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ScienceDirect

Procedia Technology 20 (2015) 162 – 169

Procedia Technology

The International Design Technology Conference, DesTech2015, 29th of June – 1st of July 2015, Geelong, Australia

Tangible Interaction Design: Preparing Future Designers for The Needs of Industrial Innovation

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Abstract

The last decade has seen a remarkable uptake of interactive systems, products and services. Their design requires a shift from the traditional skills of material product-focused designers. We argue that the creativity in designing these information-enriched products needs to stress both physical properties and interactivity. The challenge is finding an educational approach that can equip industrial design graduates with stronger creativity instead of overstating the awareness of new technologies. This approach should extend rather than replace the knowledge, skills and experience from traditional design education. Using Monash University as the test bed, Tangible Interaction Design Education (TIDE), the cornerstone of this pedagogical model, provides an approach that blurs the boundaries between tangible objects and intangible services.

Peer-review under responsibility of School of Engineering, Faculty of Science Engineering & Built Environment, Deakin University

Keywords: Creativity, Design Education, Industrial Design, Interactivity, Tangible Interaction

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doi:10.1016/j.protcy.2015.07.027

1. Introduction

An explosion in new ICT technologies has been seen in recent years: smart products, in-home care appliances, e-Health devices, health assistive systems and services. The interactive behaviour-oriented nature of smart-devices and services opens up possibilities for developing better systems and services for physically and mentally vulnerable people.

The proliferation of computing into everyday appliances draws product designers towards IT informational/interactive product design [1-3]. For instance, answering industry needs requires strengthening a designer’s skill set to include 'user behaviour analysis', 'user context analysis', 'reverse engineering', etc. Industrial design education must not only satisfy user’s needs, but also focus explicitly on the interactions between them. Following the emergence of physical objects that are integrated with information infrastructure [4, 13], industrial design education is facing new challenges: how to create effective and meaningful interactive behaviours through integrating computational and physical entities. While designing with smartness and interactivity adds a novel element to design practice, industrial designers are facing the problem of questioning the conceptual alteration of ‘creativity’ when designing such products. In design education, this raises following questions:

1. What knowledge framework would be appropriate and necessary for fostering such creativity?
2. How can we develop an appropriate syllabus to cultivate the new generation of designers?
3. What new knowledge components need to be added to the current curriculum?

Nomenclature

e-	electronic-
HCI	Human Computing Interaction
IT	Information Technology
MADA	Monash Art Design & Architecture
TIDE	Tangible Interaction Design Education

Until recently, the classical-style syllabus that has dominated most university-level industrial design education, has emphasized the product’s physical form, with due consideration for ergonomics and experimental psychology. Such an approach has successfully met industry needs for decades, but the recent appearance of smart products has led to a new demand: how to deal with user behaviour [5]. Smart products introduce an interactive dimension beyond the product’s physical shape. Although the technology may not be always apparent to users, such products are now pervasive [7].

Departing from the classical style, the Interaction Design Association (2004-2010) regards interaction design as defining ‘the structure and behaviour of interactive products and services’. This definition recognises that the last two decades have witnessed ever-increasing computing power, miniaturisation of computer chips, and pervasive use of the Internet. As Visser [11] has suggested: ‘Due to the incredible increase in both product and system complexity that the use of advance technology enables, it is more important than ever for industrial designers to step up and engage more directly with interaction design.’

Compounding the issues introduced by these emerging changes, the responsibility of design educators extends beyond teaching students hands-on skills and producing good products, to include nurturing students’ qualities in the new era, such as creativity, aesthetics, and flexibility. Creativity is a major criterion for student-designed products in industrial design courses. All stakeholders, industry, students and educators expect to see good ideas from students, embodied in innovation and state-of-the-art technologies. Broadly, creativity means the ability to create something not only novel but also valuable; in design, creativity refers to the quality of originating new ideas, concepts, functionalities, approaches etc. to satisfy user’s needs.

In this paper we argue that the innovation and creativity may occur through Tangible Interaction Design Education (TIDE). Tangible interaction draws its technology and methods from a variety of disciplines in addition to industrial design, human–computer interaction (HCI), engineering, and psychology [9]. We need to complement HCI with human-human interactions and human-environment interactions, while also considering physical functionality, usability and user experiences. Altering the existing syllabus aims to help graduates tackle the design challenges of the information age, and develop the knowledge and abilities to ensure rewarding design careers.

