Augmenting Everyday Objects – A Reflection on Reuse as an Interface Design Method

Beat Rossmy
beat.rossmy@ifi.lmu.de
LMU Munich
Munich, Germany

ABSTRACT

This paper presents three projects which are based on the reuse of existing objects as new Tangible User Interfaces for the purpose of (a) education, (b) exploration and (c) creative expression. The already existing familiarity of the users with the basic interaction concepts of such systems can help to (a) breakdown barriers and increase accessibility of technologies as well as (b) can create playful and enjoyable experiences. The authors give a short overview over their conducted work and the resulting insights as well as a reflection about the process in retrospective.

CCS CONCEPTS

• **Human-centered computing → User interface design**.

KEYWORDS

TUI, Embodied Interaction, Every Day Objects

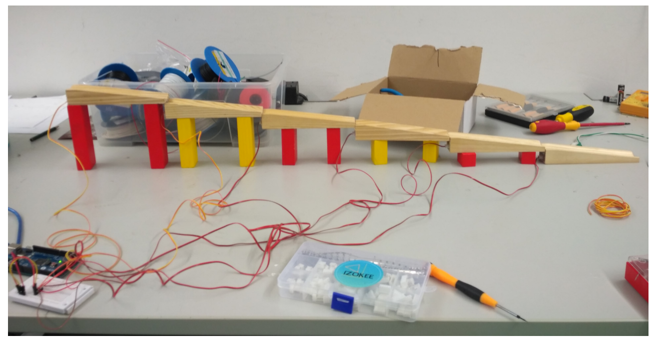

Figure 1: MarbleTrack consists of a set of typical as well as prepared marble track elements. The prepared elements trigger sounds if the marble passes. Children can restructure melodic and rhythmic information by rebuilding the track.

1 INTRODUCTION

Tangible User Interfaces (TUI) [6] enable users to interact with computers in ways that go beyond the simple properties of common peripheral devices. They form a strong bond between virtual/digital items and their respective physical representatives. To design interactions that are easy to learn and access, researchers and designers often use mental models to create familiar user experiences. The reuse of objects known from the everyday context can be a method of approaching the design of such interfaces. "Augmenting everyday objects" is, as seen by the authors, the symbiosis of an already existing object with a new use, an extended interaction or the integration of new properties. This is a common process found in interaction design and especially in projects from the field of embodied interaction [1]. Existing objects can therefore be used and augmented with technologies [10, 11] or interfaces can be designed that are inspired by or which replicate everyday objects.

In this paper we want to share insights generated from three projects which not just simply made use of mental models to design interaction artifacts but heavily build on existing popular objects such as toys or educational tools and their respective properties to create TUIs. We want to reflect the following aspects we had in mind during the concept phase and tried to achieve by reusing existing objects, toys or games in the realm of TUIs:

- build on prior knowledge to create self-explanatory interactions.
- integrate specific properties into interfaces to design interactions that are subject to an internal logic.
- expand capabilities of existing tools to bring digital information into the physical world.

2 RELATED WORK

New technologies [2] and hardware platforms such as the Makey Makey microcontroller [3] enable researchers and hobbyists to easily create tangibles out of everyday objects. Many of such artifacts are created by taking existing objects, adding electronics for interactivity and designing a interaction around the context of the object. Ishii et al. [7] used

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the metaphor of bottles as containers to give an interface a set of meaningful interactions. Opening, pouring and other interactions performed with fluids can easily be transferred by the user to the context of digital information. Thus, this approach is not new but instead has a long tradition in the HCI and TEI communities.

Though, it can turn out to be quit hard to successfully implement such interface concepts [5], the elegance of this approach lies in the foreknowledge users already collected during their interaction in their everyday life's. Therefore, they can easily interact with such objects by using associations and recall strategies known from familiar objects. RopeRevolution [13] uses the object of the rope to create a novel interface. Children play with ropes, during sports we interact with ropes and a rope is even a metaphor for a human relationship.

Our own research projects use every-day objects but mainly their overarching concepts. In the following we present three prototypes applying this technique and we report about our experiences and insights during the research process.

3 MARBLE TRACK

In the Marble Track project (see Figure 1) we tried to give children easy access to the manipulation of music sequences. We literally reused a marble track by integrating sensors into the wooden track elements. The goal was to create a classical set of track elements which children could normally play with but additionally would trigger different sounds each time the marble passes a specific trail element.

Therefore, we integrated magnet switches into the thickest part of the track elements. These switches are closed if the magnetic marble passes the respective element. Thus, melodies and rhythms can be created by lay out prepared and unprepared elements in the specific order.

To evaluate the system and to generate initial insights we conducted a qualitative and observational user study in a kindergarten. This was especially helpful to validate:

- If the children liked as well as understood the concept.
- Which group dynamic processes were triggered by the interface.
- What problems existed with the implementation outside the lab context.

Further, the evaluation helped us to collect inspirations and ideas for future developments of the concept.

