INTERWEAVING DIGITALITY IN THE FABRIC OF DESIGN

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ABSTRACT
Products that embrace and integrate an invisible, digital world are appearing around us in a rapid pace. This emerging type of products introduces a new dynamic between people, objects and the context or use. The integration of embedded, pervasive and digital technologies in products imposes several challenges for the industrial designer. Designing in a world where an increasing amount of objects are becoming digital and digitally connected opens up a lot of design possibilities on the one hand, but challenges several established tools and methods industrial designers have been using in the past on the other hand. In this paper, technology abstraction methods are used in a creative process in order to engage industrial design students (not necessarily technologically skilled) in the design of products that operate in a digitally connected world. We present a process that was evaluated during a weeklong workshop. During this workshop, the potential of technology abstraction methods and how they can aid industrial designers to better communicate ideas that crossover between digital and non-digital worlds were evaluated. The eventual goal of this process is to provide industrial design students, practitioners and/or educators with an open, yet structured platform complementary to established tools and methods. This is in order to better define, prototype and communicate product and product interactions that interweave digital elements into their context of use.

Keywords: Prototyping, digital creation, technology abstraction, interaction design

1 INTRODUCTION

The confluence of digital technology and the everyday life of people has gained an increasing amount of attention and popularity in recent years. A good indicator for this is the exponential adoption of the smartphone [13], a technological device that allows people to interact with the digital world independent of their physical location. Advances in technology like the smartphone have a direct impact on our social behaviour, e.g. people start to look up facts on services like Wikipedia or Google during everyday conversations. By doing this, technology gets intertwined in the way we interact with each other and the world. In current usage, the technology used is often still very visible. A smartphone has a display; it is a device that people physically interact with. However, looking ahead, a recent update of the Gartner Hype Cycle indicates the importance of the upcoming 'Internet of Things' [4]. The Internet of Things (IoT) is a concept in which all objects around us are linked to a network, together creating a connected world. Within the IoT, all objects are given a digital presence using integrated sensors and actuators that generate data and output certain actions about the object and its environment, thus allowing other devices and objects to communicate with each other through a digital network [12].

The design space that emerges when the digital and non-digital presence of products are combined, sets the scene for the research presented in this paper. For the industrial designer, two challenging characteristics of this design space are the constant switch that has to be made between the tangible and intangible aspects of a product and how certain decisions have influence on the total interaction cycle from the end user point of view. In literature, the type of products that a designer creates in the before mentioned design space are referred to as spimes [11] or meta-products [6]. An important feature of spimes and meta-products is that the role of the designer becomes less visible than before. Within this 'category' of products, the designer creates interactions between people, tangible products together with the data streams these products digitally generate or receive from other sources. In order to design, create and evaluate such interactions, designers and design education needs to revise existing methods in order to incorporate this new dynamic needed to design for the connected world [8] [9]. This paper presents the setup and preliminary results of a pilot design assignment that involves the design of products with an underlying digital technology. In the setup of this assignment, a variety of tools and methods are used which allow industrial designers with various interests and backgrounds to be creative in the identified design space.

2 TECHNOLOGY ABSTRACTION

Generating and communicating fresh ideas ought to be a core competence of product developers and industrial designers. However, communicating ideas that involve a blend of digital and non-digital interactions require a different approach than a static presentation or system visualisation for both communication and verification purposes. The dynamic properties that are embodied in digitally interactive products are, in most cases, impossible to sketch on paper. Interactions need to be explored and experienced by potential users in order be evaluated or designed. The creation of, for instance, experience prototypes, is essential to get a grip on the potential of emerging technologies since methods like these allow for an appropriate communication about the generated interaction concepts [2]. Currently, creating such an experience prototype often involves specific technical knowledge such as computer programming or electronic circuit design [9]. Mastering these tools, which allow the creation of such prototypes, is often a hard boundary for the industrial designer.

From the technological side, a substantial amount of work has been done in order to facilitate the creation of digital prototypes. This evolution is often referred to as 'sketching in hardware' [7], which ideally means that industrial designers could sketch with (digital) hardware in a similar way and with a similar complexity than they would sketch with pens and markers on paper. Existing toolkits such as the Arduino platform, LEGO Mindstorms or Phidgets have already shown that technological complexity can be greatly reduced during the creation of digital prototypes. Yet, the downside of most existing systems and tools is that people still need a certain technological affinity in order to pick up 'sketching in hardware' as a useful tool. Existing tools therefore do not always fulfil the wishes of a designer because they (i) require a designer to have an understanding of computer programming logic and (ii) are in many cases regarded as a means to an end instead of being a means that supports a creative process.

