Industrial design in a post-industrial society- a framework for understanding the relationship between industrial design and interaction design

Håkan Edeholt and **Jonas Löwgren**

ABSTRACT
Industrial design and interaction design meet in the development of ubiquitous computing or Ubicomp, i.e., the currently emerging situation where information and communication technology move from the desktop to pervade most aspects of our everyday world. We show that the material qualities of Ubicomp coincide with the areas where contemporary industrial design and interaction design overlap the least. The conclusion is that interdisciplinary approaches are urgently needed in order to go beyond turf-protective notions of labour division and external expert support. Our analysis indicates that our joint efforts should be concentrated on issues concerning Ubicomp materiality, dimensionality and aesthetics; design representation; and production processes.

INTRODUCTION

Design is, by definition, an activity that 'modifies the world'. However, the complete opposite also seems valid today: a changing world seems to modify the activity of design.

Contemporary trends in product development seem to be on the threshold of a major change regarding the kind of mainstream products that will be developed during the years to come. In a kind of ecological balance, diversification and specialization have always developed in concert with increased complexity and integration. But for some time now it has been obvious that technical integration and complexity are growing faster than diversification and specialization can balance. The imbalance has evolved to a level where we believe a more profound kind of integration is needed.

As an example, we have all noticed how telephones are becoming more and more like computers and vice versa. The two traditions seem to converge by adding both technology and functionality from each other's domain. But even when we no longer can distinguish a PDA from a mobile phone, it is still merely a small, mobile phone/computer with computational and communicative capabilities. It is a hybrid, using the phones and personal computers of today as role models and by that not only adding functionality but also problems such as increased complexity. But beyond the hybrid a new and more profound integration might emerge, with synthetic qualities rather than additive. This new integration takes use qualities as the point of departure, and pragmatically employs the technology needed in order to augment our daily life, ***as we want to live it***, rather than demanding us to adjust our lives to requirements posed by the technology. In fact, the more mature ICT (information and communication technology) becomes, the more it will be able to leave the protected nursery of personal computing and enter our everyday world in a sensible way. No more like an intrusive child craving continuous attention, but rather like a humble, skilled and mature assistant, an extra hand, augmenting our lives according to our own choices

The current impact of ICT and the potential of future developments represent huge upcoming challenges to designers. And just as the products, per se, must be developed beyond mere hybridisation of contemporary products, we believe it is due time to discuss a more advanced way of integrating the different design disciplines needed in this process. The two disciplines discussed in this paper are Industrial Design and Interaction Design, representing core actors in the development of ICT based on requirements given by the real world rather than the virtual. We sketch the background of the two disciplines and suggest a framework for discussing their integration in a constructive way. The main contribution of this paper is to set the stage for an urgently needed discussion on how design practice and education needs to adapt to the emerging contexts we are actually designing for.

THREE POINTS OF DEPARTURE

To provide a setting for the subsequent discussion, we briefly outline the background from three different perspectives. The one of the product and the one of the two design traditions at hand.

From Mechanical Systems to Ubiquitous Computing

Today the kitchen seems to be a kind of melting pot for new designs. But are there any general trends behind the hype? We believe there are; for the sake of argument, we would like to discuss well-known kitchen appliances as an illustration of more general trends.

The perhaps most important device, the stove, has remained very much the same since the days it was heated with wood or charcoal. One fire gave heat to the hob, the oven and maybe a water heater. At that time, it seemed very sensible to pull all the heating functions as close to the fire as possible. This arrangement remained long after the requirements posed by the single fire disappeared. Recently, however, we have seen how these functions have been divided into separate appliances. First the water heater disappeared, often joining forces with a separate central heating system. More lately, the hob and the oven were divided. Moreover, a range of complementary heating appliances has emerged, such as wireless water boilers, coffee machines, rice boilers, microwave ovens and toasters.

