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PROTOTYPING FOR NON-DESIGNERS: REFLECTING ON THE USE OF INTERACTIVE PROTOTYPING TOOLS

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ABSTRACT
Scientists and designers show different problem-solving strategies. Where scientists generally adopt a strategy of analysis; designers are more inclined to solve a problem by synthesis. Instead of striving for a deep understanding and analysis of the problem, a designer tackles a problem by quickly generating a satisfactory solution. Prototyping is one of the tools for designers to conceptualise and realise new product solutions. Fifteen students in their final year at the university following Political and Communication Sciences received an introduction to the programs Makey Makey and Scratch. All participants had little to no experience with programming and prototyping. The reflections on the workshop are described from a teacher and students' point of view through qualitative interviews and a post survey. Results shine a light on the level of enjoyment, satisfaction and barriers of the students about the new learned tools. We conclude that interactive prototyping for non-designers is valuable and other non-design disciplines can quickly integrate such tools.

Keywords: Interactive prototyping, programming, designer, non-designer

1 INTRODUCTION

Scientists and designers have different strategies to solve problems [1]. Van Aken contrasts the empirical research paradigm applied in 'explanatory sciences' such sociology or physical sciences with the 'design sciences' like medicine and engineering. The former most significantly follows and inductive or deductive reasoning approach, with an emphasis on the ability *describe, explain and predict* [2]. By contrast, the design sciences take an abductive ways of thinking, which can be considered *best guess leaps* [3].

In general students from engineering and medicine schools, educated following the design paradigm follow, a problem solving cycle and aim to produce solutions to field problems [2]. The first step in the problem-solving cycle results in a problem definition, next is the analysis and diagnosis of the problem where after a solution can be designed. This is followed by the implementation process in which results are being put into practice and can be evaluated in the final step. This may lead to the definition of a new problem or in the beginning of a new problem-solving cycle.

The differences between design sciences and explanatory sciences are empirically illustrated by Lawson [1], arguing that where scientists generally adopt a strategy of analysis; designers are more inclined to solve a problem by synthesis. The notion of design synthesis is similarly presented by Kolko [3] who argues that through design synthesis, abductive logic can be applied. More generally, instead of striving for a deep understanding and analysis of the problem, a designer tackles a problem by quickly generating a satisfactory solution [4]. This is done most prominently through prototyping [5] and helps designers to conceptualise and realise new product solutions.

The different approaches are compared by evaluating graduation projects of students from the different graduation fields [2]. Students of explanatory sciences follow an empirical cycle, and aim at a descriptive and explanatory knowledge [6].

Recent years has seen an increased attention to the ways in which designers think, popularised under the term ‘design thinking’ [7]. Yet, despite the increased attention given, students from non-design backgrounds have limited to no prototyping experience, notwithstanding the noted benefits of *collaborative prototyping across organisational boundaries* [8]. This suggests that the ability for non-design students to participate in prototyping activities despite their lack of formal prototyping knowledge can be beneficial to design outcomes.

Prototyping specifically has seen a rise in prominence through the Maker Movement due to the technical and infrastructural developments. Papavlasopoulou [9] describes the maker culture as a philosophy in which individuals or groups of individuals create artefacts that are recreated and assembled using software and/or physical prototypes. Partly through these efforts, a number of DIY toolkits like Arduino, Sensoboard, Lego Mindstorms and Makey Makey have become commercially available and affordable. They offer new opportunities for people to be creative and offer often the first contact with software programming.

More generally, the ability to quickly develop prototypes subsequently allows designers to test or validate their prototypes [10]. This can happen by incorporating acting out a system’s use and functionality, with prototypes replicating as much functionality as possible (i.e.: see bodystorming [11]). Similarly, designers might use prototypes to create the illusion that a system is working through a Wizard of Oz type study [12].

Educational theorists such as Papert [13], with his constructionism theory, demonstrated the importance of learning through a creative learning process, noting *the role of the teacher is to create the conditions for invention rather than to provide ready-made knowledge.* It is following this idea that maker tools slowly get their place in the primary and secondary schools especially in science, technology, engineering and mathematics learning (STEM). However, this wave is has only happened in the last few years in the schools in Belgium [14].