An important pitfall is that the designer gets lost in technical details during prototyping, which often overshadows the larger picture of the designed digital interaction. A method that brings an alternative to this is 'magical bits' [5], which proposes several small technology demonstrators that can be used to explain certain technological concepts. Magical bits allow being creative with certain technologies without having to know the precise way it works. This type of method puts the focus back on the interaction with technology, but still originates from a technological starting point. Very little methods or tools that support a digital creation process start from the context of use or the interaction with objects and the world around us as such. Methods that do start from the context of use are very good at mapping context in a visual way, but very often rely on more 'static' methods such as storyboarding or paper prototyping. An example of this is the network focused design method (NFD) [6], which offers a well thought out structure and tool overview for designing products in a connected world but does not go beyond established creative methods. The contextmapping [10] approach allows to deeply incorporate user insights in a design process, it often includes the creation of mock-ups and tangible artefacts to inform design but does not aim to bridge interactions between digital and non-digital product ideas.

Rounding up reflections on existing tools and insights, the profound integration of digital technology in the early phases of an industrial design process either seems very technical or does not communicate the product idea in an appropriate way at a specific stage in the design process. Therefore, the crossover between digitally prototyping functional products using sensors and actuators or prototyping using established methods such as storyboarding, acting out or movies still remains challenging. The open, yet structured process presented in this paper, aims to enable industrial designers to take abstraction from technology in the early phases of the design process. This process offers various entry points, with the eventual goal to engage both people with or without technological knowledge or affinity in the design of products for the connected world. In this way, a platform for defining digitally augmented products is created which supports various levels of technological abstraction. By doing this, the designer is motivated to initially think creatively and eventually use technological artefacts or prototypes to support the communication of concepts, instead of letting technological constraints define the interaction from the first moment. In other words, taking abstraction from technology enables industrial designers to initially ‘forget’ [1] what is technologically feasible at a certain point in time. In this way, designers can come up with what might seem unrealistic concepts at first but once they are evaluated more profoundly several aspects can often be prototyped or made in a way that the concept does become feasible. Therefore, when prototyping with technology, the technology should stretch to the idea and not the other way round.

3 METHOD & PROCESS

In order to further explore and evaluate the potential of context driven technology abstraction methods, a weeklong workshop was set up. This workshop was part of a larger workshop-week program, in which a number of workshops ran side by side. The central theme of this workshop-week was ‘design for kids’, which was predefined by the organisers. Since objects play an important role during all developmental stages of children, the ‘design for kids’ workshop platform provided us with a very useful context to explore the Internet of Things topic. We therefore named the workshop ‘the Internet of Kids Things’, referring to both the importance of objects (things) in the lives of children and the upcoming Internet of Things phenomenon. Beforehand, we set the objective to support various groups of students in exploring the interaction possibilities that emerge when objects and things that children use during play become digitally augmented. The goal was not to create digital versions of existing toys, but to create integrated product initiated by interactions, which are, as a result, meaningful to their users and seamlessly integrate in the context of use.

In total 11 industrial design students participated, their experience level ranged between 2nd Bachelor and 1st Master. All of them had a basic understanding of industrial design and had been involved in student projects before this workshop. 4 participants had previous knowledge in programming a digital system, mostly using the Arduino microcontroller board. During the workshop the students worked in groups of two or three. The students with programming experience were spread over the groups, by this we tried to level out the experience level and skills available to each group. During the workshop, two supervisors actively followed up the students and gave feedback where necessary. In order to document the workshop process, every student group was requested to at post at least twice a day to a group blog set up by the organisers.

The workshop consisted of three big parts, context exploration, idea generation and prototyping. During both context exploration and idea generation, making prototypes was encouraged. The workshop participants were explicitly asked to use as little of the ‘conventional’ interaction design visualisation techniques such as storyboarding or movie making.

3.1 Context exploration

The aim of this first exploration was to identify a network of actors and objects in the chosen context. To do this, an adaption of the first step in the networked focussed design method (NFD) [6] was used. Since the workshop time was limited, the organisers had predefined five different contexts the students could start from. These were ‘wooden train toy’, ‘toddler cycle’, ‘playmat tiles’, ‘swimming pool’ and ‘dress up chest’. For each context, an A3 size visual collage was provided in order to kick-start the process. There were no age limits or other constraints set, neither were there any specific elements mentioned that had to be included in certain contexts. Once each group had chosen a context, the workshop participants were asked to create two visual maps, indicating how (i) all actors and stakeholders within a certain context were connected and (ii) how all objects in that context were connected. This differs from the original NFD method, since it focuses only on actors and actions within a context. As the ‘Internet of Things’ was a central element of the workshop, exploring the given context from the ‘things’ point of view seemed to be crucial. By making both visual maps, the groups were able to explore and understand their chosen context in a short amount of time (half a day). Additionally, it gave them a working document that they could use throughout the rest of the workshop. Looking ahead, in the end of the workshop these maps gave the participants a means to trace back their eventual designed product to their very first analysis. In the end, this provided a way to point to the foundations of an idea.