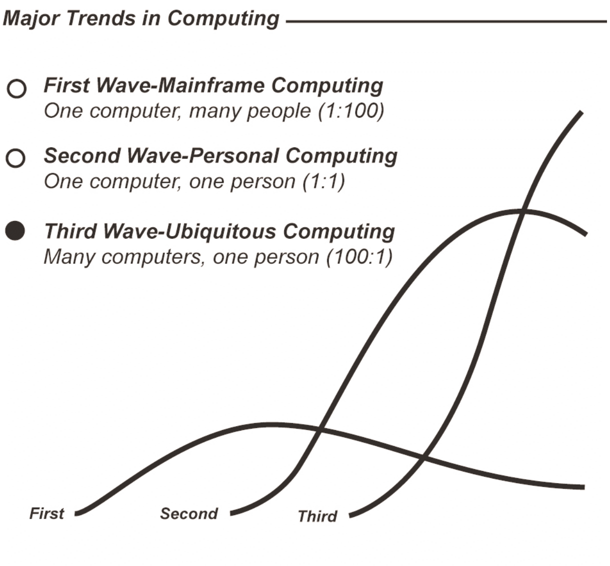
Would it have been possible to predict this evolution? Probably, as it follows a well-known pattern of division and specialization. According to TRIZ, 'the evolution of a technological system is frequently accompanied by diversification and differentiation of characteristics and functions of various segments of its working organ' (Fey and Rivin, 1997 pp.45). Using the same arguments, one could predict that we will see a very similar pattern when it comes to the opposite functionality, i.e., to keep food cold. As chilling, from a technical point of view, is more advanced than heating it is no surprise that the fridge still resembles the traditional larder. But how will it–most likely–develop in the years to come? Will it also divide, specialize and diffuse to the places where it is most needed? If that is the case we might soon see a cooled milk jug that resembles the wireless water boiler next to the coffee machine. Or, why not put a cooled decanter of water at the conference table? Or, a cooled butter dish next the toaster on the kitchen table?

However, general rules of technical trends do not only predict division but, perhaps as importantly, also the opposite: how different technologies tend to integrate in new and novel formations. TRIZ calls it a transition to a 'higher-level system' when technical systems evolve in a general direction from mono- to heterogeneous bi- or poly-system (Fey and Rivin, 1997 pp.40). Most important for the purpose of this paper is ICT integrated in completely new ranges of products. The kitchen is by no means an exception. The range of integration starts with crudely ***adding*** traditional ICT functionality on top of just as traditional kitchen technology. The prototypical example is a fridge with a display on its door (Electrolux and Ericsson, 1999). On the next level of integration, ICT is integrated in order to ***support*** traditional kitchen technology. Examples of this would be how an oven can be programmed to change its behaviour in a certain preset sequence. However, an even more advanced level of integration would be if ICT and kitchen technology were ***integrated in entirely new kind of products***. The similarities between ICT and food preparation in terms of sequential action processing are thought provoking in this respect. Starting from scratch, and given the new technical opportunities available, what kind of kitchen appliances would actually be most suited to preparing our food? Are there other ways to do it beyond the traditional kitchen appliances we use as role models today?

Another approach to understanding the forces behind the differentiation vs. integration of ICT in everyday products takes a simple axiom as a point of departure:

> *The number of computer users is increasing relatively fast but the number of computers (CPUs) is increasing even faster*

In the early days of ICT, there were only a few computers for many users. This is the phase of Mainframe Computing, where many people were served by one computer. As the number of computers increased faster than the number of users, we eventually reached the second phase, appropriately referred to as Personal Computing with one computer per person. Unfortunately, the single user and the single computer tend to exist in uneasy symbiosis, staring at each other across the desktop without really inhabiting each other's worlds. As the number of computers continues to grow faster than the number of users, we are approaching a third phase where many computers distributed throughout our everyday environments serve one user. This development, predicted by Weiser and labelled ubiquitous computing (Weiser, 1991), disappearing computing (EU, 2000) or pervasive computing (IBM, 1999), literally enforces a reconsideration of the uneasy person-computer relations of Personal Computing.



What are the characteristics of Ubicomp, apart from the user/computer ratio? First, think of the PC as a ***centralized*** and ***general*** tool, able to execute a lot of ***different*** tasks. The aspect of being both general and centralized implies that activities have to come to the computer. For a long time, more and more of the physical world seemed to end up ***inside*** the computer, with 'virtual reality' as the most extreme vision. Moreover, in spite of the generality of the PC, its basic structure is still built on the single metaphor of the traditional office. As a consequence, office work has transformed from being an administrative support for the actual activity, into becoming the 'main way of doing things'. Consequently, as designers, we are today actually designing in a context–and using tools–developed with an office clerk as the role model. Many other professions have changed correspondingly.

