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Integrating Interaction Design into Industrial Design Processes

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Abstract

The digital revolution is dramatically changing our world, and the ubiquitous applications of computer in our lives have made digital technology an indispensable part of the infrastructure of our living environment. Digital technology is being cleverly embedded in various products to enhance their performance, allowing the resultant products to possess the properties of both physical and computing entities. The shifting nature of products has expanded the realm of industrial design to direct its course toward the design of interaction design. Furthermore, it has reshaped the product-development process and coordination of teamwork. While the digital revolution is still progressing, this study sought to propose an innovative product-development process suitable for the post-pc era.In this research, the curricula integrating industrial design and interaction design of design-school and university programs were first reviewed, while several user-interaction oriented processes of product development adopted by the industries were also examined. The contents and procedures of user-interaction design then were further analysed. Accordingly, an innovative operational approach that integrates interaction design with industrial design was proposed. At the end, the proposed flowchart was verified and polished by the trial of its application to a practical case. The proposed new approach can be used in studio-based curricula, and its previous trials had produced encouraging and valuable results.It is hoped that, through integrating the new approach into school curricula or increasing its application within the industries, this research may inspire the designers to keep comprehensive perspectives as they embark on a new project. In addition, this research intends to encourage a new thinking in design education and methodology, as well as in product development.

Keywords

Interaction; Interaction Design; Industry Design.

1. Introduction

The digital revolution is dramatically changing the world we live in the ubiquitous use of computer enables digital technology to become part of the infrastructure of our environment. The book “The invisible computer” written by Donald Norman illustrates that technology has been seamlessly woven into the fabrics of our lives. We are getting used to the idea of using digital entities as the basic elements of products and the infrastructure of our environment to achieve quality services and performances.

Prof. Keiichi Sato at the IIT indicates that the new product paradigms are designs that link up physical and media spaces, and physical products that combine computing and networking functions into seamless infrastructures to serve our needs. [14] As products are becoming hybrid artefacts, we should regard physical design and software design as one and develop both simultaneously. Product

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design in the near future will mean to successfully translate meaningful information structures into physical forms and to smoothly install digital products into the physical structures of objects that are to contain them. In view of the ever-evolving trend in the realm of design, the IDSA（Industrial Designers Society of America）held a three-day conference named "IDSA Design About: Interactive Edges" at Microsoft's Conference Center on November 15, 2000. More than 120 designers and scholars attended the conference to explore new horizons in design. The conference was aimed at bridging the gap between current practices and the future of interaction design, and the event marked a milestone in industrial design by stimulating more thoughts on the connection between industrial design and interaction design.

Technological advancements are changing the appearances of products and the services they provide. The shifting nature of products will in turn fundamentally transform the process of developing products. New products will be developed from outside in, instead of from inside out. In other words, the user interface expected to fulfil user anticipations will be designed first, followed by the construction of the core hardware or software used to support the functions. This shift will convert the product development process into an interdisciplinary, concurrent design approach. While the domains of the related disciplines are being redefined, we as industrial designers must think about how we should define our own field as it evolves further. Today, industrial design means something more than simply dealing with the physical properties of objects, e.g. form, colour, texture, and so on. It must go further to take into account the interactive system, the operational logic and path, and new user-interaction possibilities that meet user expectations. Furthermore, the design must seek to link up the physical space with digital functions so that digital technology may work to enhance the performance of the physical entities, while the physical space serves to improve the function of digital technology as well. The aim is to create a friendly and pleasurable experience for the user by creating recognizable links between the content of the product and the user's comprehension.

A new approach that integrates interaction design into the industrial design process is proposed in this paper. It can be incorporated into school curricula or adopted by the industry while inspiring students and designers to keep comprehensive perspectives as they embark on a new project. In addition, this research intends to encourage a new thinking in design education and methodology, as well as in design practice.

2. Related work

With the broadening application of embedded computing system in consumer products, the study of various aspects of HCI curriculum is becoming an essential part of design education. Some schools are well aware of the changing climate in industrial design in terms of professional requirement, and are looking forward to devising a new approach to integrate Human-Computer Interaction (HCI) into industrial-design curriculum. Among these schools, Carnegie Mellon University (CMU) is known for having developed a user-centered interdisciplinary concurrent system design methodology（UICSM）with the collective effort of electrical engineers, mechanical engineers, computer scientists, industrial designers, and human computer interaction students to generate a complete prototype system. The method has been applied to the design of wearable computers, and the process can be broken down into four phases as listed in table 1. Some other schools, such as the universities of Loughborough and Staffordshir in UK, have begun to integrate HCI into their design curricula as well. Still some schools, such as Glasgow of Art and University of Glasgow, both in UK, seek to develop joint interdisciplinary programs looking into the human centered engineering design approach.

