INTERNATIONAL CONFERENCE ON **ENGINEERING AND PRODUCT DESIGN EDUCATION**
13-14 SEPTEMBER 2007, NORTHUMBRIA UNIVERSITY, NEWCASTLE UPON TYNE, UNITED KINGDOM

DIGITAL PRODUCT DESIGN

Dr Jon Rogers[1], **Tom Hulbert**[2]
[1]*University of Dundee*
[2]*Luckybite*

ABSTRACT

Product design is a rapidly evolving subject. Product design and its relationship with engineering on the other hand can be argued to be going through a much slower evolutionary process. Why is it that the significant majority of product design and engineering programs are really about product design and mechanical engineering? In this paper we would like to review this relationship and propose a new direction, one already taken by industry that engages with computing and digital electronics as a focus. Underpinning this new direction is the development of microcontroller technologies that enable small programmable digital devices to be embedded within the designed products. For education, research and industry this is having a profound effect on the products and design-concepts that are emerging. We will provide a review of the technologies that are appropriate and available to design education and give examples of products/projects that demonstrate the direction that this paper proposes that product design education should take if we are to educate product designers for their digital futures.

Keywords: Product design, interaction design, physical computing, mechanical engineering, playful technologies, hands-in design, critical design, electronics.

1 INTRODUCTION

“The status of engineering as a profession and as an academic discipline is cause for concern” [1]

Product design and mechanical engineering have a relationship going back over 50 years and for good reason, yet this relationship is becoming strained and is now due to be re-evaluated. In this paper we wish to present a position where product design moves in a new direction, taking the principles and lessons from the past, but applying it to a new digital future lead by the mobile digital technologies that are currently exploding into our lives.

In this paper we will focus on the role of programmable microcontrollers that enable small programmable digital devices to be embedded within products. We propose and set out a position, whereby product design fully engages with this new technology. The timing of this new direction is directly attributable to two factors – the emergence of Interaction Design as a discipline in its own right [2] and the beginnings of the bedding down of microcontroller technologies in the context of accessibility of skills to education; from school age through to post-graduate programs.

1.1 Defining Digital Product Design

Digital product design is the design of products using embedded digital technologies.

In this paper we are not proposing that 'digital product design' is a radical new idea, rather a definition and future direction of an approach to design that has emerged over the last decade. After all, embedding electronics into products is not new but this has traditionally been carried out purely as an engineering activity. To include the designer in the design of the whole system requires designers to not just understand the language of electronics but also to have the skills to create prototypes that explore the *behaviour*[1] of the product. In the last decade, accessibility to programmable devices has vastly increased with the introduction of high-level language microcontrollers. The assimilation of microcontrollers into design programs began in the UK when Gillian Crampton-Smith restructured the then Computer Related Design (CRD) course at the Royal College of Art, from CAD to one that formed the basis of Interaction Design. Alongside the teaching program, CRD research further developed the concept of using electronics as a design material. Projects such as the *critical design* approach of Anthony Dunne and Fiona Raby's Placebo [3] and the *playful technologies* approach of Bill Gaver [4] have created a benchmark for future use of technologies in product design. In parallel to the approach of CRD, MIT media labs were also designing using digital technologies [5]. One of the aims of the 'tangible media group' was to 'couple bits with graspable physical surfaces'. While the approach was very much within the remit of Human Computer Interaction it provided a platform for a more product focused approach. *Programmable Bricks*, developed as a collaboration between MIT media labs and LEGO formed the basis of the extremely popular Lego Mindstorms that are now being used to teach fundamental principles of digital product design. More recently, the tangible media group have developed *Topobo* – a set of physical units that enable the recording and playback of physical motion [6].

