and design approaches in the design process.

"Designer [participant] as Designer [role] using Designer-driven [function] for the purpose of Innovation [Design] of System [outcome]"

Applying the components of designer-user interaction ontology (see Figure 2) to this project, in the first cycle (C_1), designer (participant) took their original design role as a designer (Designer as Designer) and discovered new features and functions for identifying designer's design ideas (DDI). To generate design ideas, the SAP's individual or group designers used Axura and Invision as new product design prototype tools and developed a variety of tangible design prototypes. Based on the internal design ideas by designers (DDI), the SAP designers validated their design prototypes by themselves (DDE) in order to determine desirable, feasible, and reliable design outcomes. This discovery and validation cycle (C_1) supported how designers could identify their design ideas (DDI) and generate suitable design prototypes by their evaluations (DDE) in the design process.

"Designer [participant] as Designer [role] & User [participant] as User [role] using Participation [function] for the purpose of Innovation [Design] of System [outcome]"

The second cycle of this project illustrates co-creation with actual users in the design process (C_2). From the first discovery and validation cycle (C_1), the SAP's designers decided certain prototypes as the outcomes of designer's interaction. In the second cycle (C_2), the SAP designers entered co-innovation with the actual users. The designers of SAP invited current SAP users into their co-innovation process (C_2), and it is held as virtual or actual participations between SAP designers and actual users once a month.

"Designer [participant] as User [role] & User [participant] as Designer [role] using Co-creation [function] for the purpose of Innovation [Design] of System [outcome]"

In this monthly co-innovation (C_2) cycle, the objective is that designers directly interacted with actual users in order to evaluate their developed design ideas and qualified prototypes. In the monthly co-innovation process, the designers and the users take the reversed design roles (designer as user and user as designer) and they reflexively interact with each other with reversed roles during the co-innovation process. Users evaluate the identified design ideas based on the prototypes (UDE) and they sometimes suggest user's design ideas (UDI) directly into designers' design ideas (DDI) with a design role (user as designer). From the lessons arising out of users' design evaluation (UDE) and the users' design ideas (UDI), designers reconfigure the current design ideas and prototypes in order to release final design outcomes in the design process. On the other hand, SAP designers sought to deeply understand actual user's information environments and generate user's values into designer's everyday design activities and interactions with a design role (Designer as User).

The SAP project story demonstrates a product innovation process by Designer-User interaction. That is how designers' everyday interaction cycle (C_1) was transformed by the cycle of users' validation and discovery (C_2). These series of monthly co-innovation workshops provided a participation and co-creation space between designers and users (participants) in order to discover

users' latent desires, needs, and behavior patterns effectively with the role of designer as user and evaluate the design prototypes with the role of user as designer. In this project, the different types of prototypes act as boundary objects, which connect everyday designers' interactions as their design ideas and prototypes, reflect on users virtually. As the SAP project stories on the designer-user interaction presents, this highlights how designers can effectively communicate with both designers and users and generate effective knowledge artifacts and boundaries (Salazar-Torres, Colombo, Da Silva, Noriega, & Bandini, 2008; Shariq, 1998) between designers and users in order to identify successful design innovation.

Implication and Conclusions

In this research, we seek to provide an ontology of designer-user interaction with a view of knowledge management theoretically and empirically. This would provide positive directions and guidelines of designer-user interaction to the interdisciplinary design research communities in the management, innovation, user-centered design, and participatory design studies.

First, it conceptualizes the ontology of designer-user interaction from a knowledge management perspective (Alavi & Leidner, 2001; Davenport et al., 1998; Nonaka & Takeuchi, 1995). In previous research, designer-user interaction has been theoretically debated in the management science, information systems, and design research fields. In previous design studies, a few studies have developed ontology of conceptual design (Chen, Zhang, Xie, & Zhao, 2015; Galle, 2009). In their studies, they identified basic concepts of the scientific ontology (Chen et al. 2015) and fundamental meanings of Gero's FBS model of designing (Galle 2009). Considering the designer-user interaction, the participatory design (PD) research and the user-centered design (UCD) communities developed the concept of designer-user interaction theoretically and methodologically. PD research emphasized design function that simulates a variety of design actions and activities among multiple stakeholders' during a design process. Particularly, it is considered highly qualified engagement and co-creation among diverse stakeholders the core of a design process, and the PD scholars sought to theorize design function (e.g. ideal participation and effective collaboration actions and activities) in the design process. On the other hand, the UCD scholars explored design approach of how designers could effectively communicate with users in order to understand users' needs and their information environment in the design process. Thus, their research developed a variety of practical design language, methods, and methodologies to invite users into designers' design process. Like PD and UCD design communities, prior researchers sought to identify theoretical and methodological propositions of designer-user interaction. Yet, these studies did not present basic components of designer-user interaction as an ontology of designer-user interaction, focusing only on the design function and approach in the design process. In our study, we have presented the ontology of designer-user interaction with a view of knowledge management to overcome this gap on designer-user interaction. It highlights the types of knowledge on the designer-user interaction, and the systemic relationships among them. Thus, our study explores an ontological knowledge of how designers could interact with actual users in the design process.

