THE ROLE OF COMPUTING TECHNOLOGIES IN PRODUCT DESIGN AND PRODUCT DESIGN EDUCATION

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ABSTRACT
During the academic year 2003-04, the University of Illinois at Chicago's (UIC) Industrial Design Program underwent a curricular evaluation and restructuring. During this time, one of the most debated topics was "What is the role of computing technologies in product design?" and "How do we integrate this into an industrial design curriculum?" After a series of these discussions, I came across a statement by John Maeda that addresses this issue of technology and its relationship to design education. He states: "Many people ask me where design education should be heading. What should be the curriculum? How many computers should be bought? What kind? Two years ago I had surprisingly clear answers to these questions. Today I do not."[1]
Although discouraging, reading this was affirming of my own thoughts and feelings about technology as it relates to design and design education. It often seems that the more knowledge gained with respect to interactive technologies, the less clarity about its place within product design education. Despite this ambiguity, it is clear that interactive technologies have greatly changed the field of product design and they are not going away. The computer has become an integral part of our lives, and has influenced changes in design methodologies, production processes, and the very meaning of 'product'. So, how do we deconstruct concepts around these ideas in order to give it clarity and structure in a curricular format? This paper will explore:

1. The relationship of computing technologies to product design through influences on methodologies and end products
2. The integration of computing technologies influences into a product design curriculum

A goal for this paper is to spark a discussion that addresses the issues surrounding these relationships (product design-education-technology) in order to gain some clarity about how to move forward as we struggle to integrate this into our design curricula. Although change is inherent in technology, it is a constant within an educational context. This paper is designed and will be presented in a way that sparks a discussion about these issues, and not presented as a model of how to do so. It should be noted that this will be a theoretical discussion on these issues, since the implementation of the curricular restructuring will not take place until the Fall of 2005.

Keywords: education, curriculum development, technologies influences on product design education, virtual prototyping, product as experience, changing nature of product, experience design, ubiquitous computing, interaction design, networked products, user experience

1 INTRODUCTION

The computer as an object has been around for approximately 50 years and the early 1980's brought the computer into mainstream consciousness through Apple's introduction of its Macintosh. Computers and computing technologies are changing the world through the ways we live, work, and play. Their influence is also apparent in its effects on the field of product design – both as a tool for designing and in changing the very nature of 'product'. During the University of Illinois at Chicago's curricular restructuring during the past year, the computer's influences on product design and product design education were one of the main topics discussed and the influences were distilled into two major categories. Firstly, the computer is used as a tool in designing – virtual prototyping provides better visualization of design ideas, manufacturing can be streamlined, and collaborative work tools enable design communities to form regardless of physical proximity. Secondly is their integration into products - products are no longer isolated physical entities but become interactive as computing becomes imbedded within them. Interactive products can no longer be evaluated only with respect to their physicality through form and ergonomics, but also must be evaluated with respect to the system of the object including integrated software, services, and experiences. We must not only design how people interact with the object, but design how people interact with the system surrounding the object.

The first part of the paper proposes to address these two topics through examples, while the second part of this paper will address UIC's approach regarding the integration of these influences within our new curricular structure.

2 COMPUTING TECHNOLOGIES INFLUENCE PRODUCT DESIGN METHODOLOGIES

Methodological change is one type of influence computing technologies have had on the field of product design through the advancement of virtual prototyping, the development of collaborative work tools, and shifts in manufacturing techniques.

2.1 Virtual prototyping

The development of virtual prototyping has increased designers, clients, and evaluator's abilities to visualize design proposals. With faster and better visualization tools, designers and architects are better able to show their proposals in order to maximize the understanding of any particular design. People are able to view designs before they are built, which not only saves time and money but also enables clients and evaluators of the design to become active participants in the process of designing. Architects use virtual reality to envision buildings before they are built in order to evaluate the space more accurately. Automotive designers are able to create virtual models that enable visualization of many concepts in order to narrow their ideas and spend time on those with the most promise. They can more easily make changes to their virtual ideas - it is easier and faster to create digital models than time intensive physical models.

2.1.1 World Trade Center

A New York Times article discusses the impacts of virtual prototyping on the recent World Trade Center memorial design competition through a methodological shift that is now enabled through better visualization tools. "The results are extraordinary, and open up all kinds of new possibilities, not only for the entire civic process. They also call attention to one of the oldest paradoxes of architectural practice: the techniques which architects use to render their buildings."[2] With the increasing use of visualization tools, not only is presentation made better, but it also helps to shape the objects being created. Not only may we see things before we build them, but designer, maker, and evaluator may participate more freely in the process of designing.