Designers using electronics as a material reached beyond academia and into industry most significantly with IDEO's Social Mobiles project [7]. Social Mobiles, or SoMo, was a mixture of playful technologies and critical design where the series of designed prototypes were not to act as a consumer product, but more to communicate the breadth and depth of IDEO's design team to their clients and the public. Graham Pullin, project leader at that time, refers to the reasoning behind doing such an internal project as:

"Social Mobiles let us take a step back and prioritise the people around the immediate user for a change. Social Mobiles started as a playful reinterpretation of the mobile telephone, and the social and anti-social theme emerged strongly as the project progressed."

---

[1] The use of behaviour is deliberate – it shows that the designer is not only considering the product function, but also the *experience* of the person using the product.

2 HANDS-IN DESIGN

To understand the approach we are proposing, where the designer works with electronics as a material, we present a new model for representing designing for/with electronics using three layers of abstraction:

- **Hands Off**: where design provides a social or cultural commentary – an approachbest typified by Tony Dunne [8]
- **Hands On:** where products are used as part of the design process, but the product has been designed elsewhere – for example, Cultural probes where existing products were re-designed to fit within a design research context [9]
- **Hands In:** where the product is designed through a bottom up process of prototyping behaviours using discrete components. This approach is described in more detail by Rogers [10].

The value of prototyping

Put quite simply, better products are designed if the designer is able to engage with prototyping of electronic behaviours. Something is always missed when a huge chunk of a project is outsourced – particularly when this has traditionally been the behaviour determined by electronic interaction.

Electronics as the interface between technologies

A criticism of electronics as the focus for product design, is that it could create a very narrow field of product design. Our view is that electronics enhances the value of mechanical technologies by better integrating mechanical functionality into product behaviour and experience. Further to this, by taking the approach of electronics interfacing between technologies, you can extend the role of product design to include interface design, smart materials, interaction design, smart textiles, fashion and media arts – alongside mechanics, physics and computation.

3 REVIEW OF TECHNOLOGIES

Thus far, this paper has created a position on our vision of a digital product design future – critiquing the relationship with mechanical engineering and suggesting a new direction encompassing electronics as a medium for interdisciplinary research and teaching. However, as part of this debate, we would like to provide a precursory review of technologies currently available that we consider being appropriate to digital product design.

Ever since machines entered into society, we have wanted to create and interact with the new possibilities that machines have created. Inventiveness is an intrinsic part of our psyche. Mechanical systems enabled us to control and automate processes otherwise impossible, unsafe or simply mundane – the Victorians automated everything from puppet shows to communications systems and created the backdrop for modern communication and computing [11]. Microcontrollers have created an entirely new landscape that engineers, designers, computer scientists, artists and home-hobbyists, resulting in an explosion of subjects that now include electronics as a core unit – whether media arts or mechanical engineering. This interdisciplinary explosion happened when the programmable interface – or programming environment – began to become user friendly and move beyond assembly language. The approach described here is best summed up in a recent book by Dan Sulivan and Tom Igoe [12] on setting the language of *Physical Computing.*

Microchip's PIC microcontroller has it's origins in the 1970s, when General Instruments developed the first Peripheral Interface Controller and has become the world standard for microcontrollers – particularly with their 16Fxxxx range. The PIC is the most universally used microcontroller and has been adopted by many product designers as a way of embedding technology and interactivity. The advantage of the PIC is its cost (£1-£10+) per unit. However, traditionally, the PIC is aimed at the technical user. This has created a fragmented development environment involving several software programs to compile, link and download the programs.

Parallax's Basic Stamp first launched in 1992 and now sells millions of units every year to hobbyists, schools and universities around the world. They were able to create a development environment around PIC microcontroller that enabled a single integrated develop environment (IDE) that enabled high-level PBASIC commands to be downloaded and interpreted on-board the Stamp. This was and is an incredibly powerful design approach. Much of the difficulty with programming a microcontroller is in both the development environment – which is often fragmented requiring more than one program to compile, link and download the code through a separate (off-board) programmer. The Basic Stamp is a robust, stable, platform that provides an access route to more complex PIC based systems. The significant disadvantage to the *hands-in* designer is the price (£30 -£50).