3.2 Idea generation (lillidots)

Once the visual context maps were made, the participating students were given one full day to generate ideas using elements from their context exploration. In order to facilitate this process, the lillidot method [3] was introduced. Lillidots are a way to generate and define ideas incorporating technology in a very early stage of the design process. The method allows a designer to think freely, but in a structured way. This allows for better communication about an idea in the future phases of a design process. A lillidot is defined as 'something of variable size that can attach itself to any object, person or space. You can talk to a lillidot and it can talk to you. A lillidot can tell you everything about the object, the person or the space it is attached to or that it observes. The lillidot can work together and talk with other lillidots independent of their location.'

Each group of students were given several sets of blank lillidot sheets (Figure 1, left), each set of lillidots represents one idea. A set of lillidots always consists of a title sheet, where the general idea is defined and (optionally) quickly visualised. Bound to this title sheet are a number of lillidots needed to construct the idea. These separate lillidot sheets split the general idea into smaller parts. For each part, the specific functionality needs to be defined. For example, 'a lillidot is stuck to my T-shirt – it measures my temperature. In order to do this, it first needs to have skin contact, then it needs to start measuring, then it needs to save the measurement to eventually make the data available'. By splitting an idea up into separate lillidots, specific attention is given to how the system behind the idea works, what actors, actions and objects are needed in order to make it work. From a technical point of view, the lillidot method is basically a high level abstraction of a sensor or an actuator. The important part when using lillidots however, is that the technological link is never made explicit. This (i) enables people without any technological affinity to define an idea that will eventually be driven by (sensor) technology and (ii) provides a detailed description of an idea, which will ease the integration of digital elements in the prototype.

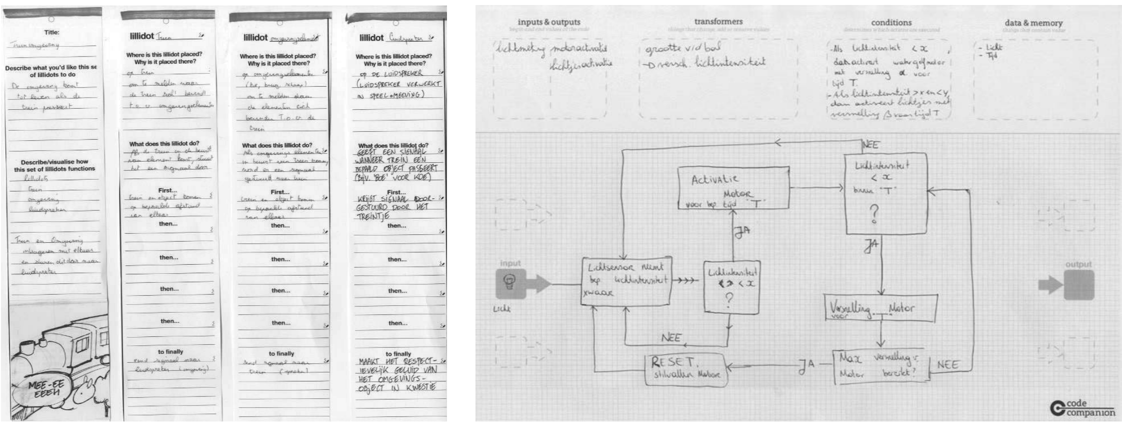

Figure 1. (left) filled out lillidot sheets (right) filled out code companion

3.3 Idea to code (code companion)

The Code Companion (CC) is a tool for designers that attempts to bridge the gap between idea and code. The idea behind the CC is that by having the designer sketch the framework of what the computer should do before actually programming, a better understanding of what needs to be programmed will be created. The CC is an A3 sheet with designated areas for each of the three steps of the CC process (Figure 1, right). After the idea and intended interaction is fully defined, the first step is to determine the input(s) and the output(s) of the hardware sketch. The second step is asking: 'what kind of tools would a computer need and what would be the parameters of these tools be?', designers will be forced to think about the actions of a computer. These 'computer tools' have been organized in three categories on the CC: Data/Memory (values & variables), Transformers (tools that change, add or remove items from Data/Memory) and Conditions (determine when Transformers should be used). The final step is sketching a path from input(s) to output(s), using the defined tools. The CC is an iterative tool, designers can define new tools at each of the steps as they see fit. The CC leaves a large amount of interpretation to the designer for his or her own ideas, but forces them to think about how computers would interpret.

