



The Role of Interaction Design in Smart Product Development Activities

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ABSTRACT

Although interaction design is a rapidly growing and even evolving design practice today, interaction designers still often have to explain what an interaction designer actually does and argue that their specialty is not something that anyone could do without a formal education both to stakeholders and clients who buy their designs. Furthermore, there still seems to be confusion when the job of industrial designers and interaction designers are overviewed together. The aim of this article is to build a background for the role of interaction design in smart product development activities within relationship to industrial design. Based on its strong roots within industrial design, this study also aims to present the relationship between industrial design and interaction design in the same activities. We conducted this research by having an interdisciplinary literature review and a field research consisting of 2 phases such as a series of interviews and a case study. The most extensive collaboration between industrial design and interaction design is seen at *Planning* and *Concept Development* phases which are the very early steps of product development activities. Compared to industrial design, interaction design is foreseen to have a wider activity area, a more strategic role in especially in early design process such as *Planning*, *Concept Development* phases of smart product development activities.

Keywords: Interaction design, industrial design, design practice, design processes, role sharing

INTRODUCTION

Industrial design, as a professional practice, has been influenced and continues to be influenced by different dynamics activity wise and content wise throughout its history.



One of these dynamics which affected industrial design strongly is the arrival and development of information and communication technologies (ICT) (Moggridge, 2007; Valtonen, 2007; Cooper et al., 2007; Akoglu & Valtonen, 2012; Akoglu and Valtonen, 2014). Developments in ICT shifted industrial design discipline and practice from the notion of product as object to product as event by the need of understanding dynamic and interactive products better within the scope of human behaviour. Creating new types of products, complex version of existing products, documents, environments and services have become widespread (Buchanan, 2001; Sato, 2001). Based on the developments above, it is clear that the professional landscape in design has been changing. These changes have triggered a change in professional landscape and new design professions emerged in smart product development activities. One of these professions is interaction design.

The emergence of new design professions such as interaction design in design processes defines new areas for design but also causes existing design professions such as industrial design to re-locate itself while it works together with interaction design. As a core example for this study, Ulrich and Eppinger (2004) put industrial design practice that was supposed to include issues about aesthetics, ergonomics and user interfaces together whereas engineering design included mechanical, electrical and software design. Overbeeke and Hummels (2014) argue that industrial designers were not able to catch up with the development of ICT in terms of interactions embedded in products in these words:

The development of technology intensified; the size of the microchip decreased and, simultaneously, its possibilities increased. The technology push spurred on the functionality of appliances, thus offering the user unlimited possibilities and an enormous supply of electronic and digital products. Industrial design missed out on this major industrial development; designers missed the electronic boat, more specifically 'the interaction with the ungraspable'. The design of the physical form and the design of the interface of interactive products were separated. (Overbeeke & Hummels, 2014).

Nelson and Stolterman (2012) states about the collaborative nature of design and put forward that design activities are group activities with roles that have complex relationships. In the same way, smart product development activity undoubtedly requires a teamwork including different practitioners from diverse backgrounds such as design, engineering, marketing, management and such together with issues in close connection to the culture and structure of organizations and to the individual and team motivations. What we would like to do in this paper is to zoom into the role of interaction



design in smart product development activities with a specific focus on its relationship with industrial design in the same activity.

This study was conducted via an interdisciplinary literature review and a field research consisting of two phases such as a series of interviews and a case study based on a specific product's early design process. The literature review included different fields such as industrial design, human-computer interaction, software development and the development of ICT. The interviews, as the first phase of the field research, were conducted to examine how the field of study has been perceived; to examine definitions, design and development processes within a general perspective and the potential roles of industrial design and interaction design with the support of key contacts from leading design consultancies at Silicon Valley in USA. The second phase of the field research was a case study based on a representative product's literature review, user feedbacks and interviews with experts from different professions on the product's early design process to understand the roles of industrial designers and interaction designers. We put significantly representative quotes from the 2-step field study to point out the existing and potential roles of interaction design in smart product development activities. This study was finished in 2010 and then updated by the recent literature review.