2.1.2 Simulate to innovate

Michael Schrage, an MIT Media Lab instructor, speaks of the relationships between design, art, business and innovation. He believes increasing the use of visualization tools is the key for innovation, and strengthens this through his mantra: 'simulate to innovate'. Instead of talking about concepts abstractly, rapid prototyping allows designers the ability to get physical fast. "It creates conversations between people that would not otherwise take place. ... Innovation is shifting from spec-driven prototypes to prototype driven specs. The result is prototypes and products that customers have actually codesigned rather than merely described. ... Prototypes are far less ambiguous than words."[3] He outlines three principles that exploit the benefits of rapid prototyping: 1) "More is better. 2) Use prototypes to create differentiated designs. 3) Record and review design discussions."[4] Schrage believes that a successful design process stems from successful interactions among the participants.

2.1.3 NASA's antenna design

NASA's has created 5 nanosatellites, which are scheduled to start measuring Earth's magnetosphere in late 2004. NASA's researchers used an innovative design process by employing genetic algorithms and 32 linux PCs to generate the design for the satellite. "The computers generated small antenna-constructing programs (the genotypes) and executed them to produce designs (the phenotypes). Then the designs were evaluated using an antenna simulator."[5]

2.2 Manufacturing processes

Computing technologies have created innovative manufacturing techniques for products, summarized through the examples below:

2.2.1 Streamlined manufacturing

Recently, Cappellini sought to utilize manufacturing techniques that were transferable from one industry to another through the design of a chair by Thomas Meyerhoffer. In this project, Meyerhoffer utilized methodological tools employed by the Apple design team in their process. "Cappellini of Italy sought his expertise for its contemporary furniture. Meyerhoffer brought new tools - and a new approach - to the process. Thanks to 3-D modeling and rapid prototyping, his design went straight from CAD data to production."[6]

2.2.2 Printing

Saul Griffith, of MIT, recently developed a manufacturing technique for an innovative device that manufactures low cost eyeglass lenses by printing the lenses. This idea won Griffith the Lemelson-MIT student prize (an annual award of $30,000) to work on this 'desktop printer' for low-cost eyeglass lenses. This device is designed as "An innovative device for manufacturing low-cost eyeglass lenses in developing nations."[7]

2.2.3 Mass customization

Computing technologies provide many opportunities for product customization. Examples include customizable web sites, customizable cell phone rings, customizable computer desktops, personalized jeans (Levi's), a chair could be made to fit its user, etc… Technology could enable individualized product generation through mass produced, yet customized unique objects. "For example, the Dutch designer Hella Jongerius created a range of ceramic tableware in which 'irregularities' introduced into the clay produced variations in the form of each plate. A number of her recent design experiments have recognized the potential of new manufacturing technologies to 'mass produce' individually 'unique' products." [8] Mass production takes on new meaning from what we know it to be.

2.3 Ways of working: collaborative work tools

Collaborative work tools and online communities are one way the web has been used to bring together individuals that are divided by physical boundaries, but united in work purposes. A nice example of this can be found at www.processing.org, which is a project created at the MIT Media Lab that showcases the advantages of a collaborative online environment. This website is created by computer graphics artists/designers, and created for computer graphics artists/designers. It is a web based software platform that provides a collaborative working environment for designing and art-making through a software program that is downloadable and free. It provides tutorials, critiques, software help, code, online courses, online exhibition space, references, discourse, workshops, and references for everyone interested in becoming a part of this community.

3 COMPUTING TECHNOLOGIES INFLUENCE THE NATURE OF PRODUCT

As computing technologies become more ubiquitous, they are influencing and changing the nature of product. Products are no longer discrete physical entities unto themselves, but the influences of systems, services, and experiences become important components of their creation. A shift is occurring from mechanical based products to interactive ones as computers become imbedded in many of the objects that surround us, including products such as cell phones, digital music players, ATM machines, digital cameras, and computers. "There are already twelve computer chips for every man, woman and child on the planet"[9], which will only continue to increase. Products today cannot be viewed as isolated physical entities, but as objects with connected capabilities that expand their outreach.

