The Integration Project: A New Educational Model for Interactive Product Design

Validating Utility, Performance, and Experience

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Part I: Responding to Technological and Social Change

New technologies are fundamentally changing the way we learn, work, and play. Technical knowledge and understanding alone are inadequate to deal effectively with many of the implications of new technology. This raises questions concerning both what technology can do and what technology should do. In either case, the products, systems, and services we create with new technology are of little value if we can't readily understand what they are, what they do and how to use them.

From our perspective, one of the keys to addressing the complexity of interaction is a balanced understanding of both the technical (utilitarian and performance) issues and human (social and cultural) considerations [5]. To ensure our solutions to these complex problems do in fact meet design expectations, it will be critical to integrate an active prototype testing and validation process into the design development cycle. We believe this must also be part of the education process (see Figure 1).

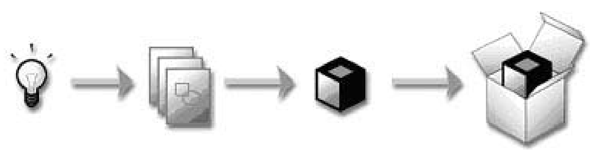

Figure 1: The course objective is to develop an interactive product, system or service from 'concept to reality'—prototyping and user validation are critical benchmarks.

Design Education and New Technology

Changes in technology are forcing us to rethink the role of design education with respect to both business and society. At the Institute of Design in Chicago, John Heskett has been investigating the role of design in everyday life. "Design is simultaneously becoming more specialized in some respects, with more detailed skills in specific areas of application and more generalist ones in others, with hybrid forms of practice emerging…On another plane is the difference between designers as form givers, determining form in a manner that allows no variation… or as enablers using the possibilities of information technology and powerful miniaturized systems to provide the means for users to adapt forms and systems to their own purposes [6]".

The implications of Heskett's analysis are significant. We appear to have reached a fork in the road where each design school will have to judiciously plot its own future trajectory. Currently, too many alternatives requiring too many prerequisites exist to manage them all with any degree of success.

Information Technologies in the Human Context

In recognizing the impact of the increasing role of computing in people's lives, Terry Winograd at Stanford University was among the first to identify a design practice whose outcome and focus was a qualitative process rather than a "thing" or an object. He labeled this new practice as "interaction design." Winograd identified the need to focus on the perceptual and psychological aspects of human experience by rooting interaction design equally in graphic design, psychology, communication, linguistics and computing science [32].

Much has changed in the few years since Winograd identified the need for teams with diverse skill sets to focus on the individual user in efforts to provide better solutions to problems associated with desktop computing [20, 21]. Today's networked wireless technology represents a more significant challenge and by its very nature will require multidisciplinary solutions [14]. We now have the capability to embed sensor technology in virtually all products that we produce. These pervasive computing devices and ambient technologies will be aware of their surroundings and capable of responding to people in everyday situations. In addition, these devices will all be connected and capable of talking to one another or anyone else anywhere else in the world. The implications are astonishing. The world as we know it will change. In response, design has a more critical role to play in a more complex scenario [13, 31].

Technology, Context and Experience

In 1999, Pine and Gilmore identified a shift in consumer preferences in the business world. They observed the increasing rate at which products were reaching market saturation, a point at which products effectively become a commodity. Based on these observations, they suggest that in order to circumvent the typical product price war associated with commoditization, or put more simply, in order to add competitive value to product or service offerings, it will be critical for business to shift from a product and service based economy to an 'experience economy'… where business caters to lifestyle experience [22].

The design theorist, Richard Buchanan, similarly argues for a paradigm shift in all design fields from the external to the internal to address these same concerns. He has identified a historical trajectory of moving progressively through "four orders of design," from symbolic through to things, actions, and environment [2].

Patrick Jordan, an expert in the field of human factors, has carried this argument one step further when he identifies that it will be critical for designers to develop a far richer understanding of people in order to design the kind of pleasurable products to meet people's new lifestyle expectations [8].

Part II: Reconstructing Design Education

If we combine these factors, it becomes apparent that we are now at the leading edge of a wave of technological change that will affect all aspects of everyday life in a profound way. The next generation of designers will need new skills and knowledge to negotiate this new terrain. In turn, design schools must respond to this challenge. Problem-based learning [11] and project-based learning [1] provide useful models. The goal is to develop constructivist, project-based learning environments combined with a reflective practice approach to design [28, 29].