Ubicomp potentially represents the complete opposite. The tasks to be accomplished neither need to adjust to the computer nor be moved to it. Following the same evolutionary pattern as the traditional kitchen stove, the computers begin to come in different flavours, specialized and adapted to the specific task at hand. Instead of a 'virtual reality' we get an 'augmented reality'. The technology in itself demands less attention the more mature it becomes. Focus can therefore move from handling the tool to doing the actual task. If the designer prefers, s/he could now move back to the model workshop, but still having ICT support available at the fingertips. The car mechanic does not need an office in order to use the Internet when ordering spare parts. Instead he might use the car as the information navigation structure, ordering the part to be replaced with a specialized input device. As we will be able to pay our private bills where the act of paying makes most sense, 'home offices' might become obsolete. These specialized and ICT-augmented devices are usually called ***information appliances*** (Norman, 1999). Just like the kitchen appliances discussed before, they are highly specialized and therefore more efficient, easy to find as they are placed where they are needed most and easy to use as their specific form contains a lot of additional tacit information.

From Craft to Industrial Design

The complex evolutionary patterns where division and specialisation seem to coexist with new and novel ways to integrate is not valid only for how products like kitchen and information appliances have evolved. It could just as well be the way to tell the story of industrial design. Starting far back: Already when Adam Smith made the competitive advantages of 'division of labour' evident (Smith, 1776), he did not only pave the road for the industrialized mode of production, but also for an evolution where craftsmen either had to move in a more artistic or a more industrial direction. The main bulk moving in the industrial direction was divided into 'implementers' and 'specifiers', roughly corresponding to blue-collar workers and designers. Even though engineers initially would do the actual design, industrial design, as we understand it, eventually evolved from the need to achieve qualities in addition to the purely technical ones. At least in Scandinavia, the new profession typically grew out of two different educational traditions, the one of Arts and Crafts on one hand, and the one of Architecture on the other (i.e. roughly corresponding to the 'implementers' and the 'specifiers' of the preindustrialized society).

This background still has a profound influence on contemporary industrial design. The basic elements are the three perspectives of the artist, the general expert and the engineer. At one extreme, we can recognize the ***artist*** demanding total personal freedom of intuitive expression. The artist stands in contrast to the analytically skilled ***project leader*** who believes that mastering the design process will do the trick, and by that satisfying even the most demanding client. The third extreme is represented by the ***technology freak,*** seeing opportunities everywhere without being hampered by established engineering rules and know-how. Professional industrial designers usually represent different blends of all these three perspectives.

Even though the perspectives can be blended in many different ways, there are a few core skills that generally distinguish the industrial designer. Crucial examples include the ability to bridge the gap between the wishes of a specific manufacturing client and the needs of a general user, the ability to explore new possibilities, and the communication of these possibilities in both tangible and visual ways. Industrial design typically applies these and other skills to the three-dimensional physical products being the hallmark of industrialized society.

From Systems Development to Interaction Design

Compared with industrial design, interaction design is a very young discipline. Some would even question its existence. However, it is clear that the last ten years has seen the emergence of a new practice of use-oriented development of ICT, where methods and concepts as well as didactic approaches are increasingly informed by the established design disciplines.

This emergence, of course, coincides with the introduction of ICT in everyday life and society at large through the growth of the Internet and related technologies. From the 50s to the 80s, information technology went from being a computational tool for scientists to a critical component in most areas of business and administration. Theory and practice in ICT development followed suite, with a strong emphasis on rational support for enterprise goals. Disciplines such as information systems development, software engineering and human-computer interaction were established under the same teleological umbrella.

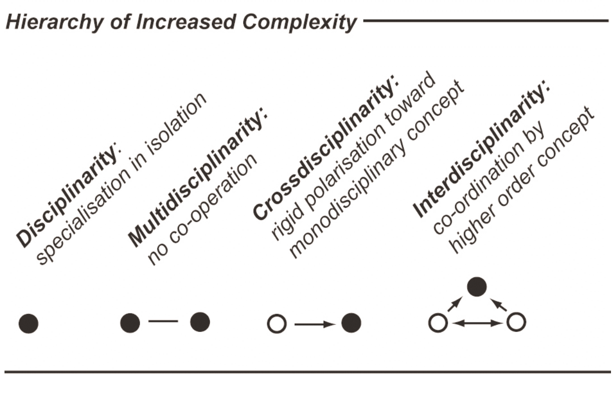
In the 90s, when computing technology and digital communication quite suddenly became attractive outside the workplace for personal and social reasons, the playing field widened. Utility and usability are no longer the only determining factors for success in ICT deployment. Use becomes discretionary. Symbolic values and affective qualities of the use strongly influence the decisions to take up and continue to use a certain design.