Similar arguments also can be seen from the curriculum development at Purdue University. As Qian et al. [8] put it: "For a designer, being able to merely design interaction is a good skill, but being able to control, amplify, and support the human-product interaction is even more desirable."

2. Tangible Interaction Design

To embed the concept of Tangible Interaction in our curriculum development, we adopted a contextual behaviour-centred perspective. Tangible Interface/Interaction is a term originating from computer science describing a data-centred approach to mapping the physical and digital worlds. In the early stages of its use for design, Tangible Interaction focused on tangible interfaces [10]. According to Mazalek and Hoven [6], tangible interaction has different connotations in different fields and can mean: “a data-centred view (Computer Science and HCI); an expressive-movement centred view (Industrial and Product Design); a space-centred view (Arts and Architecture)”. Achieving successful Tangible Interaction Design therefore requires the following skills:

- *The ability to creatively communicate information*: Tangible interfaces can greatly enhance our ability to represent and manage information—highly relevant for commercial success in Industrial Design.
- *The ability to create/creatively integrate physical/tangible objects*: Ullmer and Ishii [10] described Tangible Interaction as a method of “giving physical form to digital information and its subsequent physical control.” The essential task of Tangible Interaction is thus to combine digital functions and manipulations into physical forms in an appropriate and meaningful manner.
- *The ability to create/ creatively integrate any physical medium as interface*: From an environment perspective, Tangible Interaction focuses on tangibility and full-body interactions, embedding computing in the everyday environment and supporting intuitive use.

To articulate the characteristics of such integration, TIDE draws on several related fields such as general education in interaction design, industrial design, IT/computing science, media art, and information design. Nonetheless, according to Wang et al. [12] there are several major areas of focus that distinguish TIDE from these related fields: tangibility, context and behavior, usability, functionality, and adoption of a user-centred approach, training in both traditional design and IT, and broader range of applications.

3. Tangible interaction philosophy in university design education

On the one hand, embedded technology and large-scale networking allow integration and augmentation of physical objects with information infrastructure, which requires a focus on 'behaviour', 'system', 'service', and 'information technology'. Focusing on these components also facilitates the linkage between knowledge from traditional industrial design with interaction design. This linkage requires a different design model and process in order to discover related problematic issues.

Using the TIDE module in our industrial design responds to the issue raised by Dourish [3], that there is still a need to explain why Tangible Interaction works so well for users. The syllabus intends to help students think about and conceptualise the physicality of their systems. Putting themselves into the user’s shoes helps industrial designers to grasp accurate design thinking. How these methods are applied will become apparent from the students’ outcomes example in the following section. The main objective of such focus is to enhance students’ understanding of user needs, and to establish certain forms of rapid ethnography.

TIDE is distinguished from traditional industrial design education by stress on how to nurture students with creativity from the perspectives of ‘behaviour’ and ‘context’. Therefore, it is crucial to support and guide students to gain empathy and understanding with users.

4. Case study: Tangible Interaction Design teaching at Monash University

Since the early-1990s, the Department of Design at Monash University has successfully developed a ‘studio-based’ approach to teaching industrial design students across various arenas, such as product design, sustainable design project, technical drawing and modelling.

This ‘studio-based’ learning style has been considered as the main teaching philosophy at Monash’s industrial and product design courses, through the design and realisation of physical artefacts. For instance, the essential components of industrial design modules (from the 1st till the 3rd year undergraduate-level) were: 2D and 3D CAD/CAM, workshop training, studio practice, design projects, materials and manufacturing, and applied technologies. The reality was that Monash's industrial design students are still mono-disciplinary in their approach to design problems. During their studies, there were limited opportunities for them to be exposed to multi-disciplinary issues that may affect their design work. As a result, most students found it difficult to deal with the design topics related to present and emerging E-Product industry, such as the design of smart systems, appliances, and services.

Through years of collaboration with GM, Holden, and Dyson, colleagues at Monash began to reflect on their first-hand experience of how leading manufacturers were developing new products. Companies were clearly changing their innovation focus from traditional products, the design of which had been driven by ergonomics, engineering and manufacturing, to smart systems which are more focused on IT, connectivity and user behaviour. At the root of this change was the realisation that economic wealth was increasingly created by selling not only physical products but also systems, services and virtual products.

During the development of this curriculum, some interaction design featured changes have been made to module teaching and developments in the overall existing industrial design curriculum at Monash. The overall aim of this change was to better align the curriculum to the external drivers outlined above.