There are several key pieces to this puzzle in addition to the array of tools and methods embodied in the current designer's toolbox. Some of the more important include teamwork, the need to develop a working knowledge of new technologies, the need to develop an understanding of the way people live, work and play and perhaps most important is the need to prototype and validate the new design concepts in the field in the hands of prospective customers and end users.

Teamwork

According to the design historian, Victor Margolin, as designers consider more knowledge about the product cycle in the process of conception and planning, the act of design becomes a more complex activity and as a result product design is now frequently done by teams of professionals that include, along with designers and engineers, social scientists who are trained to study the characteristics and qualities of human experience [12].

Although the necessity to work in teams on complex design problems tends to be well recognized in business and industry, the education system has been slow to follow with the exception of a handful of notable programs [24]. One of the pioneers in the multidisciplinary team-based project approach in education is Larry Leifer at Stanford University. Leifer's research has clearly demonstrated the synergistic potential of the multi-disciplinary team-based approach specifically in engineering education [10]. More recent initiatives undertaken at Arizona State University [24] and University of Illinois at Chicago [18] have validated the success of a similar model for multi-disciplinary teams working in Industrial Design Education.

Understanding New Technology

We have seen a similar pattern in our abilities to assimilate new technologies into our education system. According to Scott Midkiff, the editor of *IEEE Pervasive Computing*, pervasive, or ubiquitous computing requires the integration of multiple technologies, including software and hardware and human-computer interaction (HCI). In a recent article he identifies a need to foster a multidisciplinary team-based approach to effectively overcome this hurdle. Once again, there are a handful of notable prototypical programs that have been successful in this area. He cites the Rapid Prototyping of Computing Systems course at Carnegie Mellon University in which students from Computer Science, Electrical and Computer Engineering, Human-Computer Interaction and Robotics work together on complex collaborative design projects [19].

Another good example is a new design program to integrate AI and Smart Technologies in Industrial Design Education pioneered by John McCardle at Loughborough University. He argues that it is clear that in order to address the increasing emphasis on the design of functional products within education, design students will require a stronger foundation in the basic elements of technology [16, 17].

Understanding People

The third piece of the puzzle is the necessity to develop a more thorough understanding of people and the quality of human experience.

At Ohio State University, Liz Sanders argues that "the people that we design for are the real virtuosos of the Experience Domain. They are the ones who will create their own experiences

[26].” Accordingly she suggests it is essential that we use new tools to encourage and engage these ‘ordinary’ people in the design and development process to help us learn to better satisfy their needs [25].

Paul Rothstein, at Arizona State University also echoes Sanders sentiments and has developed a research and design method called “a (x4)” to provide designers and educators with a tool to develop design scenarios about user experience [23].

These tools and techniques are providing designers with a better understanding of the implications of lifestyle changes identified in the earlier work of Pine and Gilmour. They are also providing the key to new participatory design methods—to engage the prospective audience throughout the design development process.

Prototyping and Validation

The final step in the process is the ability to successfully integrate the individual pieces. The only way to do that is to place the product in the hands of the prospective users…Our concerns in this regard can be understood through this brief anecdotal prototyping tale presented by Lars Erik Holmquist, of the Viktoria Institute at the Doors 7 Conference in 2002.

“This was a stick that you would put in your flower pot, just like an ordinary flower stick, but it would do all kinds of things. It would start monitoring the plant’s well being, so it would know if I was watering it, if I was talking to it, it could communicate the plant’s feeling(s) to me, it could communicate with other plants, it would run forever by getting its energy from the Sun and the soil, like the flower did and so on [7]”.

It turned out the student’s magic plant stick was purely conjecture. As designers and design educators we have probably all seen this scenario. Holmquist used this example to underscore the fact that “ubiquitous computing is hard… (and that) because ubiquitous computing is really hard, there are a lot of really deep technical problems that you really need to solve before you have a chance of getting anywhere near this vision [7]”.

The importance of prototyping has long been recognized in the field of industrial design and its value is well documented in both design and management circles [9, 27, 28]. In addition, as Holmquist points out, the development of effective intelligent interactive products and systems is a complex process with significant social implications. Without prototypes to support the viability of new concepts, many new ideas will remain unsubstantiated and highly questionable. For these reasons we believe prototyping should, in fact, be an intrinsic part of the development process for this new generation of interactive products and systems.