Table1. Four phases of UICSM

Product cycle	Task
Conceptual product	Product Definition Requirement analysis, user needs evaluation/ product design definition Technology Survey

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	Technological assessment/ mechanical form/ product feature form
Configuration design	System Architecture Specification Dependency matrix Subsystem Specification Product design specification
Detailed design	Detail design place and route/ mechanical、 electronic、 software mock-ups / thermal analysis/ task dependency graph/ user feedback
Manufacturing	Implementation Printed circuit design/rapid prototype of housing System integration

Prof. Frankel at Carleton University in Canada maintained that industrial designers should be capable of designing a good interaction system. She compared the procedures of interaction design with that of industrial design, which is listed in table 2, and then proposed an approach to integrate the processes of user-interaction design into industrial-design curriculum. The aim was to permit greater involvement of industrial designers in the related product-development process. She further pointed out that the value of this approach lay not necessarily in turning students into UI experts, but rather, it helped them see clearly their roles and duties as designers in the design process

Table2. A comparison of these processes reveals the parallels between them（by Prof. Frankel)

Industrial Design	**User Interaction Design**
Analysis and problem definition	Analysis and definition of problem
Visual ideation	Written specification for product
Visual concept development	Scenarios of use development
Prototyping	Storyboard development
Definitive design development	Detailed specification document
Production	Programmer code product
Market ready	Market ready

IDEO, a prestigious design consultancy, has developed a series of digital products with the special-purpose interaction. The consultancy basically adopts a five-stage process to carry out each design program. The process can be further explained as the followings:

(1) Understanding： Designers need to understand the context of the product: the relevant technologies, competitive environments, potential market segments, and the current forces of change in the arena where the product will appear.

(2) Observing: Observation at IDEO emphasizes the need not only to observe activities that are tied directly to the intended design, but also to get a broader view of what people do in related areas, their habits, and their concerns.

(3) Visualizing and predicting: In the third step, the designers' attention finally turns to the object or system in design. In addition to brainstorming, sketching, and prototyping, the team uses the technique of creating characters and scenarios to portray and predict how the end product will be used, the context in which it will be used, and the functionality it is aimed to provide.

(4) Evaluating and refining: In this phase, the design team carries out repeated cycles of analysing, observing, sketching, and prototyping, similar to the spiral development model.

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(5) Implementing: The end product can be presented in various forms, a written document, a software simulation, and/or a videotape.

From these examples make it clear that the design requirements for information appliances and related products inherently different from traditional industrial design requirements. Interaction design plays an essential role in the new product development. As the boundaries of computer, communication, and consumer electronic are blurring, the movement suggests exciting new possibilities but also poses new challenges in design education and practice. Creating the user experience for these products and services requires the same interaction design as the object affordance. In this study the main stress fell on incorporating interaction design into industrial design process for improving professional skills of industrial designers and posed a new thinking in design education and practice.

3. Interaction Design

User-interaction interface provides access to the internal resources of a product. It is composed of the controls, display devices, display element, and operational logic embedded in the software. Interaction design is interdisciplinary training that can be divided into three areas: information design, interactive design, and sensorial design. Detailed descriptions of these categories are given below.

3.1 Information Design

Information design is the start of any interactive project, and it represents the process of organizing and presenting data. The major tasks of information design include recognizing the demand of target users, defining the functions and contents of the product, and organizing these contents into a flowchart that displays grouped functions in hierarchical orders. Information design goes beyond categorization to mapping out a structure for the content so that the user can have a better sense of how the product works. The flowchart constitutes the basis of interactive design.

3.2 Interactive Design

The most crucial characteristic of interactive design is that it enables products to follow the path and direction of the user's activity. Interaction design converts the flowchart, which clarifies content and structure of the product, into a storyboard that specifies the operation and the user path of the product. Accordingly, the process of progressing from information design to interactive design means turning information into user experience.

A storyboard is a communication tool to visualize the sequence of user activities. By using the storyboard as a tool, designers can predict user activities in a given context to discover opportunities and problems. The user experience may then be efficiently transformed into knowledge that is valuable to the designer.

3.3 Sensorial design

Sensorial design is purposed to create the appropriate use of various media and input/output devices in accord with human senses. Every medium has its own attributes and excels in different types of communication. To create good interactive experience, designers should try to understand more about the senses and perceptions of target users. Think about how their senses function, how these senses relate to each other, and what a designer can create for them. An effective, attractive outcome of sensorial design not only is able to coordinate all sensorial details, but also is capable of fulfilling the functions and content of the product.

Based on the above analysis, it can be concluded that interaction design includes three processes: (1) information design; (2) interactive design; (3) sensorial design. Table 3 compared the aforementioned three-stage process with another three-phase model of the product-design process suggested by Archer [3]: (1) analysis: classifying and grouping gathered information to elaborate the specification; (2) creation: searching for suitable solution principles and establishing functional structure; (3) execution: developing prototype designs and conducting manufacturing documentation, and reveals the similarities between the two models. Information design aims at organizing the contents into a

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flowchart, which corresponds to the analytical phase in Archer's model. Both the stages try to analyse the problem and work out the specification. Interactive design intends to translate the different types of interaction and controls into a storyboard to be transformed into concrete user experience. It is parallel to the creating phase of the latter. They both concentrate on the conceptual design. Sensorial design tries to explore input/output possibilities and put them into practice to produce a prototype to be validated and modified. It accords with both the creating and executing phases suggested by Archer.