Based on this, our ontology illuminates 504 paths of designer-user interaction could systemically take through design functions and approaches to create design outcomes in the design process.

Second, it empirically explores an ontology of designer-user interaction in the design process. In previous studies, researchers developed a variety of design knowledge (e.g. design methods and methodologies) of designers. The established design vocabularies considered effective and efficient design functions and approaches of how designers could create design outcomes in the design process. Although PD and UCD studies expanded the boundaries of design environments from designers to users or multiple participants, they do not document the ontological knowledge and practice of designers' activities with users and their interactions in the actual design contexts. With this research gap, we analyzed ninety-nine design projects stories, and elucidated components of the design function and design approach as distinct knowledge of designer-user interactions in the design process. As Figure 2 presents, design function and design approach reveal a cycle of how designers could work with users. In particular, the design function demonstrates tangible design actions and activities with users (e.g. participation, interaction, and co-creation), while the design approach clarifies intangible design actions and interaction with users (e.g. design strategies and orientations) in the design process. Our design ontology includes the latent cycle between design function and approach by designer-user interaction, and it provides a new type of design knowledge that deals with a design vocabulary consolidating tangible (design functions) and intangible (design approaches) design components with users in the design process.

Third, this designer-user interaction ontology provides practical guidelines of how designers could interact with actual users in the design projects. In prior designer-user interaction studies, scholars theoretically identified conceptual directions of how designers could interact with actual users. Since then, participatory design (PD) and user-centered design (UCD) scholars have addressed weaknesses of designer-user interaction and improved it from the traditional client-centered design approach. To conduct this, they invited diverse methods and managerial decisions from ethnographic research, user interviews, usability testing, or ergonomic studies. Broadly speaking, their design function and approaches have theoretically invited users into designers' design projects. Yet, it has been ineffective for practitioners to grasp the contextual interactions with users. In the actual design projects, the established design methods and models have limitations, because the established design knowledge did not support the requirements of current changing contexts (knowledge and practice) in IT, systems, user experience, innovation, and services. Indeed, complex business environments call for multiple aspects, more effective methods, and contextual relationships with users in creating successful management and innovation applications. In reality, there were no directions and guidelines to identify users and communicate with them. Therefore, this research tries to theorize the contextual inquiries that designers and users could use to create interactions in the design process. Based on the large amount of project stories (collected ninety-nine project narratives), this study sought to identify an ontology, dealing with characteristic interactions with users, in actual design contexts that designers could encounter, participate in, and engage with users in the design process. Therefore, our ontology of designer-user interaction

suggests the whole interaction context between designers and users, and it would give a positive design knowledge for explicating a practical action plan for design practitioners.

Limitation and Future Research

Like other studies, this study also has limitations.

First, we believe that the collected ninety-nine project stories as a dataset would be enough to analyze the ontology of designer-user interaction; however, an extended empirical dataset might provide richer contexts and more enhanced designer-user interaction ontology, because complex design environments could present a variety of types of distinct interactions between designers and users in an actual design project.

Second, the identified ontology of designer-user interaction might be modified or differently interpreted, because this study followed a qualitative research with a grounded theory approach. Therefore, we cannot include perfect contexts of designer-user interaction in a design process, and other studies could differently define the components and sub-components of designer-user interaction. Also, the radically changing design, technologies, and innovation environments could change the contexts, concerning their requirements in business industries or customers by their specific ways.

We believe that our study opens the ontology of designer-user interaction with a view of knowledge management, and it can be extended by diverse interdisciplinary studies into the communities of design, innovation, technology, and management. To theorize better ontology of designer-user interaction and overcome current limitations, we suggest future studies that would deal with more multi-dimensional complex designer-user interaction contexts and the enlarged design project cases to reinforce, modify, and expand the current ontology of designer-user interaction.

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