Bridging the Disciplines

Based on our research it had become clear that it would take an interdisciplinary approach to effectively address these complex problems while at the same time it would be necessary to work towards a well-balanced understanding of both the technical (utilitarian and performance) issues and the human (social and cultural) considerations. In effect the specification for our new educational model pointed to a new curriculum built around a core combination of design, information technologies, and human-computer interaction with additional support in the areas of cultural studies, electronics and business.

The dilemma, of course, was simply the logistical nightmare of adding all of these requirements to an already overloaded design curriculum.

Part III: The Program Structure

For the past four years, we have been building the infrastructure of a new school to address a new generation of undergraduate and graduate students equipped to tackle the full potential of interactive products, systems and services. These products and services can and should be designed from the outset to address the needs of real people in everyday situations. Our goal is to foster a better understanding of the need to develop integrated solutions to meet the individual social, cultural, environmental, and technical issues associated with emergent technologies. Detailed analysis, advanced prototyping, and user field-testing are integral elements of the curriculum to ensure solutions adequately address human-centered concerns. Typical projects focus on opportunities to capitalize on wireless, networked technologies and fall into categories ranging from software applications and electronic games to hybrid software/hardware concepts for ubiquitous computing devices and/or ambient technologies.

The program consists of streams in performance and media art, interaction design and information technology. All streams have significant computing course content in addition to core interdisciplinary requirements ranging from social and cultural studies to business management. The capstone course brings together all students in these three streams in a collaborative interdisciplinary team-based, studio-type course that is taught in an online environment. Through a comprehensive sequence of six modules, the students pool their knowledge, skills and personal interests to design and develop new ways to use technology to respond to everyday needs. The course, which runs for a full academic year, requires each team to develop and prototype concepts, assess the viability of their ideas, conduct extensive user testing and further refine projects based on real-user input (see Figure 2).

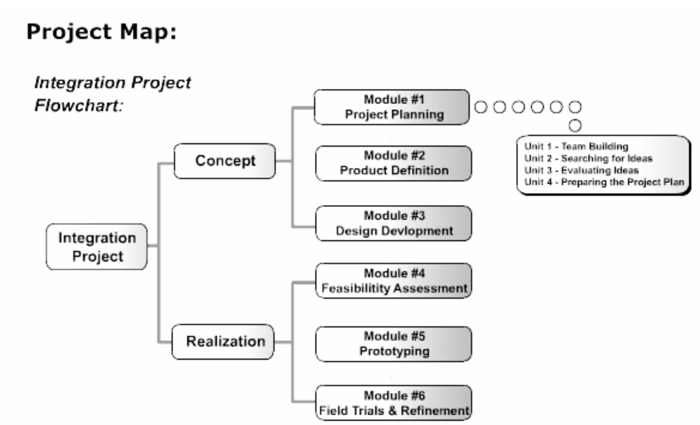

Figure 2: An online interactive flowchart provides an overview of the modular structure of the course.

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Teaching Environment

Although this course has a face-to-face lecture component there are no traditional design studio facilities. Each module runs for five weeks and every fifth week is devoted to formal presentations. There is a 1 1/2 hour lecture per week for the entire class, along with three 1 1/2 hour lab sessions for sections of 20 to 24 students. Extensive online course reference materials and discussion forums are accessible 24 hours a day to complement the lecture sessions. Students also have unlimited access to ‘open’ computer lab facilities.

The Curriculum

The Integration Project, as it is presently structured, runs for a full academic year. In the planning stage there was a deliberate attempt to emulate a real-world scenario with the recognition that the duration of the project would always be limited by the length of a semester. The course is logically and semantically divided across two semesters. The fall semester is devoted to the ‘concept’ while the spring semester is devoted to ‘realization’. The break between semesters provides an effective separation between the two distinct aspects of the project. Students have the freedom to speculate and experiment in the first semester with a clear reminder at the beginning of the second semester to recognize the scope of the deliverables due by year-end.

In addition each team is encouraged throughout the project to identify potential faculty or industry mentors to assist with those aspects of the project they may not be familiar with. In conjunction with this effort, we have an industry liaison officer who has assisted in linking many teams with relevant industry contacts.

Phase I: Concept

The fall semester consists of three sequential modules including Project Planning, Product Definition, and Design Development, which culminate in a well-defined concept by the end of the first semester. Although the three modules are of equal duration, there is an allowance for variation if a team can substantiate modifications to the proposed project.