The paper begins with a brief explanation on the changing role of industrial design as a profession in product development activities and followed by an explanation of the role of interaction design in software development activities and in human-computer interaction field within a historical perspective in order to understand the current situation of both industrial design and interaction design professions. The research method, findings of the interviews and the case study are discussed respectively. The study concludes by redefining the roles of interaction design and industrial design based on Ulrich and Eppinger (2004) in smart product development activities.

METHODOLOGY

The empirical data for this research was gathered through a series of interviews and also a case study based on a product's process. We had the field research part of this study in the Silicon Valley, USA. The reason for choosing the Silicon Valley in USA is that not only it has been accepted to be the centre for designing smart products, but also has been the centre for key institutes and companies such as Xerox Parc, Stanford Research Institute (SRI), Apple and IDTwo in the history and development of interaction design.

The interviews, the first phase of the field research, were conducted face to face in Silicon Valley, USA with five key professionals from leading design consultancies that have



pioneer work in creating innovative smart products internationally, such as IDEO, Cooper Interaction, Smart Design, Swim Interaction Design Studio and LUNAR Design. The interviewees were Bill Moggridge (Co-founder, IDEO), David Cronin (Head of Interaction Design, Cooper Interaction), Gitta Salomon (Founder, Principal, SWIM Interaction Design Studio), John Edson (President, LUNAR Design), Sheila Foley (Smart Design, San Francisco office).

The second phase of the field research was as a case study based on a representative product's literature review and interviews with professionals who worked in its design and development process from different disciplines. After a review of secondary resources to select specific products which had the possibilities of being representative ones, product selection criterion was prepared, we got in contact with firms and design consultancies such as Apple, Nokia and LUNAR Design. We conducted the case study on a product called Pasco Spark which was designed by LUNAR Design and was launched to the market in 2008 autumn. Since the subject of the case study was a product which was a very new one at the time of the study, there were actually just very few sources about using the product, the design process, user feedback and such. The interviewees of this case study were the design manager, the user researcher, the industrial design lead and also the interaction designers who worked throughout the product's design and development process. This set of interviews was conducted through the Internet.

The interviews were semi-structured in both sets of the field research. The data were connoted using broad headings which were prepared before the interviews and the case study. Under these headings, personal opinions and reflections were differentiated from statements that could be validated through other data. At this stage, also statements for some more specific issues such as integration of interaction design in product development activities, role sharing, tools and methods, user interface design-themes that had appeared frequently during the transcription process-were also connoted. Both sets of the interviews were transcribed and then sent to the interviewees for approval and information. We classified the data gathered from the interviews into groups (themes) which we identified according to the literature review. We produced the overall data of the research by content analysis and conversation analysis. Content analysis provides a way of treating interview data as capable of yielding quantitative findings (Krippendorff, 2004). But as we embraced qualitative methods in this research, we did not use the last stage of content analysis which enables interview data turn into quantitative form. Instead, we used conversation analysis in order to interpret the qualitative interview data.



The first phase of the field research, the interviews, has a general scope when compared to the second phase, the case study. The scope of the interviews has been how the research subject is perceived and practiced in industry; finding out the generic design processes of design consultancies, the relationship between industrial design and interaction design in the same activity and possible roles of those two disciplines. On the other hand, the case study has concentrated on a specific product's design and development process aiming to clarify roles of industrial design and interaction design step by step; also the relationship between two design professions in the same activity. As Yin (2003) states, the case study research method as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used.