Interaction design has grown out of this development (which is further detailed in Ehn & Löwgren, 1997). It is characterized by viewing ICT development as a design discipline, in the strong sense of the word. At the same time, it is marked by its heritage in enterprise-oriented fields such as information systems development and human-computer interaction, as well as its professional ties to the IT and telecom industries. The growing pains are significant and there are more debates than consensus on the nature and delimitations of the field of interaction design (see, for example, Alben, 1997; Löwgren, 2001; Winograd, 1997). Still, it is a fact that more and more people work in, study and teaches the ***design*** of ICT (as opposed to the development or engineering of the same). Hence we claim that it is relevant to start analysing it in terms of a discipline, and particularly its relations to industrial design in the face of ubiquitous computing. That is the purpose of the rest of this paper.

DISCIPLINARY INTEGRATION

An obvious starting point for the discussion of disciplinary relations is the seminal work of Erik Jantsch (1972). This is the original source of concepts such as multi- and interdisciplinarity, concepts that have subsequently gained widespread use (and abuse) in everyday discourse. For our purposes, it will be necessary to briefly review the original intentions of the work.

According to Jantsch, the notions of multi-, cross- and inter- represent three levels in an evolutionary hierarchy. Discussing disciplinary integration, he takes the traditional disciplinary approach as a point of departure. If the traditional disciplinary approach is specialization in isolation, ***multidisciplinarity*** simply refers to adding different isolated disciplines without any direct cooperation in between (as a technician and a designer, working independently, coordinated by an external project leader).



The next step on the evolutionary ladder would be *crossdisciplinary*, where one discipline supports the other within the other's own discipline (as when a technician is brought in to facilitate some technical aspects of a designer's concept).

Interdisciplinarity is the most advanced step. It involves direct cooperation in both directions, where the outcome typically could not be achieved entirely within any of the disciplines involved (as a technician and a designer working closely together, and by that developing entirely new kinds of artefacts and/or experiences).

A FRAMEWORK FOR THOUGHT AND ACTION

In order to better understand the relations between industrial design (IndD) and interaction design (IntD), it is helpful to analyse them both in terms of a few key dimensions. We have identified three dimensions each for the general areas of the ***Process***, the ***Material***, and the ***Deliverable***. The dimensions are accordingly labelled P1-P3, M1-M3 and D1-D3 below.

Each dimension has two aspects, which are not to be confused with endpoints on a linear scale. For some of the dimensions, the aspects are more or less opposed in the strict sense, but in general it is perfectly possible for a discipline to score high on both aspects.

For each aspect, the disciplines of industrial design and interaction design are scored on a three-point scale: the discipline is ***highly*** oriented, ***somewhat*** oriented, or ***not to any significant degree*** oriented towards the aspect. The scoring of both disciplines was made independently by the present authors and then joined, showing an interrater agreement of 92%.

The scores represent our understanding of the current best practice in the respective discipline, as opposed to ideal or desirable ways of working that are proposed by visionaries or found in isolated cases but not in the mainstream practice. We want to emphasize here that we study highly simplified characterizations, ideal types rather than broadly descriptive statistics of the two disciplines. Still, the simplifications are not entirely ad hoc but based on our experience from many years of core membership in the respective professional and academic communities involved. It is our hope that the dimensions we propose and the assessments we make of industrial design and interaction design can serve as useful tools in the ongoing process of synthesis and transgression.

P1. Design process [explorative, analytical]. An *explorative* design process is open and searching, in terms of problem framing as well as proposed solutions. It is acknowledged that the understanding of the problem and the ideas of appropriate solutions grow in tandem, where partial solutions can be proposed early in the process with the purpose of probing the design situation and reframing the problem. An explorative process is also divergent at times, in the sense that it develops multiple alternatives. An ***analytical*** design process starts from the assumption that the problem can be analysed and specified first, then solved through design. A common ambition is to formulate requirement specifications that drive the design and development process in a traceable way, and provide the baseline for delivery testing. If the requirements in the specification are fulfilled, then the design process is successful.

Industrial design processes are ***highly*** explorative, ***somewhat*** analytical.
Interaction design processes are ***not significantly*** explorative, ***highly*** analytical.