Insights

During the study four groups of two children (3-5 years) played for up to 20 minutes with the interface. A short introduction demonstrated the basic functionality of the prototype. After the hands-on-test all children gave feedback about their experience. It turned out that the most interesting insights were generated based on the observations taken through the play time. Nevertheless, the questionnaires could be used to show the acceptance and overall positive grading of the interface.

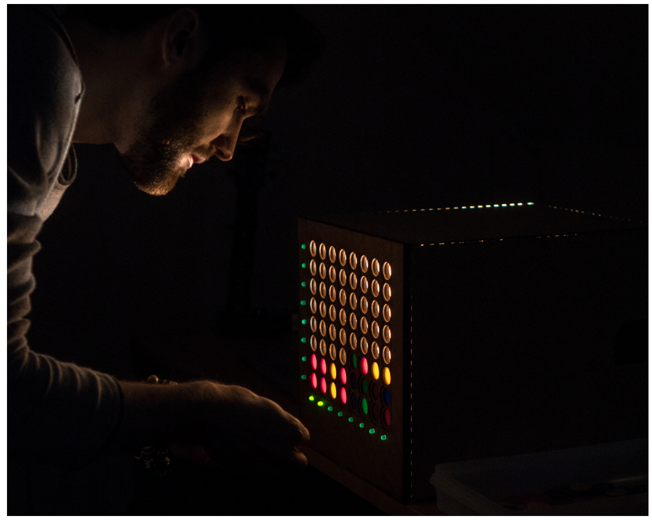

Figure 2: A user playing ConnectFour in the upright (irreversible) position. Chips, once dropped into the grid, can not be removed individually. Either the user reacts to the unintentional outcome of an action or restarts by opening the lid and removing all chips at once.

Overall all children could easily interact with the marble track. Even if they stated that they had no prior knowledge of such toys (what is questioned by the authors) they understood the concept and were able to apply the interaction properly. The causality of objects moving from elevated towards lower situated areas is of such fundamental nature that in fact even novices can execute it easily.

Regarding the implementation the following observations were made. Obviously the wired track elements have potential to cause problems. Wires can be unintentionally be pulled out of jacks, connections can be broken and cables could end up in a huge knot. Nevertheless, the wires triggered a thought process that caused the children to question the cause of the sounds. Some ended up switching the elements but afterwards rewiring them to proof that not the element but the wire determines the triggered sound.

The social dynamics of the group play started conversation about the functionality but also triggered children to offer help and to initiate joint processes.

4 CONNECT FOUR

The ConnectFour interface (see Figure 2) arose from the idea how irreversible interactions can shape the interaction with user interfaces. Because musical interaction was targeted as the application area, we decided to reuse the widely known game "Connect four". This game offers two advantages that the intended interaction can be based upon. First, the game itself reassembles as grid which is a common interface in music sequencing and easily translates into pitch and time properties. Second, the game mechanics forces to player to build upon its former decisions. Once a chip has been dropped into the grid it can not be removed until the game ends. That means that the game mechanics create a commitment to decisions and therefore in theory could push the user to more thoughtful and less spontaneous actions or force the user to creatively react to his/her former actions in a feedback loop.

In the conducted study the interface could be transformed into a horizontal positioning which enabled the user to place and remove single chips freely. This allowed us to evaluate the influence of the irreversibility on the users actions. We focussed on the following points:

- Which interaction was preferred by the users.
- If the users were able to adapt their typical reversible workflows.
- If the workflow influenced the perceived creativity of the musical outcomes.

Insights

20 users (24.2 years in average) participated in an observational study. The users had to perform 3 rounds of interaction with each version of the interface (reversible/irreversible) during their performances they had to use the "Think aloud" protocoll [12] which enabled us to follow along with their thoughts, problems and strategies. If users are more restricted in their workflow than are typically used to, it is predictable that they will feel limited. Exactly this result has been observed in our questionnaire performed after users had the chance to perform several rounds of interaction with both variants of the interface.

Nevertheless, they stated higher agreement in question categories such as "I have considered my next steps well." or "I have reacted to previously entered notes." in the context of irreversibility. The overall difficulty and level of restriction of the irreversible interaction principle was rated clearly higher than the reversible one. The interviews further revealed that there are basically two categories of users. The ones who are flexible and an able to react spontaneously to unintended developments and the others who are more target oriented and had trouble to adapt to new situations. Most of the users would have chosen the reversible interaction over the irreversible interaction and have been more satisfied by their generated outcomes of the same interaction type.

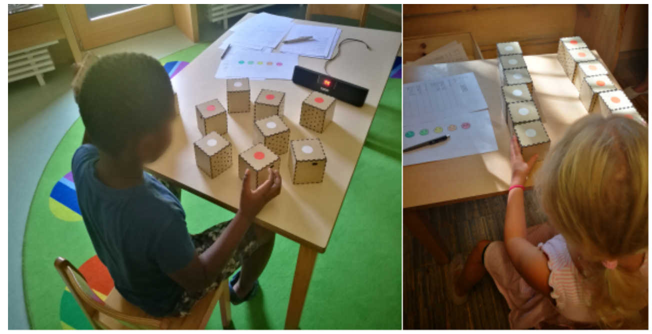

Figure 3: Children using SoundBoxes. By shaking the boxes they can trigger the associated sounds. The blue and red sets both contain the same sounds. The children have to find the corresponding counterparts.