PHASE 1: THE INTERVIEWS

We conducted the first set of interviews in order to find out how the field of study has been perceived; to examine definitions, design and development processes within a general perspective and potential roles of industrial design and interaction design with the support of the key contacts from leading design consultancies as mentioned at Silicon Valley in USA. Some of the design organizations in which our interviewees used to work did not have in-house interaction designers or industrial designers based on the type of the activity areas the organizations were involved in. The design consultancies which we contacted with in order to have interviews, were determined due to 3 criterion: Consultancies which have both industrial designers and interaction designers in-house; in-house product design and development process; consultancies which have only industrial designers in-house; outsourcing interaction designers when required; consultancies which have only interaction designers in-house; collaborate with other design consultancies working on projects with their in-house industrial designers.

The reasons for aiming consultancies with different profiles in the first phase were to uncover the design and development processes and design approaches of the consultancies within a general perspective. We also aimed to find out in which phases these two design disciplines gather to work intensively and collaboratively and scatter to work much more within their smaller teams in smart product development activities.

The series of interviews also served as a baseline for the case study that we accomplished in the second phase. The questions of the interviews were open-ended ones in order to get as much as data from the interviewees. We prepared the questions which would fit into the following titles that we determined to create after the literature



review: (1) definitions of industrial design and interaction design, (2) generic product design and development process, (3) involvement of interaction design in product design and development activities, (4) relationship between industrial design and interaction design in the same activities.

The design process in this paper is grounded on the product development activity phases which have been put forward by Ulrich and Eppinger (2004). The product development activity consists of phases such as *Planning*, *Concept Development*, *System Level Design*, *Detail Design*, *Testing and Refinement* and *Production*.

The work of industrial design and interaction design are shown in Figure 1 according to the first set of interviews. During the *Planning* phase, both industrial designers and interaction designers concentrate on user research, needs and requirements of the client, market research data and literature review. Although both design professions concentrate on the same factors, they handle those issues from different perspectives. While industrial designers try to understand users from a perspective based on ergonomics and anthropometrics, interaction designers concentrate on understanding users' mental models and processes. At the end of *Planning* phase, both industrial designers and interaction designers have roles in creating concept, use and context scenarios. These steps in *Concept Development* phase are the ones which collaboration and cooperation are seen the most between industrial designers and interaction designers.

Concept Development phase is the one where the basic design decisions are taken. Due to the basic design decisions, both design professions create alternatives for the project. These alternatives are tested by gathering the mock-ups generated by industrial designers and paper prototypes generated by interaction designers. Both design professions generally work in their teams in *System Level Design* phase. At this point, although neither of teams is totally independent to each other, they frequently cooperate in order to discuss and exchange ideas. In *System Level Design* phase both industrial designers and interaction designers continue creating design alternatives. When the design concept has been being generated, the roles of industrial designers and interaction designers have been indefinite in terms of creating the form of the product and the location, form, colour and material of physical controls which users interact with.

		PRODUCT DESIGN AND DEVELOPMENT ACTIVITY (Ulrich and Eppinger, 2004)	
		Industrial Design	Interaction Design
PRODUCT DESIGN AND DEVELOPMENT ACTIVITY (Ulrich and Eppinger, 2004)	Planning	Stake holder research Research for sample competitor products User research (needs, preferences; especially using market research data, anthropometrics) (Cronin, 2005)	Stakeholder research (Cronin, 2005) User research (needs, preferences, mental models) (Cronin, 2005; Edson, 2005; Salomon, 2005) Field research(literature overview) (Cronin, 2005; Edson, 2005)
	Concept Development	Ergonomic considerations Product form, physical considerations, Physical controls on the product (Cronin, 2005; Edson, 2005; Salomon, 2005) Qualities of materials Production methods; production cost, etc (feasibility research) (Cronin, 2005; Edson, 2005)	Persona creation(Cronin, 2005) Generation of work flow (Cronin, 2005) Generation of use cases (Cronin, 2005; Edson, 2005) Development use and context scenarios (Cronin, 2005; Edson, 2005; Salomon, 2005) Software structure (Cronin, 2005) Software platform generation for interaction (feasibility research) (Cronin, 2005)
	System Level Design	Alternatives for the form of the product Alternatives for placement of physical controls on the product (Cronin, 2005) Material alternatives Mockups (Cronin, 2005) Research for production cost of physical controls (Cronin, 2005)	Mental models Software platforms, structure of platforms and qualities Framing Validation of scenarios Alternatives for the physical controls of the product (Cronin, 2005) Paper prototype (Cronin, 2005) Affordances (Edson, 2005)
	Detail Design	Material qualities Color, pattern (Cronin, 2005)	Graphical User Interface User perception Typography, color (Cronin, 2005)
	Testing and Refinement	Relationship between users and the product in terms of ergonomic considerations and user needs.	User and product interaction Consistency of behavior with the whole product Corporation with graphical user interface and software developers
	Production	Corporation with engineers (Edson, 2005; Foley, 2005; Moggridge, 2005)	Corporation with graphical user interface and software developers (Cronin, 2005; Salomon, 2005)