P2. Design representation [depictive, symbolic]. *Depictive* design representations, simply put, look like the intended final result. Examples of depictive representations are sketches at various levels of detail, volume models in various materials, and presentation drawings. A ***symbolic*** representation is one that expresses aspects of the final result other than its appearance. For instance, flowcharts, information structure diagrams and user task sequences are examples of symbolic design representations.

Industrial design representations are ***highly*** depictive, ***not significantly*** symbolic
Interaction design representations are ***not significantly*** depictive, ***highly*** symbolic.

P3. Production process [physical, virtual]. Once an artefact has been designed and constructed, it has to be produced for consumption. ***Physical*** production refers to material artefacts that are manufactured from physical parts. The manufacturing process consumes raw materials; it requires machinery and tools. In physical production, each unit to be produced carries a production cost that sometimes represents a significant part of the consumer price. ***Virtual*** production, on the other hand, refers to software and similar artefacts which in principle have no production cost. Once the first instance of the final product is completed, it can be manufactured in infinitely many copies with costs incurred only for distribution.

Industrial design production is ***highly*** physical, ***not significantly*** virtual.
Interaction design production is ***not significantly*** physical, ***highly*** virtual.

M1. Material [tangible, virtual]. A ***tangible*** design material is one that is built out of atoms that can be touched and sensed. To continue the figure of speech, a ***virtual*** design material is built out of bits. Virtual materials correspond roughly to the notion of software.

Industrial design materials are ***highly*** tangible, ***not significantly*** virtual.
Interaction design materials are ***not significantly*** tangible, ***highly*** virtual.

M2. Dimensionality [spatial, temporal]. A ***spatial*** design material extends mainly in the three dimensions of physical space. Concepts such as volume and three-dimensional form are closely connected with spatiality. ***Temporal*** design materials unfold over time. Temporality entails concepts such as story and interaction.

Industrial design dimensionality is ***highly*** spatial, ***not significantly*** temporal.
Interaction design dimensionality is ***not significantly*** spatial, ***highly*** temporal.

M3. Aesthetic focus [visual, experiential]. A ***visual*** aesthetic focus is concerned with the form of an existing or proposed artefact in itself. An ***experiential*** aesthetic concentrates on how the existing or proposed artefact is perceived, mainly in terms of its use.

Industrial design aesthetics are ***highly*** visual, ***somewhat*** experiential.
Interaction design aesthetics are ***not significantly*** visual, ***highly*** experiential.

D1. Scope of deliverable [product, use]. The ***product*** scope of a deliverable implies a perspective where the artefact itself is at the focus of attention for manufacturing, marketing and retail. If the deliverable is scoped in terms of ***use***, then the artefact is embedded in multiple layers of activities and other artefacts, making it more of a service offer.

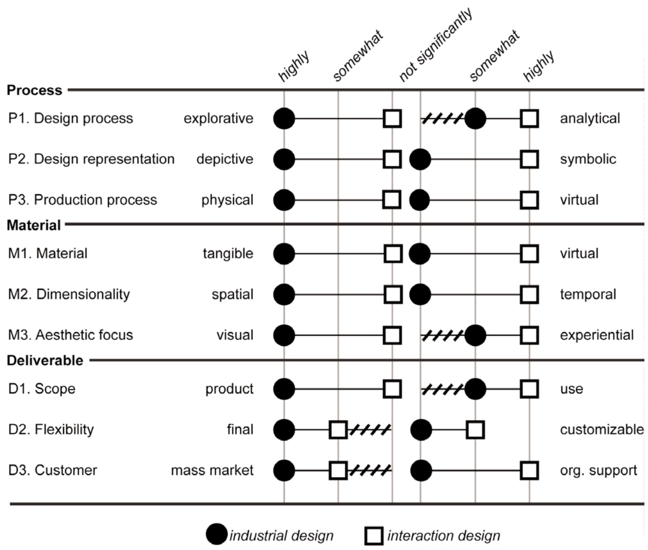
Industrial design deliverable scope is ***highly*** product, ***somewhat*** use.
Interaction design deliverable scope is ***not significantly*** product, ***highly*** use.

D2. Flexibility of deliverable [final, customisable]. A ***final*** deliverable is relatively static after delivery. It is largely used as delivered and in particular, no functional modifications to the artefacts are anticipated by its designers. ***Customisable*** deliverables are intended to be modified and further developed after delivery. Customisation is sometimes performed by the customers, sometimes by the designers or by third-party actors.