Despite the attention given to more abductive approaches to problem solving, research also shows that the making approach is most prevalent in STEM education [9] with other disciplines reluctant to adopt this approach. Making activities could support learning processes that will not only focus on a specific subject like mathematics but also involve the 21st century skills acquisition [15].

In sum, scholars identify among designers’ alternative ways of solving problems that is strongly associated with creation of solutions through prototyping. In this paper, we explore how non-designers can use low-fidelity rapid prototyping tools such as Makey Makey [16] and Scratch [17] to create interactive prototypes. Instead of their typical problem-solving strategy of analysis, we asked them to solve a problem by synthesis [1]. Fifteen students in their final year at the university following political and communication sciences subscribed for an interactive prototyping workshop during an innovation week. They received a six hours introduction to the programs Makey Makey [16] and Scratch [17]. Two days after the introduction, the participants needed to present a working prototype of a smart home concept, this for a persona of their choice using their new acquired prototyping skills. All participants had little to no experience with programming and prototyping. The reflections on the workshop are described from a teacher and students’ point of view through qualitative interviews and a post-online survey.

2 METHOD

We used for the sample of this study fifteen students in their final year at the University of Ghent, from the faculty of political and communication sciences. They subscribed for an interactive prototyping workshop during an annual innovation week. Six males and nine females participated in the workshop. Five final prototypes were presented in groups of three. Prior to the workshop, only one participant used makers tools like Scratch in or outside his school education. Others had never been in contact with any programming or prototyping tools.

Presence of the students during that week was mandatory, but the students were not remunerated nor scored for their participation. The given assignment was: “Create a Smart Home concept for a persona of your choice. Make his life better, or more pleasant. Present the product in a presentation of five minutes with the use of Makey Makey & Scratch.”

The workshop was spread over a week. First, students received a six hour introduction - divided over two days - to Makey Makey [16] and Scratch [17]. These digital tools were chosen because of their popularity in the maker movement [9]. Following the two days, the teacher was available for support. On the last day of the week, participants were urged to present a working prototype of a smart home concept, using their new acquired prototyping skills. The reflections on the workshop are described from a teacher and students' point of view through qualitative interviews during the workshop and a post-online feedback questionnaire.

2.1 Technical information

We shortly describe the programs Makey Makey and Scratch that were introduced to the students during the workshop. Makey Makey was initiated by two students at MIT Media Lab. It is marketed as *"an invention kit for the 21st century. Turn everyday objects into touchpads and combine them with the internet. It's a simple Invention Kit for Beginners and Experts doing art, engineering, and everything in between*." By clipping the alligator clip to an object, the computer thinks you are pressing the keyboard. By mimicking the keyboard and the mouse, the Makey Makey lets you control your computer with conductive objects going from a banana to a copper coin or a graphite drawing. The components come in a little box. It comprises of a motherboard, wires with alligator clips and an USB port to connect the motherboard to the computer [16].
Scratch is another project of the Lifelong Kintergarten Group at the MIT media Lab. It is provided free of charge and brought to life to create stories, games, and animations. Scratch helps young people learn to think creatively, reason systematically, and work collaboratively — essential skills for life in the 21st century [18]. The combination of the two prototyping tools gives the users a broad set of possibilities to bring their idea to life. With the use of cardboard, Play-Doh... in combination with Makey Makey, they make their product tangible. Scratch is used to visualise actions such as alarms going off, or the environment in which the product could operate such as the smart home.

3 WORKSHOP RESULTS

All ideas were presented by the students with a working prototype which used Scratch and Makey Makey. Students showed a level of creativity. They used knowledge from the introduction course and found own solutions to animate the prototypes, for example by importing own text fragments or YouTube movies. The students presented their products in a short pitch. Below we briefly describe the five different prototypes.
Smart tile: (Figure 1) This new product is designed to make the home a safer and more pleasant place. A sensor integrated in a tile gives messages to person hitting the tile. Different cases are prototyped and presented. For example, a tile that warns you not to hit a glass door when you step on it. Functions were expanded to other domains, like a tile playing a particular song when entering the children's room or setting an alarm when the tile detects that a child fell out of bed. During the presentation, the students pressed on a box made of Play-Doh and aluminium foil to mimic a foot stepping on a tile. The box was connected with Makey Makey wiring, to play YouTube movies through Scratch.