Figure 1. Roles of industrial design and interaction design in smart product development activities

What we found out according to the statement of interviewees is that industrial designers try to understand users from a perspective based on ergonomics and anthropometrics, where interaction designers concentrate on understanding users' mental models and



processes. At the end of *Planning Phase*, both industrial designers and interaction designers have roles in creating concept, use and context scenarios. These steps in *Concept Development* phase are the ones which collaboration and cooperation are seen the most between industrial designers and interaction designers. Additionally, *Concept Development* phase is the one where the basic design decisions are taken. Based on the essential design decisions, both design professions create alternatives for the project. These alternatives are tested by gathering the mock-ups generated by industrial designers and paper prototypes generated by interaction designers. Both design professions generally work in their teams in *System Level Design* phase. At this point, although neither of teams is totally independent to each other, they frequently cooperate in order to discuss and exchange ideas. In *System Level Design* phase both industrial designers and interaction designers continue creating design alternatives. When the design concept has been being generated, the roles of industrial designers and interaction designers have been indefinite in terms of creating the form of the product and the location, form, colour and material of physical controls which users interact with.

Although interaction design was considered to take part from the very first step of smart product development activities as a common aspect from the interviewees, they stated that there were different approaches in the industry. During the interviews except from IDEO, we found out that there are significant phases in which interaction design and industrial design collaborate in design and development processes. When we overviewed the design and development processes of the firms, interaction design based consultancies stated that some of industrial design based consultancies contacted with them to work together after having fundamental design decisions, even after defining the product's form. The interviewees emphasized that this situation had negative effects on the product's success and innovation (Cronin, 2005; Moggridge, 2005; Salomon, 2005).

PHASE 2: CASE STUDY

The second phase of the field research was a case study based on a representative product's early design process by interviews with professionals from different disciplines who worked in the product's process. Having gained data from the first phase of field research, we focused on the fuzzy front end of product development activities because we found out that collaboration between industrial designers and interaction designers takes the most intensive and the roles of industrial and interaction designers are the most indefinite. After having a series of criterion for selecting a product as the subject of the case study, we contacted with companies such as Apple, Nokia, Philips Design and LUNAR Design. LUNAR Design accepted to have a case study on a product which was launched to the market in 2008 autumn. The product is used for education that enables



students aged between 12-16 years old explore the world and make discoveries in basic sciences both inside and outside the classroom. The interviewees were the project manager, the interaction designers, the industrial design lead and the user researchers who worked throughout the product's design process in LUNAR Design. As well as having a role as interaction designers, the interaction designers had roles as the project manager and the user researchers in the design process. The reason for also taking a role as the project manager was because of the complexity of the product's functionality and content based on the explanations of the interviewees.

The questions for this set of interviews were prepared based on definitions, the design process and the roles. The definitions were asked to find out how different experts in the same design activity see their and other team members' roles in the same design process. We aimed to find out how the design process was handled by not only as a holistic process, but also as a process in terms of both industrial design and interaction design. In other words, it was important to find out if there were any similarities or differences in their design processes and to find out the specific roles of industrial designers and interaction designers in the same design activity. We asked the questions regarding these three aspects to all the experts even if they were not from the profession which the questions were about in order to find out what they thought about other design teammates' roles or work descriptions in the same design activity.