Industrial design deliverables are ***highly*** final, ***not significantly*** customisable.
Interaction design deliverables are ***somewhat*** final, ***somewhat*** customisable.

D3. Customer for deliverable [mass market, organizational support]. A ***mass market*** view of customers entail consumer-oriented marketing, large numbers of potential customers that are essentially unknown to the designers, and in most cases the possibility for the customer to choose whether to buy and use the product. On certain markets, the mass-market view also implies competition between products aimed at the same customer purchasing decision. An ***organizational support*** view of the customers is related to bespoke development, consulting and contracting work where a single customer organization receives a tailor-made deliverable. Typically, the eventual users of the deliverable are identified and relatively few. In many cases, they have no choice of whether to use the deliverable or not.

Industrial design customers are ***highly*** mass market, ***not significantly*** organizational support.
Interaction design customers are ***somewhat*** mass market, ***highly*** organizational support.



As the diagram shows, each of the disciplines has a rather clear orientation towards one of the aspects for most dimensions. The overlap between the disciplines in this analysis as a whole is only 14%, with four dimensions showing zero overlap, four showing 25% overlap and the Flexibility of deliverable dimension showing a 33% overlap. Our intention here is not to use these observations for quantitative analysis or descriptive statistics, but rather as a basis for a discussion of the relations of industrial design and interaction design in the face of ubiquitous computing.

According to Jantsch, the entrance level of disciplinary relations is the ***multidisciplinary*** approach. In our case, it would typically be enacted in processes where industrial designers and interaction designers work separately on the same product, either in a sequential or a more concurrent mode. Coordination of the work is typically done on the different ('higher') level of project management. One of the main advantages of multidisciplinary work is that neither industrial designers nor interaction designers need to change their accustomed ways of working dramatically. As long as there are useful specifications with clear interfaces to the other discipline, the designers can continue to do their work much like they have always done.

This explicit division of labour is feasible mainly in cases where the product to be designed has a standardized set of interaction modalities, such as a keypad and a small display on a cell phone. It tends to reduce industrial design to the shaping of physical form, interaction design to keystroke sequences and display layout, and product development as a whole to a process of incremental changes. It is probably safe to say that a multidisciplinary approach is the most common way today of integrating industrial design and interaction design in the ICT and telecom industries.

The next level of interest for our discussion is the ***crossdisciplinary***, where the two domains of competence are starting to integrate but always under the control of one of the disciplines. The flow of communication and coordination between the two disciplines involved is strictly unidirectional, with one discipline enlisting the other for expert support in particular tasks. Our field provides examples of the two possible directions: industrial design companies such as Ideo starting to involve interaction designers in their (increasingly digitally oriented) work, and corporate R&D institutes in the field of information and communication technology such as IBM Almaden bringing in industrial designers in their product concept development.

In a crossdisciplinary approach, short-term effects may be beneficial but the representatives of the enlisted discipline will eventually start to feel the effects of being removed from their mother discipline. The practical knowing-in-action of a designer requires a community of practice for maintenance and development; eventually the enlisted designer runs the risk of representing only received knowledge such as information from professional conferences and publications, etc. This point is made already by Jantsch (ibid., p. 222), who states that the crossdisciplinary approach 'threatens to blur aims and purposes in the development toward higher forms of coordination.'

Considering the drawbacks outlined above, it would be sensible to make a distinction between sources of inspiration and real team members in crossdisciplinary development of new products. Members of the enlisted discipline would typically play more transient roles in the process, introducing ideas, perspectives and values from their mother discipline as provocations or frame-breaking propositions. This is no panacea, however, since statements from another discipline are easily dismissed as irrelevant unless there is a clear commitment on all levels to understanding ‘the other’ and its implications. This is easier said than done, particularly in times of scarce resources and pressing deadlines. It is perhaps no surprise that crossdisciplinary inspiration approaches are more frequently employed in R&D settings than in market-oriented product development.

In ***interdisciplinary*** work, disciplines and domains of competence are truly integrated and coordinated by means of shared, higher-level viewpoints and purposes. Disciplinary contents, practices and interfaces evolve in concert to better achieve the shared goals. And, importantly, the goals will also evolve under the joint influence of the integrated disciplines. This is a crucial difference between inter- and crossdisciplinary practice, which among other things entails that interdisciplinary work has the potential to address issues and problems beyond the confines of each discipline involved.