Table 3. A comparison between interaction design and the product design processes

Product-design process		Interaction-design process
Analytical phase Classify and group gathered information to elaborate the specification	←	**Information design** Organize the contents into a flowchart
Creative phase Search for suitable solution principles and establish functional structure	←	**Interactive design** Map types of interaction and controls onto a storyboard
Executive phase Develop prototype designs and conduct manufacturing documentation	←	**Sensorial design** Produce a prototype

4. An approach to integrate interaction design into industrial design processes

By matching the processes between interaction design and product design, this study proposes an approach that integrated interaction design into industrial-design processes. The flowchart is illustrated in table 4 and the procedure can be articulated in detail as follows with a student's work, E-Menu.

Table 4. An approach to integrate interaction design into the industrial-design process

Analysis	**Clarifying**		Gather and analyze related data Observe users
	Observing		Define the product's properties and services it provides
	Specification	**Flowchart**	Deliver the specification and flowchart of the product (see in fig. 1)
Creation	**Conceptual design**		Generate conceptual ideas to explore possibilities in the interplay between the physical space and digital space (see in fig. 2)
	Storyboard	**Paper prototype**	Use scenarios and storyboards (see in fig. 3) to present and predict the situations of products in use from multiple perspectives. Meanwhile, map out paper prototypes (see in fig. 4) to illustrate nonlinear storyboard of user interaction possibilities.
	Detailed design		Complete the detailed design
Execution	**Mock-up**	**Screen prototype**	Produce mock-up (see in fig. 6) for checking the details of the product's appearance and performance Produce screen prototype (see in fig. 6) with software for simulating user's path to accomplish a task. Submit the outcome and the following documents to communicate with other parties involved. Final mock-ups, drawings, documents and so on. Detailed documentation of interaction design

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The proposed procedure indicates some significant characteristics listed below.

In the process of analysis, the specification and flowchart must be simultaneously developed to obtain a broader understanding of the product itself and a complete definition of both the physical and digital components. The step defines the objective and content of the project.

Create scenarios for the study of different situations to learn more about the users and their demands. Meanwhile, map out the storyboard to visualize and predict how the product will be used and what kind of services it should provide. Based on the storyboard, a corresponding paper prototype can be generated to illustrate the nonlinear sequence of potential user interactions. These techniques provide a practical way to convert user experience into designer's knowledge and put the conceptual ideas into practice.

In addition to using a traditional mock-up for evaluating and refining the physical properties of the product, it is necessary to build a screen prototype with software to simulate the dynamic of the user's path in accomplishing the task. It can be used to acquire the users' real-time reaction to the product's performance and to the interaction design.

To communicate with other parties involved, the project should be categorized into two types of information. Typically, I produce the final mock-up, the drawing, and related documents for manufacturer. Besides, a detailed documentation of interaction design needs to create for hardware and software engineers to execute the design.

5. Discussion

Integrating interaction design into industrial design processes positively can broaden the designers' capacities and motivate them to investigate the connections between the physical and the virtual space. However, the study shows that there is room for further investigation on the topic:

Real-life user experience is a crucial basis for product development. Nevertheless, as the designers try to create scenarios and storyboards for the purposes of simulating real-life situations, it is inevitable that they sometimes produce unrealistic pictures. Therefore, it should be, and in many cases, must be, complemented by conducting field study, such as the ethnography methods used in sociology, to achieve more desirable outcomes. These methods give designers a more complete picture of users' behaviours in a larger social context, or an everyday context, and these studies may help prevent designers from being misled by their unreal storyboards.

The Paper prototype and screen prototype are useful ways to simulate product system and capture the users' real-time reactions. There's a gap, however, between these prototypes and the real-life user experiences. To compensate that problem, I may further introduce the participatory design method used in HCI study and practice. Participatory design provides efficient ways to acquire hands-on experiences, such as using mock-ups, play-acting, and role-playing that focus on the context, not the system.

While a universal language for designers to communicate with hardware and software engineers is still absent at this point. It's believed that formulates a standard protocol, e.g. a drawing, will become an important issue in the near future.

6. Conclusion

Technological advancements are changing the appearances of products and the services they provide. New thinking and approach will surely emerge from the search of what industrial design is and will become. Industrial design means more than simply dealing with the physical properties of objects. It must go further to take into account the interactive system, the operational logic and path, and new user-interaction possibilities that better meet user expectations. Furthermore, it must seek to link up the physical space with digital functions so that digital technology may work to enhance the performance of the physical entities, while the physical space serves to improve the function of digital technology as well.

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As products are rapidly evolving, it is important to keep flexible thinking as a way of seeking a solution to a new project. The design process is not a rigid formula. Rather, it is a strategy, or a direction, for carrying out design. The approach proposes by this paper may be integrated into school curricula or applied to industry to improve their professional skills. In addition, this research intends to encourage a new thinking in design education and methodology, as well as in product development.

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