We asked the interviewees to define not only their work but also the work of other designers. The reason for asking questions concerning their work is to understand how they experienced their own work such as the design process, responsibilities and also other designers' processes and responsibilities in the same activity. We found out that industrial designers and interaction designers had clear information about each other's work briefs and design processes. But especially interaction designers and the project manager stated that they had difficulties with the client to get them to understand the interaction concepts. The project manager also mentioned that the client understood industrial design concepts much more easily.

Figure 2 shows the roles of both industrial designers and interaction designers in the product's design process. Based on the statements of the interviewees, the design process of the product consisted of 4 main phases such as research, concept generation, design alternatives and detailing design; these main phases covered sub-phases as well.

During the research phase while the design and development team concentrated on user research studies, the interviewees mentioned that interaction designers focused on

researching user mental models and processes. On the contrary, industrial designers focused on ergonomic considerations of users and competing products in the market. When the time spent on user research is considered, we found out that industrial designers passed over to other phases in a shorter time than interaction designers did. Thus we saw that industrial designers have already created general qualities and form alternatives about product when interaction designers just began creating concepts.

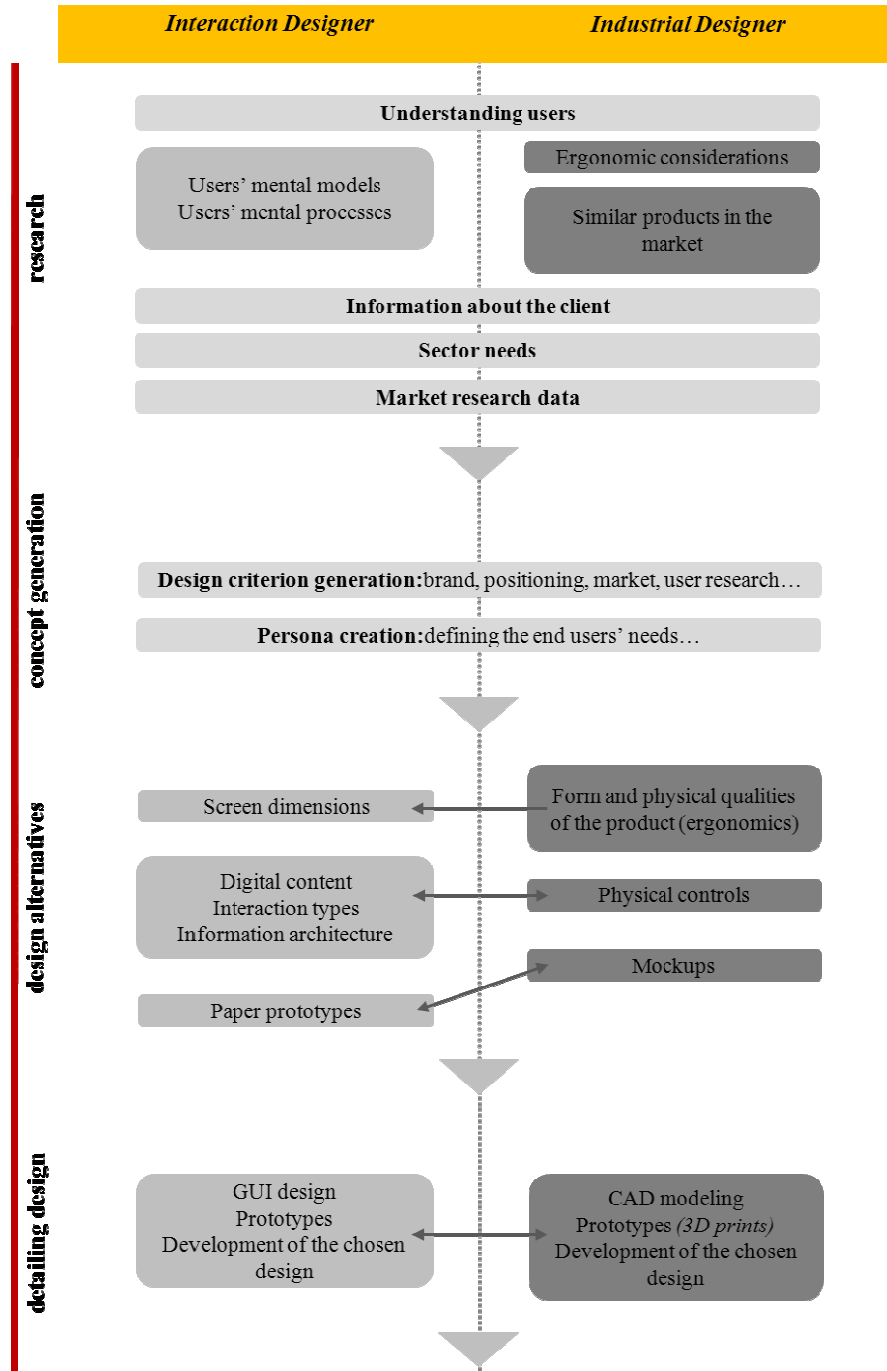


Figure 2. Roles of industrial designers and interaction designers throughout the product's design process.



The interviewees stated that during the research phase in understanding users, the interaction designers focused on researching user mental models and processes and industrial designers worked on ergonomic issues of users and finding competing products in the same market. Industrial designers and interaction designers got information about the client, its requirement and needs; then searched for the sector needs and received market research data from the client to understand the users and the sector on a larger scale. When the time spent on the user research is considered, it transpires that the industrial designers passed over to other phases in a shorter time than the interaction designers. Thus the industrial designers already created general qualities and form alternatives when the interaction designers just began creating concepts about behaviours. During the concept generation phase there were the steps to decide on what the design criterion would be. Creating the design criterion and personas have been the steps during which brainstorming sessions took place mostly.