Project Planning

The first module, Project Planning focuses on team building and identification of common goals and objectives around which the team can build a collective initiative. Students draw on their individual knowledge, skills and interests to develop a spectrum of possible ideas to serve as a baseline for a team-based project. It is critical at the outset that the team negotiates buy-in from all members to help motivate participation. During this phase, the team also develops a thorough plan to guide development throughout the project.

Product Definition

The second module deals with the development and refinement of project specifications. Each team begins by developing scenarios for a select set of ‘preferred’ ideas the team has generated in the Project Planning phase. Once the team has narrowed their project choice they split up to gather both market research and technical data to support their project concept.

Throughout this phase, each team is encouraged to open an ongoing dialogue with the prospective audience for their new product idea to assist them with a detailed refinement of their project scenario (see Figure 3). The goal is to substantiate the concept based on feedback from users.

Figure 3: ‘Voracity’ is a cell phone game platform that incorporates a proprietary location-tracking system.

Design Development
By the end of the third phase of the project, each team is required to present a detailed design concept, which typically includes preliminary models and/or proof of concept technical models to substantiate the feasibility of the project

Phase 2: Realization

The overall tone of the project shifts as we move into the spring semester. The concept is locked in and the team begins to focus on production of an operational prototype that can be used to validate their concept. Once again, the semester is divided into three sequential modules.

Feasibility Assessment
The second semester opens with a requirement for each team to reflect on their current project concept. How well does this concept embody their original intentions? How has it changed? Why? Does the team perceive the changes as positive or negative? Are further changes required?

Once the team is satisfied with their direction, the key issue for this module is to scope out the feasibility and logistics of producing and testing an operational prototype

Prototyping
Although the fifth module is exclusively devoted to prototyping, most teams have commenced and/or have been encouraged to commence some level of prototype testing far in advance of this module.

The objective for each team at this point is to produce the most effective demonstration of their concept possible. Ideally this is both a full visual and operational prototype.

Field Trials and Testing
The field-testing and user evaluation requirements are designed to bring a degree of closure to the project not normally seen in academic assignments.

Students are required to plan, design and carry out formal field testing which requires a formal ‘Ethics’ approval signed off by an independent University agency that regulates all work involving research subjects. Each team is then required to report back the results of their study including recommendations for changes or refinement.

Part IV: Key Issues

The complexity of the technical aspects of prototyping interactive products and systems is a significant challenge, particularly for those in the design community who may not have an extensive technical background in software and hardware development. Our experience indicates the 'building block' format for both the software and hardware components is a viable approach to help get students started with some degree of comfort—particularly when they take advantage of third party support from active online user communities.

At the first level, we are currently building a repository of tools and techniques to support an extensive range of ubiquitous, mobile and responsive environments. Examples of useful prebuilt components or building-block type hardware and software components to help students get started include:

- Lego Mindstorm Robotics kits
- Phidgets: 3-D widgets developed by Saul Greenberg's Groupware team at the University of Calgary. Phidgets simplify software development in interface design and allow designers the ability to plug together hardware components and to focus on the programming aspects of interactive product development [3, 4].
- Basic Stamp: a modular prototyping kit with a programmable microprocessor and a series of sensors.
- Disappearing Computer: a project of the e-Gadgets team working under the auspices of the European Union IST/FET [15]. The e-Gadgets team is in the process of prototyping a series of wireless networked 'extroverted gadgets' that add smart networked capabilities to existing objects—like tables, lamps—allowing users to create and specify interactive relationships throughout their personal work or living environment.
- MSP Max scripting language
- Macromedia Flash

At the second level, we have had some success in prototyping with Palm OS emulator software on laptop computers using our internal wireless network to simulate wireless handheld devices and/or custom applications written in Java. On the hardware side, we have also put in place a rapid prototyping machine to allow us to produce custom physical enclosures for concept prototypes as well.

At the third level, we have recently acquired a location tracking system and have initiated an order to expand our wireless network and add a series of prototyping kits comprised of handheld devices and laptop computers to extend our prototyping capabilities.

Reflection on Progress

For many teams, this level of prototyping is entirely new and requires a significant level of support and encouragement. Yet results of our first class exceeded our initial expectations with all twelve teams successfully producing and field-testing advanced operational prototypes of new product concepts. The requirement for students to engage a third party to review and independently test and evaluate projects they have developed has added a significant degree of motivation to excel. A particularly gratifying result of the project is that two of the twelve teams entered a commercially sponsored entrepreneurship competition and one of the two teams successfully competed to the semi-final round of 4 teams out of an initial field of over 100 entrants.

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