3.1 Product as system

Apples introduction of the iPod is a good example of a product that is not a product in its own right. The success of Apple's iPod lies in the integration of its corresponding software and services in order to make this object and design a successful one. This success is due to the equally important interrelationships of each component in the iPod system: the physical form of the object (iPod physicality), the user interface including the structure of the information and how it is accessed (iPod interface), the relationship to the software (iTunes), the ability to download and upload music in how the songs are transferred from computer object to MP3 player (iMac), and most recently the ability to purchase songs through their online music store (iStore). It is the combination of all these components that creates the product system and ultimately the success of the iPod as a product. A New York Times Magazine article discusses the iPods success as being difficult to assess: it's hard "to nail down whether they key is what's inside it, the external appearance or the way these work together. One approach is to peel your way through the thing, layer by layer."[10]

Other types of product systems will become more prevalent as more objects become connected to information systems. Another good example of potential for designed product systems is through the cell phones interaction with the world, which will only continue to increase in its frequency of interaction with other objects. An example of potential future uses of cell phones is shown through a technology that enables a user to pay for a parking meter through its interaction with their cell phone.[11] To pay for their parking meter by phone a user dials a toll free number, enters their parking space number, and how much time they would like on their meter.

As we enter into this new kind of product design, it is critical to understand beyond the physical characteristics of a product in order to understand the system: how it works, who is involved, and what are the influences on that system. As design elements become intangible it is very important to have some kind of methodological tools for representing and evaluating the systemic elements of the design. These elements of the system could include the innovation, the technologies, the results, the relationships, the people, and the social context. We must understand all of these links, and be able to evaluate their influences on each another in some way.

3.2 Product as service

An important component of the changing nature of today's products is in a products service. A cell phone is a good example of an object that needs to be evaluated from a much larger level than its form, and service is an important component of its evaluation. A recent example of a products dependence on its service is through a personal experience with Verizon's customer service for a cell phone. The task at hand was to change the number of rings it takes (from 6 to 3) before a caller reaches the voicemail. Although there are a multitude of menus and a 130 page "User Guide", I was not able to access this feature. I call Verizon's customer service in order to figure out how to change it. After spending 10 minutes with a customer service attendant, she tells me there is no way for me to change it on my own – only Verizon is able to change the number of rings it takes to get to the voicemail on my phone. This product feature is inaccessible through this product.

3.3 Product as experience

The experience economy is a tern introduced in the late 1990's by two economists at Harvard Business School, who stated that product services are no longer enough and that product experiences are what consumers crave. "Consumers don't want services, financial or otherwise - they want experiences. Consumers …vacation at a Disney theme park or other venues that stage a feast of engaging sensations and dramatic stories for them."[12] Companies become not only concerned with commodities or services, but the experience of the object is what becomes important. "In the new economy, we hear everywhere, the customer's experience is the product! Logically, therefore, the customer's experience is critical to the health of the firm itself."[13]

One way that experience design connects with objects through computing technologies is in the form of ubiquitous computing. Ubiquitous computing is a term that describes the dispersion of computing technology throughout our environments through its connection to existing objects. As computers become imbedded throughout the products in our environment, the opportunity to maximize the benefits of design grows. Examples of ubiquitous computing are provided in a vision of the future by Henry Holtzman, which connects everyday objects to online applications. He discusses this vision through providing examples which include: holding "an empty pill bottle up to

your PC, that will call up prescription information", "a child's toy [that] will trigger online games or link to related sites", and a Starbucks that you can walk into and "flash your card in front of a reader, and you'll get your usual, charged to your account." [14]
Computing technologies help enable the creation of designed experiences. When beginning the design process for the iPod, Apple begun by asking "What's the user experience?"[15]

4 COMPUTING TECHNOLOGIES AND THEIR INFLUENCE ON INDUSTRIAL DESIGN EDUCATION

After examining the impacts that computing technologies have had on industrial (product) design, it was sought to build a framework for incorporating this change into a curricular structure. This new structure would be based on the above-discussed influences computing technologies have had on product designing (as tools for designing) and on products themselves (the changing nature of product). The goal for the restructuring was to use this learning in the creation of individual new courses that work together within a cohesive curricular whole.
John Dewey's educational development model was used in creating the new curricular structure and is based on the following program components: philosophy, goals, objectives, methods, and evaluation. This structure, along with the above learning, was then used to develop individual courses.