At the next step designers created personas based on the design criterion. After creating personas, both industrial designers and interaction designers focused on creating design alternatives. While industrial designers worked on form and ergonomics considerations and created mock-ups, interaction designers worked on the content, information architecture and created mock-ups. During that step, they tried the mock-ups within the design group and also with teachers. During detailing design phase, industrial designers worked developing the design via CAD modelling and prototypes while the interaction designers worked on the graphical user interfaces (GUI) and created prototypes. After deciding on the final version of the design with the client, both designers worked towards production.

The findings of the interviews show that during the concept generation phase, roles of industrial designers and interaction designers have been imprecise in terms of creating the form of the product, the location, form, colour and material of physical controls which users interact with. In other words, industrial designers might propose ideas for interaction designers or vice versa. While the concept generation phase and design alternatives creation phase seem to be the phases which blend the activity areas and responsibilities for both design professions in a way, there are steps especially in creating design alternatives during which industrial designers and interaction designers are dependent to each other in terms of role sharing and information exchange. Figure 6 also shows this dependency between industrial designers and interaction designers during early steps of design process. According to the results of the interviews, the phase during which collaboration and corporation between industrial design and interaction design take place is concept development. During this phase there is information needed to be



exchanged between industrial designers and interaction designers; that is to say, there are sub-phases in which both designers are dependent to each other: interaction designers need to get information about the screen dimensions in which the content and interaction is supposed to be embedded from industrial designers. Thus the dimensions of the product affect the dimension and resolution of the screen and those are the factors which affect the quality and quantity of information and the interface that are supposed to be embedded in the product. But at this point, we foresee that not only industrial designers but also interaction designers might propose the mentioned dimension information. Although this information is directly dealt with the product's form and is supposed to be within the role of industrial designers, it can be accepted as type of information in terms of product's content and its dialogue with users at the same time. On the other hand, the prototypes concerning the use of both the digital content and physical content are supposed to be compatible with each other and constitute an entirety. Because of these reasons industrial designers and interaction designers are needed to work dependent and in collaboration to each other.