4.1. TIDE teaching activities and student outcomes

This section offers a description of the teaching and learning activities developed by the author and his colleagues at Monash University. Until 2nd semester of 2014, the subjects of interaction design were embedded in a module normally taken by some industrial design students who selected interaction design from their third year of study. Under the influences outlined in the previous section, the teaching team's aim in developing this TIDE module was to offer our students the chance to develop knowledge and abilities valuable in the rapidly changing world of industrial design.

In the TIDE module, practical, project-based student activity is complemented by a lecture series. For the first half of the module, students are intensively introduced to the topics of interaction design and affordance to establish basic abilities of relevant investigation and synthesis. In the second half, based on the knowledge gained from the first half, students are exposed to topics that are more relevant to Tangible Interaction Design. Students are required to exercise, and further develop, these abilities and knowledge in a specifically designed project.

The information input and output are also explored during teaching. Students take this further in a downstream design realization activity by using an upside-down process to create their own unique systematic structure. At the end of the academic year, designed outcomes are expected to demonstrate a clear, logical and precise analysis of a chosen interactive system. The topics have always been intended to provide rather broad interests, such as 'e-Health *Systems/Services'*. In the following section, the 'e-Health' topic is presented as an illustrative example for the TIDE module.

4.2. General considerations: e-Health systems/services

The informatisation of healthcare practice is becoming ever more comprehensive and complex. By exploring this subject matter, students are prepared to deal with challenging topics and equipped with an appropriate design method to deal with such complex processes. Furthermore, an interaction-centric approach will play a vital role in tomorrow's e-Health systems, products and services design. This application illustrates well important concepts such as 'context' and 'tangible interaction'.

During the investigation and analysis phases of the current process, students were asked to be mindful of the potentially (novel) interactive relationships among users. To fully appreciate context, students need to consider a wide range of elements, such as the user, environment, market, and technology. Students are asked to construct a mapping diagram to express various contextual elements and the relationship among them, and develop an original concept to improve the e-Health system and the healthcare circumstances of the target user group. This concept must be articulated in a formal presentation covering several aspects including, among others, system architecture, use cases, interface design, and 3D form. This outcome is the elaboration of processed data into insights and subsequent opportunity and proposition statements. Fig. 1 shows a sample diagram produced by a student taking the TIDE module. Under the theme of ‘Future Health Care’, the ‘goal’ of designing the interactive system for a certain ‘Target User Group’ has been determined based on the ‘Conceptual Model’ which is supported by the ‘Technology Context’, various ‘Needs’, users’ ‘Behaviour Flow’, and ‘Environment/Situation’ context. Several interesting examples of the ‘Sample Product’ have also been selected and analysed with different emphasises, such as ‘behavioural input’ and ‘Visual Image/ Sound Output’ samples.

This diagram presents the range of user insights and derived opportunities. It also includes the teams’ proposed design brief generated from the opportunities. The ideal value proposition is one that is highly relevant to the goals of the type of user, relates strongly to the brand values and essence of the company, and has significant potential for product concepts with valuable intellectual property.