Revolution Education's PICAXE microcontroller is a relatively newcomer to the field. Again, as with Stamp they have created a product that piggy backs on the successful architecture of Microchip's PIC. As with the Basic Stamp, the PICAXE is programmed through a single IDE to download and debug code in-circuit. The significant difference to PICAXE is their price (£1.50-£5). For a student wanting to create multiple prototypes or connected objects, the PICAXE pricing removes a significant barrier in experimentation. The disadvantage is that the IDE is not as stable or robust as Parallax's IDE, however it is very useable and manageable in a student laboratory/workshop teaching environment (the author's use both Basic Stamp and PICAXE in classes of up to 50 students).

3.1 On IO boards

The authors of this paper firmly believe in the notion of *hands-in* design and that for product designers dealing over a wide range of physical scales – the best approach is to use single components that can be built and developed into any size object. This is very important. While initial setup is eased by using a project board, designers quickly encounter problems of integrating into a single object or system of objects. Often this results in two-stage product of technical platform with wires into their prototyped object, leaving a large gap in learning about how to integrate technology fully into products. For educational programs such as Innovative Product Design at Dundee and Designing Interactions at the Royal College of Art this is not appropriate.

3.2 On programming languages

The position of the authors is clear: PBASIC has emerged as the most appropriate language to program microcontrollers with. Attempts at an IDE based on C have been created by, for example, CCS, are simply clunky carrying large coding overheads to create simple results. C does simply not tailor well to microcontrollers. PBASIC provides dedicated commands for controlling pin voltage levels, reading analogue to digital converters and communicating using serially over RS232. The IO board Arduino is programmed using JAVA and again, this is not the best language to use – like C, it requires several additional libraries and code overheads to perform simple operations such as serial control.

4 OUTCOME

The outcome of designing products from a hands-in approach is exciting as it provides skills that enable a crafting product behaviour. To give a specific recent example of this, in January 2007, we ran a combined project with level 2 undergraduate Innovative Product Design and Interactive Media Design students, taught with Graham Pullin (previously mentioned). The students were asked to design and make a phone that explored future potential of phone technology. The result can be browsed at the 'phone not phone' online store [13]. This project created considerable media attention due to the fact that students were able to produce working designed products that demonstrated the potential of new forms of interaction, which would simply have not been possible given a hands-on/-off approach. The application of this approach has been taken further by several final year IPD students, most notably Michael Shorter's Audio Shelf [14] – where a shelf becomes a stereo by integrating an MP3 player into a wooden shelf; with the design twist of the volume being controlled by the weight of objects placed on it. For further information on this particular project and examples of the outcome generated by this approach, see both the IPD and Design Interactions websites [15][16].

5 THE FUTURE

The future of digital product design is pointed to by a series of classic product design, interaction design and media arts projects that have consistently created compelling, engaging objects that really do test what you can do with digital technologies. Daniel Rozin's Wooden mirror [17] creates a large wooden mirror that is comprised of automated 'pixels' of wood that are moved by solenoids to change their reflectivity – and thereby creating a sense of a pixel being on or off. This array of several thousands of pixels is controlled by a digital video camera. Bill Gaver's playful technologies Weight Furniture [18] uses load cells to control a series of interactive home furniture products. The Drift Table allows viewers to slowly float over the British countryside (and towns) by placing weights on different parts of this elegant, simple, coffee table. Anthony Dunne and Fiona Raby [3] developed a series of objects that enabled people to question and debate thoughts on the effect of electromagnetic radiation emitted through our homes (wireless networks, power cables, TVs, etc.). Crispin Jones became famous, with the launch of the Invisible Force [19] – a Victorian style office desk that displayed messages through 2cm pixels of wood that rose above the surface of the desk (using solenoids). This classic design used 256 pixels all controlled through the Basic Stamp. On a vast scale, Luckybite (www.luckybite.com) developed a completely new way to view messages in London's Science Museum. Their installation, Comment, enabled viewers to enter messages into a vast array of interconnected LED display tubes that filled the space of the museum over three floors. More recent projects such as Stuart Wood's [20] Pixel Roller, which enables a 'painter' to create large-scale painter by simply rolling an adapted paint roller over a surface – point to a future where digital product design can mediate a completely new approach to integrating technology into product design education. Where next for digital product design? In coming years we will undoubtedly see a rise in projects that involve multiple, networked, products that use wireless and internet technologies to form connections between people around the globe. We have always been fascinated with communication and whenever we can use technology to do this we, we do. We need to prepare our students for this world by adopting a ‘smarter and lighter’[2] approach to education and design technologies.