Table 1: Program Goals Related to Computing Technologies Curricular Influences

Goals	Year 1	Year 2	Year 3	Year 4
continuous innovation			x	x
technical invention / environmental preservation			x	
economic / environment / emotional / physical / social / technical				x
influences of computing technologies on product design		x	x	
effective rapid prototyping		x	x	
connections between virtual and physical prototypes		x	x	
principles and applications of interactive product design		x	x	
respond to the needs of an evolving world			x	x

4.1 Program philosophy

The first step in the curricular restructuring was to develop a new UIC program philosophy. The portion of this philosophy that corresponds with computing technologies influence, is as follows:
This leads to an approach that balances the relationships within interdisciplinary learning: aesthetics, business, engineering, history, social sciences and technology. The program takes a holistic approach to industrial design, which enables young designers to make informed and socially relevant decisions along the development path. ID at UIC is taught as being inclusive by integrating economic, emotional, environmental, physical, social, sustainable, and technological concerns.
A critical component to an effective industrial design curriculum is the ability to be forward thinking. We strive for the integration of new knowledge into our program in a way that responds to the needs of an evolving world, which results in a program that is responsive to the time both socially and technologically. Particular attention is paid to

computing technologies influence on industrial design through its relationship to new methodologies and the changing nature of 'product'.
We believe the synthesis of these ideas educates designers who will be innovative and vital participants within the design community and society as a whole.

4.2 Program goals

Based on the above philosophy, UIC program goals were defined. These are summarized in the table below, which outlines these goals as well as their timing in the student experience:

4.3 Program skills

Based on the above philosophy and program goals, UIC program skills were defined. These are summarized in the table below, which outlines the necessary skills students need to develop, their timing in the student experience, and in which course that knowledge will be learned:

Table 2: Program Skills Related to Computing Technologies Curricular Influences

Skills	Year 1	Year 2	Year 3	Year 4
2D visualization	x	AD205		
3D visualization	x	AD205		
Rapid prototyping		AD205		
Animation			AD325	
Usability		AD225	AD325	
User experience		AD225	AD325	
Interaction		AD225	AD325	
Human factors		AD225		
Materials			AD326	
Methodologies		x	AD326	x

4.4 Courses

Based on the above information, it was determined that four courses will be developed in UIC's curricular structure that deal with the impact of computing technologies on product design/designing. The subject of the first course in the series will be Virtual Prototyping (AD205) and will teach students concepts outlined in section 2.1 above: how to use digital tools in designing through better visualization, faster visualization, increased iteration, maximization of all participants understanding of the design, and the ability to get physical fast. The second and third courses will build upon the visualization aspect learned through virtual prototyping, but will conceptually be expanded to emphasize concepts necessary in designing interactive products. This two course series is focused on The Changing Nature of Product (AD225, AD325) and will emphasize the concepts discussed in section 3 including product as system, product as service, and product as experience. The forth course that will be developed is entitled Manufacturing and Methods (AD326) and will focus on the concepts discussed in section 2.2 – streamlined manufacturing, new kinds of manufacturing, and product customization. The table below outlines what will be taught and when:

Table 3: Courses Encorporating Computing Technologies Influences on Product Design

Courses	Year 1	Year 2	Year 3	Year 4
Virtual Prototyping		AD205		
Manufacturing and Methods			AD326	
The Changing Nature Of Product		AD225	AD325	

5 CONCLUDING REMARKS

The next steps in this process are to use the above philosophy, concepts, goals, and skills to develop the individual courses. The upcoming year will be spent developing the individual courses, and refining these based on new knowledge gained in and out of the classroom.

Encorporating this knowledge in the UIC curriculum is advantageous, because computers are changing our world today and greater attention is needed to designing with their impacts in mind. Technology is changing all of the time, and the impacts of technology on product design are also always changing. The potential, opportunity, and impact of technology on product design/designing must constantly be assessed.

The major disadvantage of incorporating this type of information into a product design curriculum is that this just means more skills and concepts to teach in the same amount of time within the same number of credits. Where and how do we teach all of these new skills and ideas? Is it possible to add this knowledge to an undergraduate product design program without compromising quality of education and still teach the necessary skills for becoming a product designer today. If all skills cannot be taught, where do we draw the line – which skills do we teach and which skills do we neglect?

Computing technologies influences on product design have created many new interesting opportunities and challenges for the field of product design, and due to the nature of technology this is a discussion that will not go away.

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