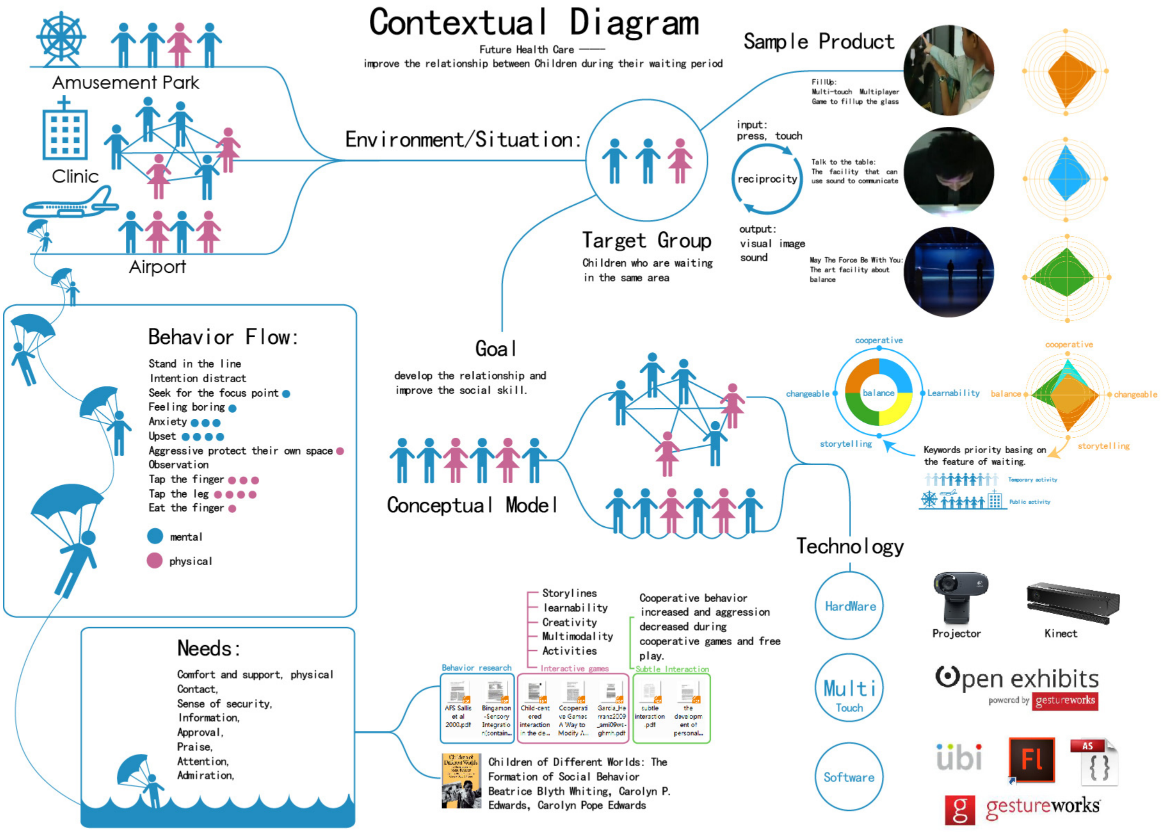

Fig. 1 The ‘Contextual Diagram’ for interactive behaviour analysis (sample assignment from Yang, Chu-Lin-2014)

4.3. The contextual approach—'user-task-environment'

User research is the most important TIDE activity in this module. The key element students are asked to explore is the behaviour of the target user group. There is a need for first-principle approaches supporting research and design of these new hybrid environments that are inherently ‘socially-organized settings’, as noted by Williams et al [14]. The primary aims of this activity are for students to develop abilities in: user's context data gathering; generating user types or personas; processing data to generate user insights; identifying opportunities for potential exploitation of the insights. Due to the small class sizes, students work individually.

The first formal outcome required is a detailed 'research portfolio', in order to demonstrate that students have developed an in-depth understanding of the needs of relevant users, and have identified significant goals and needs which can guide downstream design work. Students conduct their research by investigating a sample user group (normally 5-10 users) that is representative of the target user group. This outcome is usually a selection of relevant evidence (pictures and text), which is meant to communicate the essential nature of the user experiences or ritual. The ideal experience board has highly relevant observations and insights of user behaviour and actions, as well as ‘painting a picture’ of the experience itself. Fig. 2 shows how the conceptual system produced by a student taking the TIDE module works. This assignment is included simply to illustrate some of the significant novel processes to design a system to prevent bike accidents. The proposed product and system is the result of the user’s behavior needs. Therefore the above-mentioned contextual analysis outputs could provide great support to this design outcome, rather than presented as empirical research evidence.