Students were asked to use the CC method after they had defined their idea using Lillidots. By sketching and iterating from input(s) to output(s) and defining their own tools, even with minimal knowledge on programming, students generally come up with a control structure styled diagram. By having the students go through process of creating this diagram, a better understanding was created of what they needed to program, as well as having an overview that they can refer to when programming the interactive parts of their prototypes.

3.4 Prototyping

During the entire duration of the workshop, prototyping was a central element. From day one, the workshop participants were invited to start making small mock-ups of first ideas to test things out. Initially, these prototypes were mostly made out of cardboard and tape and were used as communication tools. Later on in the process, electronics were added to the first prototype to evaluate and design the interactivity defined during the lillidot creation. Because each team had filled out a Code Companion sheet, each team knew what they were going to make and could prototype in a very focused way. Eventually every group created a presentable interactive prototype, which was on display at the closing expo of the workshop week (Figure 2C). The main challenge faced during prototyping was the integration of electronics in the prototypes. After all student groups had a well defined idea, they were given an Arduino kit. Arduino is an electronics prototyping board, which consists of a microcontroller, several input and output ports and a USB port to upload code to is. As mentioned before, when prototyping using such tools the pitfall is that designers loose themselves in code and technical details. For this workshop, we therefore choose to work using the Arduino Tinkerkit shield. By using Tinkerkit, students could plug sensors to the arduino using pre-fabricated electronics boards and connection wires (Figure 2B). In this way, the students only had to program and the design the desired interactions and were not faced with electronical circuit design issues.

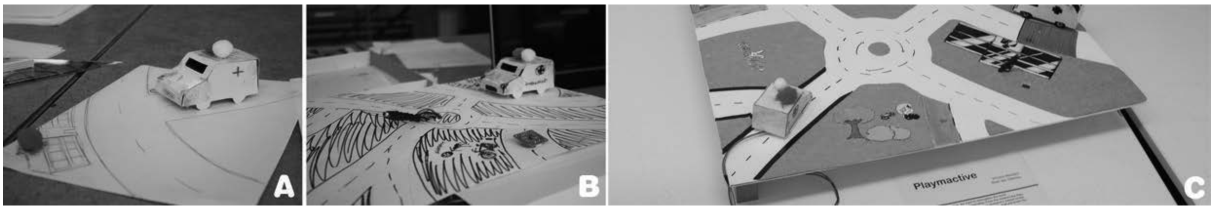

Figure 2. Prototyping process - from non functional mock-up to working interaction prototype

4 RESULTS

The quality of the prototypes and the interactive functionality of each prototype were of a very high standard to create in a week, starting from scratch. After a first evaluation, the structured, yet open methods offered were very valuable to the student groups. This was very clear during the very early phases of the process where the template sheets provided the teams with a clear ‘task’. This gave them a way to communicate in a less conceptual way than they would in a totally free brainstorm. Because each early phase had a certain deliverable linked to it, a design decision could always be traced back to a specific phase. This proved to be particularly valuable when the students moved from the visual context maps to the lillidots. They could clearly see what combinations of actors, objects and actions they could use and which they were using so far. When communicating their ideas to the workshop supervisors, this also helped to understand where certain ideas came from and how they should be interpreted in their context.

When the teams started to make their prototypes functional using the Arduino, there were several problems with writing code. Most of these were related to specific commands that were not known by the participants. Because each team had a thought about their code using The Code Companion before they started to actually write a first line of code, the process of moving from concept to working prototype happened in a structured way. The limitation of existing digital prototyping tools is that writing code often does not appeal to designers. By offering other entry points, such as lillidots and The Code Companion, less technically skilled participants were able to define and explore their idea step by step before starting to ‘code’.

Working with pluggable electronics (the Arduino tinkerkit) clearly made the creation of digitally interactive prototypes easier. The workshop participants could focus on designing their interaction, without having to tinker with electronic circuitry. Because the available sensors and actuators of the

Tinkerkit were limited, several groups made creative use of certain sensors in order to communicate parts of their interaction. An example of this is the use of a linear slider to simulate the distance a toddler cycle has to objects in its surroundings. Although it required some manual input, the interaction between the world and the designed product could still be experienced.

5 CONCLUSION & DISCUSSION

This paper introduced several methods, which allow industrial designers to design and create in a digital, Internet of Things world, regardless of their knowledge or background in technological creation. We evaluated the potential of using technology abstraction as a starting point to define and prototype products that intertwine digital elements in non-digital products and vice versa. Within the context of this paper, a point of that is often raised is whether industrial design education should teach students how to program or not. Looking back on the process presented in this paper and referring to the work by Bannon [1], being able to communicate digitally interactive ideas which challenge established technologies might be more important from the designer's view. It is important to offer methods to create in the digital world that provide various entry points in order to not only get people with technical interest or affinity in the loop.

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