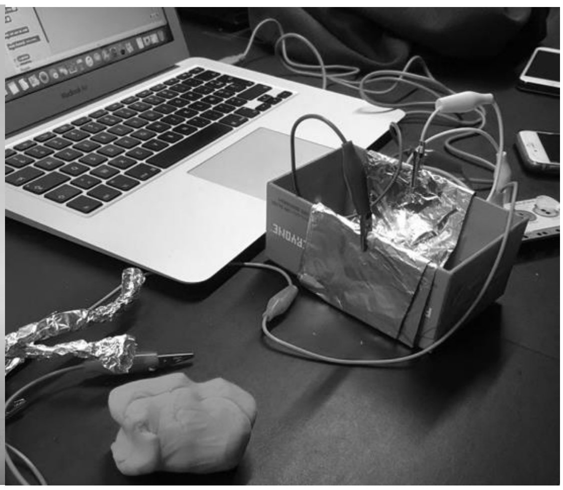

Figure 1. Students prototyping and testing the Smart Tile
Figure 2. Initial prototype of Scatterbrain

Scatterbrain: (Figure 2) This is a set of talking products to help habitants ease down the rush hour in the morning. When grabbing a backpack, it says "Hey! Don't forget your lunch". The door says: "don't forget the keys". For the prototyping, participants first tested the functioning on a box wrapped with conductive aluminium foil. Later, they wrapped real objects like a door handle and backpack and connected them with alligator clips. These are connected by USB with the Makey Makey motherboard and computer to play the sounds. Participants acted and presented their products in a playful way, mimicking the principle of bodystorming [11].

Smart Stairs: (Figure 3) This product helps to make the home a safer place, it detects motion and switches on the light. When several steps are hit simultaneously a possible fall is detected and urgent authorities are contacted. The prototype brings a combination of a miniature figure and stairs in Play-Doh attached to the Makey Makey motherboard with an animation in Scratch for sound and light visualisation. When a miniature figure hits one or several stairs, different types of animations in Scratch (displayed on a laptop) simulate light effects and the arrival of the ambulance.

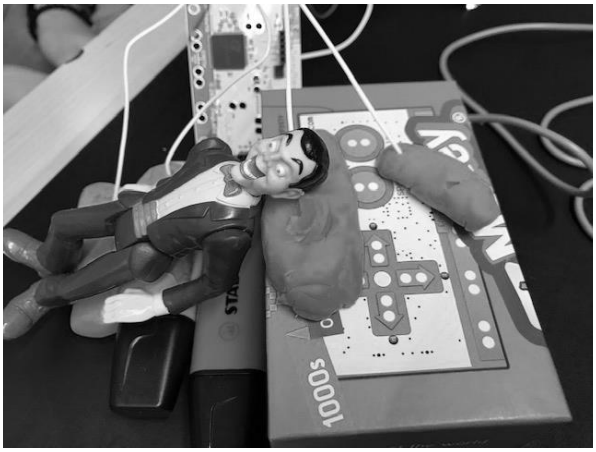

Figure 3. Smart Stairs, the fall of the miniature figure triggers an animation in Scratch
Figure 4. Study Bowl prototype with sound effects in Scratch

Babybutton: This product is designed to help parents survive the morning rush. One push on a button in the kitchen, starts a series of actions in the children's bedroom. The bed moves, and the child is undressed, a shower head appears from the ceiling to give a shower, the child is dressed and slides to the dining table. In this case, only the button is physically prototyped. The child, the showerhead and the clothes are animated in Scratch because participants found this more credible.