It is hard to point to successful examples of industrial design and interaction design in interdisciplinary cooperation, for obvious reasons. Building and sustaining interdiscplinary work is extremely hard and costly; it will not take place until it is necessary. We argue that the recent development towards ubiquitous computing in all areas of everyday life represent precisely such a necessity. To substantiate this point, let us return to our dimensional analysis of industrial design and interaction design.

As illustrated by the diagram above, the dimensions of Design representation (P2), Production (P3), Material (M1) and Dimensionality (M2) show a clean bipartition with no overlap between industrial design and interaction design. This is due to the essential characteristics of the materials historically involved in the two disciplines, and how they reflect on means of rendering designs and producing deliverables.

In this perspective, Ubicomp represents a design material at odds with the historically rooted material differences. Ubiquitous computing is tangible and virtual (M1). Its dimensionality is spatial as well as temporal (M2). Its aesthetic qualities are visual as well as experiential (M3).

These material qualities in turn mean that the design representations used must be depictive as well as symbolic (P2). The production processes must handle both physical and virtual manufacturing (P3).

Hence, five of our proposed dimensions are intrinsically determined by the move towards Ubicomp. The remaining four dimensions are determined mainly by other factors. For instance, the character of the design process depends on traditions, process skills and personal abilities of participants. The framing of a Ubicomp deliverable–i.e., whether it is scoped as a product or as a use, whether it is final or flexible, whether it is a mass market product or an organizational support–depend among other things on the design situation at hand.

CONCLUSIONS

The technological and societal development towards ubiquitous computing intrinsically challenges the current relation between industrial design and interaction design in five ways.

- Ubicomp is a tangible and virtual material.
- Ubicomp has spatial and temporal dimensionality.
- Ubicomp has visual and experiential aesthetic qualities.
- Ubicomp requires depictive and symbolic design representations.
- Ubicomp requires physical and virtual production processes.

This implies that the integration of industrial design and interaction design needs to be rethought in order to address the rapidly emerging design situations of our immediate future. What we need is new concepts, tools, work practices and methods that transgress simple labor division or hierarchical expert support. In other words, we need to move beyond multidisciplinarity and crossdisciplinarity towards interdisciplinarity. How this is accomplished in professional practice, education and research is beyond the scope of this paper, but hopefully the topic of lively debate henceforth.

REFERENCES

Alben, L. (1997). At the heart of interaction design. ***Design Management Journal*** 8(3):9-26

Ehn, P. and Löwgren, J. (1997). Design for quality-in-use: Human-computer interaction meets information systems development. In Helander, M. et al. (eds) ***Handbook of Human-Computer Interaction. Second, completely revised edition***, pp. 299-313. Amsterdam: Elsevier.

Electrolux and Ericsson (1999). ***Screenfridge [Internet]*** Available at http://www.electrolux.se/screenfridge/. Last visited at 2003-01-27

EU (2000). IST Call for proposals, Feb 2000 ***[Internet]*** Available at ftp://ftp.cordis.lu/pub/ist/docs/fetdc-2.doc

Fey, V. R. and Rivin, E. I. (1997). ***The Science of Innovation***, The Technology of Innovation Engineering Series, Book 1

IBM (1999). IBM System Journal, Pervasive Computing, Vol. 38, No. 4, 1999 ***[Internet]*** Available at http://www.research.ibm.com/journal/sj38-4.html. Last visited at 2003-01-27

Jantsch, E. (1972). ***Technological Planning and Social Futures,*** Associated Business Programmes Ltd, London.

Löwgren, J. (2001). From HCI to interaction design. In Chen, Q. (ed.) ***Human-computer interaction: Issues and challenges***, pp. 29-43. Hershey, PA: Idea Group Publishing.

Norman, D. (1999). ***The Invisible Computer,*** MIT Press

Smith, A. (1776), ***The Wealth of Nations***

Weiser, M. (1991). The Computer for the Twenty-First Century, ***Scientific American,*** pp. 94-10, September 1991.

Winograd, T. (1997). From computing machinery to interaction design. In Denning, P, Metcalfe, R. (eds.) ***Beyond calculation: The next fifty years of computing***, pp. 149-162. Springer-Verlag.

Håkan Edeholt, Jonas Löwgren
Arts and Communication, Malmö University College
20506 Malmö, Sweden
+46-40-665-7000
{hakan.edeholt, jonas.lowgren}@k3.mah.se