6 REFERENCES

[1] Hills G. and Tedford D., “Education of Engineers: the Uneasy Relationship between Engineering, Science and Technology”,Global J. of Engng. Educ., Vol.7, 2003

[2] Moggride. B. “Designing Interactions”, MIT Press, 2006

[3] Dunne A. and Raby F., “Design Noir: The Secret Life of Electronic Objects”, Birkhauser, 2001

[4] Gaver, W. Designing for Homo Ludens. I3 Magazine No. 12, June 2002

[5] Ishii, H. and Ullmer, B., “Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms, Proceedings of CHI ’97, ACM

[6] H. Raffle, A. Parkes H. Ishii and Joshua Lifton, (2006) “Beyond Record and Play: Backpacks: Tangible Modulators for Kinetic Behaviour”, SIGRAPH’06, ACM

[7] Social Mobiles , http://www.ideo.com/case_studies/Social_Mobiles/, accessed March 2007

[8] Dunne. A, “Hertzian Tales”, MIT Press, 2006

[9] Gaver, W., Boucher, A., Pennington, S., and Walker, B. (2004). Cultural Probes and the value of uncertainty. interactions magazine. xi(5), pp. 53-56

[10] Rogers, J., Townsend, D. and Duplock, P.,, “In Bed With Electronics”, Crossing Design Boundaries, Francis Taylor 2005

[11] Sulivan, D. and Igoe, T. , “Physical Computing”, Premier Publishers, 2004

[12] Standage, T. “The Victorian Internet”, Pheonix Press, 1999

[13] Pullin G, Rogers J, “phone not phone online store”, www.idl.dundee.ac.uk/phonenotphone, Accessed June 2007

[14] Shorter, M (2007), “Audio Shelf”, www.interactiveaudio.co.uk, Accessed June 2007

[15] www.idl.dundee.ac.uk/ipd, Accessed June 2007

[16] www.interaction.rca.ac.uk, Accessed June 2007

[17] Rozin, D. (2001), “Wooden Mirror”, IEEE Specturm, 8(3):69, 2001

[18] Gaver, W., Bowers, J., Boucher, A., Gellerson, H., Pennington, S., Schmidt, A., Steed, A., Villars, N., and Walker, B. (2004). The Drift Table: Designing for ludic engagement. Proc. CHI’04 Design Expo. New York: ACM Press.

[19] Jones,C. ,“The Invisible Force”, online www.mr-jones.org, Accessed March 2007

[20] Wood, S., “Pixel Roller”, http://www.random-international.com/pixelroller-overview/, Accessed March 2007

Acknowledgements

We would like to acknowledge the conversations and help of Polly Duplock, Graham Pullin, Rory Hamilton, Bill Gaver, Tony Dunne and Durrell Bishop in the development of the position paper.

Jon Rogers
Innovative Product Design
School of Design Perth Road
University of Dundee
Dundee, DD1 4HT
j.rogers@dundee.ac.uk

Tom Hulbert
Luckybite LLP
Burbage House
83 Curtain Road
London EC2A 3BS
tom@luckybite.com

---

[2] A term that Polly Duplock, course director of IPD Dundee, uses to describe the approach of IPD in relation to technology