Study bowl: (Figure 4) This innovation helps students to concentrate and stay away from their phone. A bowl recognises contact with a smart phone. When the phone is taken out of the bowl, it repeats on a monotonous tone "hey, shouldn't you be studying?". The bowl can be programmed and switched off during breaks. Again, for this prototype participants used Play-Doh, Makey Makey wiring, and sound records in Scratch.

4 DISCUSSION

Our overall rationale for this paper highlighted differences between how the design sciences approach problem solving, contrasted by the approach taken by explanatory sciences. In general, designers apply abductive reasoning, which can be summarised *as best guess leaps* [3] through a process of design synthesis. Our workshop illustrates that through the availability of easy to use DIY prototyping tools students from what Van Aken characterises as the 'explanatory sciences' [2] were also able to apply abductive approach to problem solving.

Before discussing our experiences more broadly, we first note some limitations. First, the cohort of students in this workshop – while lacking any prototyping or technical skills – were already in their final year of higher education. As a result, they might have a higher ability to absorb and learn the skills necessary to create these solutions. Simultaneously, their lack of skills also severely limited what they chose to develop. This might subsequently have important limits on the technical or conceptual complexity of the presented concepts.

Additionally, this paper summarises our experiences and does not assesses any long-term impact that workshop might have on student's problem-solving skills. Finally, given time constraints students were not in a position to perform extensive user research to inform their design decisions.

4.1 Results

Nonetheless, we discuss some interesting results. First, as illustrated by the prototypes, the workshop format of five days with intervals between teaching and self-study was successful for participants to work out a variety of products. The low threshold of use of both Makey Makey and Scratch allow students without any significant prior technical skills to create prototypes that illustrate an idea with enough fidelity. For example, by using Scratch animation as opposed to create real flickering lights, participants were able to prototype their idea to satisfactory level at a lower cost, time- and training effort.

Looking more specifically at the results produced, it is clear that the prototypes themselves stretch multiple forms and themes. More importantly, they provide concrete solutions to points of pain in the everyday lives of people like forgetting things and being distracted, even if they occasionally stretch the limits of imagination (i.e.: The Baby Button). Additionally, the chosen persona for each concept was not always themselves but included groups with which the students were less familiar, such as parents or the elderly.

Students showed creativity in the prototyping process by integrating non-learned tools such as plugin from YouTube or special effects in Scratch into the prototype. The prototypes showed a variation of product-to-user-interactions. Where today many new products interact with users through displays, some prototyped products also gave tactile- or speech feedback. Examples are the Smart Tile, setting an alarm to prevent a possible hit; the Study Bowl, playing an annoying sound to discourage study breaks or the door handle, asking inhabitants if he didn't forget anything.

Most significantly, these quick prototypes efficiently translate concepts into tangible solutions that can subsequently iterated on. For example, the Smart Tile concept originally ideated as a security product not to hit a glass door was quickly expanded in order to consider other scenarios of use such as a product for entertainment initiating music. Additionally, the prototypes enable validation through bodystorming [11] and Wizard of Oz studies [12].

From the perspective of the students, our post-hoc survey revealed a general level of satisfaction with the results. The use of prototyping materials such as Play-Doh, miniature figures, fruit; the need to work together in group and example given holding hands to make the connection between the motherboard and the prototype; the possibility to create a tangible end product… all contributed to the feeling of fun during the workshop.

A student (female, 22y) remarked that it was a lot fun and that she had the feeling that she mastered the basics. However, this view can be contrasted with another student questioning the utility of acquiring these skills, remarking that she cannot imagine applying these in practice for her future job (female, 22y). This points to the potential disconnect still prevalent between the explanatory sciences and design science. The one person who experienced Scratch before had only practiced it to create a game; the use of it to ideate and create new concepts was new and valuable to him. Prototyping tools give new possibilities to non-designers. Their current set of digital tools (PowerPoint, Word) are predominantly used to share knowledge and explain, rather than to explore.

Future research in this domain will work towards the creation of more holistic tools for the development of ubiquitous products; both for designers as non-designers. The tools should be used in the evaluation, ideation and conceptualisation of products which take interactions between the user with other users, platforms, contexts, and objects into account.

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