To summarize, the selected everyday object had the intended effect on the users. It created the need for commitment and adaptability during the operation of the user interface. Further, it allowed for immediate access based on the prior knowledge of all participants.

5 SOUND BOXES

The interface SoundBoxes is based on Maria Montessori's [9] sensorial materials. Sensorial materials [8] are pedagogic toys developed to enable children to independently learn about the world surrounding them. Each material focusses on specific object properties and triggers the children's impulse of exploring and searching for patterns and interrelations. There are materials of different sizes, colors, shapes or volumes. For each set there is a single possible order that can be discovered by the child. All these objects transfer information about real world properties and so do the objects that are concerned with auditory learning. The so called sound boxes (a sub-set of the sensorial materials) are two sets of uniform wood cylinders. Each set is marked in a specific color and both sets contain the same hidden bits inside. Rice, gravel, stones can be contained and if shook they produce distinguishable sounds transmitting information about the object qualities of the hidden bits. The task for the children is to find the two cylinders hiding the same insides.

Our goal was to expand the variety of sounds that the sound boxes can reproduce. We built a digital version that contained micro-controllers, sensors and speakers inside and thus is able to produce digital sounds (pure wave-forms, music tracks, etc.) instead of physically produced noises based on the user interaction. This allows children to learn digital sounds and train their hearing so that they can later be able to distinguish sound qualities that most adults find difficult to differentiate. Therefore, we performed a study in a kindergarten concerned with the following aspects:

- Are the children capable of operating the device and performing the intended tasks?
- Is the prototype applicable for the target group?

Insights

First of all, the prototype performed well during the study. For the current version tilt-switches and mp3 boards were used. Closing the switch by shaking the sound box triggered the on SD card stored samples. The benefit was the cost-effective implementation but a downside was the sometimes jittery playback caused by double triggering the samples. Based on the included battery and the size of the speakers used, our sound boxes were significantly larger than conventional sound boxes. Still, the children were able to operate them correctly as well as the sound quality was sufficient to playback samples in good quality. To compensate for frequency changes of the source material based on the resonance behaviour of the boxes, we applied an EQ curve to the source material that balanced under- or over-represented frequency bands.

As samples we used sound-clips from acoustic as well as synthesized versions of the same instruments and the children had to match the respective pairs. The children were able to match most of the samples but had sometimes trouble to distinguish similar sounding instruments. Based on this observation we developed the plan for future work to simplify the sound boxes to just playback standard wave forms to train the hearing capabilities of children.

6 DISCUSSION

During our different projects we could consistently observe that the usage of existing objects as starting points for the development of tangible user interfaces allows for immediate interaction without comprehensive introductions. Objects containing their own internal logic can help to design understandable and predictable tangibles. Therefore a good analysis of the intended objects as well as a thoughtful usage is key to the success of such interfaces.

Further, we observed that joyful experiences could be created by expanding the capabilities of already playful interfaces such as toys or games. Obviously this approach is not always feasible based on the context and the specific project goals. To design really integrated technology high effort has to be put into the implementation of the prototypes. Wires for power or signals can prevent free interaction but can also be used in meaningful ways to direct the attention of the users or to point out interrelations.

At the moment these interfaces are of passive nature. The digital information is directly represented by the physical state of the interface. For future interfaces a bidirectional binding of information would be desirable. Giving the system the capability to change thy physical status of the interaction artifacts could drastically expand the possibilities what such systems can actually perform.

7 CONCLUSION AND FUTURE WORK

To summarize, we made good experiences during the previously presented projects by following the approach of "hijacking objects" and reusing them for tangibles in new contexts, for expanded applications as well as for the creation of playful interaction. This approach can help to lower barriers in the interaction with computers by making the computer disappear behind a "familiar face". The familiarity can further help to create affordances that inform the way users should interact with the interfaces.

At the moment most part of the process is done in an associative manner freely after the double diamond design principle [4]. Starting with some brainstorming of objects that share intended properties or that are from the same field as the planned interaction. Ending with a convergent phase of reducing possibilities down to a single option. Formalizing this process and develop design methods to assist this process could be a helpful tool for researchers enjoying similar approaches.

To further develop one of the presented works we think of expanding the metaphor of the marble track to the area of computational thinking. The disclosure of the sequential execution of linearly arranged "triggers" can help in understanding conditional interrelations of such elements. We plan to introduce abstract trigger elements as well as a set of connectable actuators. This approach could benefit from the directness and causality of the marble track and at the same time bring computational thinking in a playful manner to children of young age.

Over all we are confident to say that the presented projects show that this approach can help in the design process of tangible user interfaces and create results that are fun to use as well as easy to approach.

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