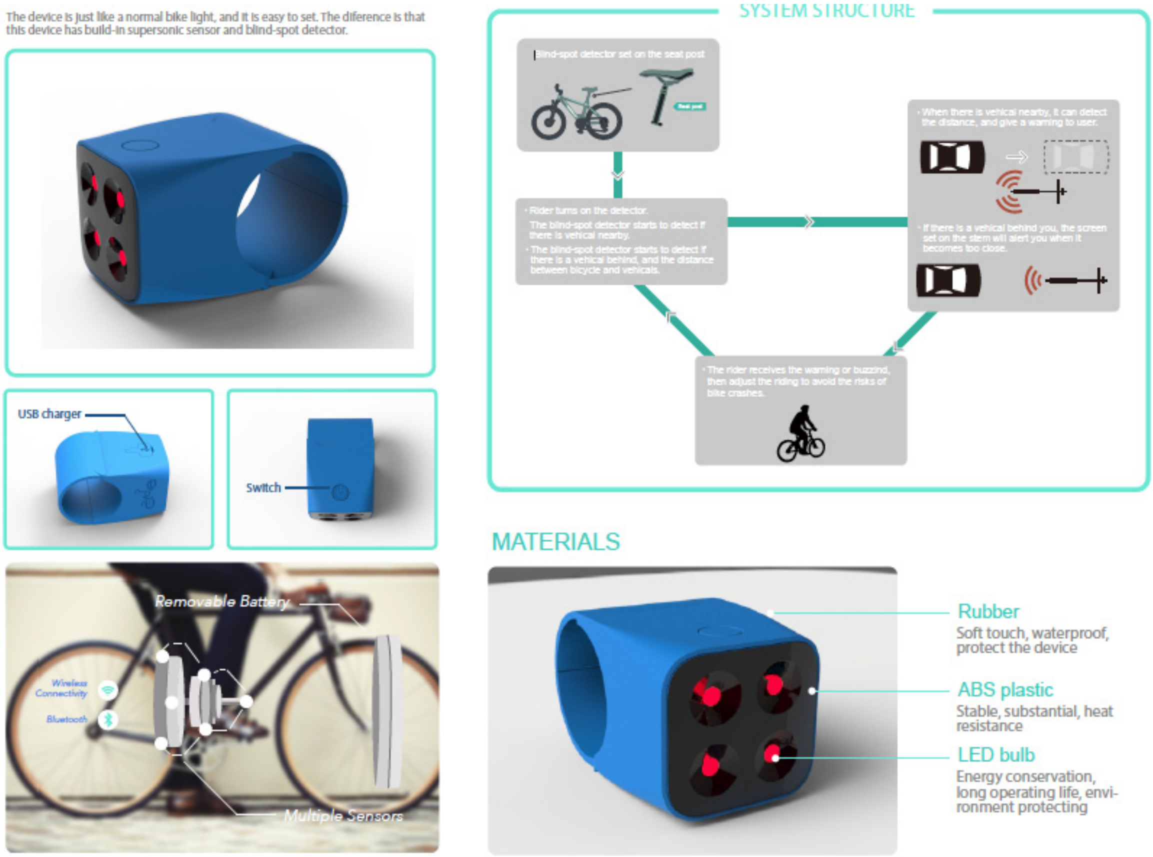

Fig. 2 Design concept of the ‘Smart-bike’ project (sample assignment from Nanan Jia- 2014)

One significant element of the investigation and research that is emphasised in the TIDE module is the behaviour of the target user group. Students analyse behaviours through areas such as processes, actions, information, environment and context. Forming partnerships with commercial companies and brand holders is an essential part of the teaching, mainly so that they can exchange information and insights. The main design outcome is a model that students have explored in the following areas:

- System design method and information hierarchies
- Production and design outcomes
- Design project documentation
- Dynamic interfaces/user experiences
- Advanced interface design.

Through the TIDE module students learn that their design research material (user and their contexts) is an important and productive outcome in its own right. A well-presented research folio has proven to be a valuable resource and highly regarded when collaborating with industry, who are also the potential future employers. The requirements for submissions from students re-enforce this view by asking for professionally presented research documentation. The teaching team made a decision to separate pre-brief user research from any downstream (product) design activity. Hence it was intentional that the user research outcomes were not limited to a designed product, but would also include systematic structure, designed interface and scenario.

5. Conclusions

Through this pedagogical development, we could summarize that design educators need to nurture the next generation designers with creativity, emphasising the following domains:

1. *Theme:* the design projects undertaken by Monash students would invariably begin with a non-traditional theme, such as e-Health or Smart-Health that would expose students to the emerging industrial needs, the new requirements of users, and require a cross-disciplinary approach.
2. *User-centred research:* necessity of providing a clear user scenario. Student-conducted research, analysis, synthesis and subsequent presentation of this context component have proven to be crucial for creating meaningful interactions in the later stages.
3. *Market relevance*: market investigation and design work that related to the real-world outcomes was often effective at motivating students.

Several topics need to be explored further. One is to understand the importance of Tangible Interaction Design related concepts, methods, processes and outcomes. When developing further TIDE units, more attention should be given to both equipping students to deal with intangible interactive behaviours, and to utilise interactive technologies. Another issue is building prototypes, beyond the traditional 'beauty in form' criteria in industrial design; achieving high-quality functional TIDE prototypes requires more interdisciplinary hands-on skills, such as the knowledge from IT and engineering fields.

Acknowledgements

The authors acknowledge the support by the International Tangible Interaction Design Lab (ITIDLab) at Monash University (Australia) and Tsinghua University (China) for this collaborative research initiative.

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