CONCLUSION

Ulrich and Eppinger (2004) mentioned interfaces which appeared as a part of industrial design process after creating alternative product architectures in System Level Design Phase. But interfaces require different set of skills rather than industrial designers' especially today anymore. As products become much more complicated in terms of their interaction with users gradually, interface design which is also accepted as a part of interaction design needs to be taken into consideration from the very beginning of product development activities. Moreover, because of the slightly different foci, interaction design needs to be a separate profession and a practice area during the product development activities. Moreover, designers need to work on designing interactions before creating interfaces. Creating interfaces are seen within interaction design profession. Therefore interaction designers need to be a part of the design team on its own from the very beginning of product development activities. Within this perspective, we divided the design title into two expertise areas as industrial design and interaction design in Ulrich and Eppinger's (2004) table in Figure3 to be able to re-define their roles. In this re-framed table, interaction designers concentrate on research together with industrial designers in the Planning Phase (Phase 0) while there were only designers working on industrial design in Ulrich and Eppinger's (2004) chart. In the Planning Phase, both industrial designers and interaction designers have active roles in understanding needs and requirements of users, clients and the market. as interaction designers focus on especially user mental models and processes, their role in user research studies have dominancy than that of industrial designers. Interaction designers



have more steps than industrial designers in the Planning Phase overall. In the beginning of the Concept Development Phase, both design professions have a common role in creating personas, use and context scenarios. Especially early steps of the Concept Development Phase are the ones during which collaboration takes place most intensively. After having taken essential design decisions, concept alternatives are created by both design professions. The design teams work in their smaller groups and meet frequently while creating design alternatives. The design alternatives are then tested by design teams by bringing mock-ups and paper prototypes together. In the System Level Design Phase design teams continue to work in their smaller groups.

		Design			
	Marketing	Industrial Design	Interaction Design	Manufacturing	Other
Phase 0: Planning	Market opportunity articulation Market segments definition	User Company Market needs Product platform and architecture New technologies assessment Persona creation	Hypothesis generation Research Stakeholder research User research Field research Modeling Persona creation Workflow generation Use scenarios generation Requirements Definition	Production constraints Supply chain strategy setting	Research: Demonstration of available technologies Finance: Providing planning goals Management: Allocation of project resources
Phase 1: Concept Development	Customer's needs Lead users Competitive products	Use and context scenarios Industrial design concepts Form Feasibility of product concepts Building and testing experimental prototypes	Use and context scenarios Other requirements Design Framework Elements Framework Key path & validation scenarios	Manufacturing costs estimation	Finance: Facilitating economic analysis Legal: Investigation of patent issues
Phase 2: System Level Design	Plans development for product options and extended product family Target sales price points setting	Generating alternative product architectures Choosing materials Defining major sub-systems Refining industrial design	Design refinement Detailed design	Suppliers identification for key components Final assembly scheme definition Target costs setting	Finance: Make-buy analysis Service: Identification of service issues

Figure 3. Re-defining the roles in smart product development activities (adapted from Ulrich and Eppinger (2004))



Based on the ever expanding role of interaction design in smart product development activities, conducting a research in the near future on interaction design management might contribute to both interaction design profession and smart product development activities.

Goodwin (2009) does not mention the different techniques and methods that both design professions use. However, according to the results of this study, there are differences in terms of methods, techniques and design language in approaching the design problem and understanding users between industrial designers and interaction designers. Conducting more case studies regarding this result might contribute to affect and develop thriving techniques, design and representation languages.

We have entered into an era where design has begun to focus on environments and systems as Buchanan (2001) states. As a result the two mentioned design professions, industrial design and interaction design have become even more parts of bigger system or service development activities. Hence having a research on how design could play a role in systems or service development activities might contribute to the developing focus on developing human-centred environments and systems.

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