Human–Computer Interaction Series

Adrian David Cheok
Anton Nijholt
Teresa Romão *Editors*

Entertaining the Whole World

Springer

Human–Computer Interaction Series

Series Editors
John Karat
Hawthorne, New York, USA

Jean Vanderdonckt
(IAG), Université catholique de Louvain Institut
d'Administration et de Gestion, Louvain-la-Neuve, Belgium

HCI is a multidisciplinary field focused on human aspects of the development of computer technology. As computer-based technology becomes increasingly pervasive – not just in developed countries, but worldwide – the need to take a human-centered approach in the design and development of this technology becomes ever more important. For roughly 30 years now, researchers and practitioners in computational and behavioral sciences have worked to identify theory and practice that influences the direction of these technologies, and this diverse work makes up the field of human-computer interaction. Broadly speaking it includes the study of what technology might be able to do for people and how people might interact with the technology. The HCI series publishes books that advance the science and technology of developing systems which are both effective and satisfying for people in a wide variety of contexts. Titles focus on theoretical perspectives (such as formal approaches drawn from a variety of behavioral sciences), practical approaches (such as the techniques for effectively integrating user needs in system development), and social issues (such as the determinants of utility, usability and acceptability).

Titles published within the Human–Computer Interaction Series are included in Thomson Reuters' Book Citation Index, The DBLP Computer Science Bibliography and The HCI Bibliography.

More information about this series at http://www.springer.com/series/6033

Adrian David Cheok • Anton Nijholt
Teresa Romão
Editors

Entertaining the Whole World

Springer

Editors
Adrian David Cheok
Mixed Reality Lab
City University London
London
United Kingdom

Teresa Romão
Universidade Nova de Lisboa
Faculdade de Ciências e Tecnologia
Caparica
Portugal

Anton Nijholt
University of Twente
Human Media Interaction Group
Enschede
The Netherlands

ISSN 1571-5035
ISBN 978-1-4471-6445-6 ISBN 978-1-4471-6446-3 (eBook)
DOI 10.1007/978-1-4471-6446-3
Springer London Heidelberg New York Dordrecht

Library of Congress Control Number: 2014940925

Printed on acid-free paper

Springer is part of Springer Science + Business Media (www.springer.com)

Contents

Contributors

Alissa N. Antle School of Interactive Art & Technology, Simon Fraser University, Surrey, Canada

Brian Birtles Mozilla Japan, Tokyo, Japan

Adrian David Cheok Mixed Reality Lab, City University, London, UK

Yoram I. Chisik University of Madeira Funchal, Portugal

Betsy van Dijk Department of Human Media Interaction, University of Twente, Enschede, Netherlands

Shigeyuki Hirai Faculty of Computer Science and Engineering Kyoto Sangyo University, Kyoto, Japan

Maarten H. Lamers Media Technology Group, Leiden Institute of Advanced Computer Science, Leiden University, Leiden, Netherlands

Ichiya Nakamura Keio Media Design, Keio University, Tokyo, Japan

Anton Nijholt Department of Human Media Interaction, University of Twente, Enschede, Netherlands

Ana Paiva INESC-ID and Instituto Superior Técnico, University of Lisbon, Lisbon, Portugal

André Pereira INESC-ID and Instituto Superior Técnico, University of Lisbon, Lisbon, Portugal

Rui Prada INESC-ID and Instituto Superior Técnico, University of Lisbon, Lisbon, Portugal

Peter van der Putten Media Technology Group, Leiden Institute of Advanced Computer Science, Leiden University, Leiden, Netherlands

Dennis Reidsma Department of Human Media Interaction, University of Twente, Enschede, Netherlands

Teresa Romão CITI, DI-Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Portugal

Elena Márquez Segura Department of Informatics and Media, Uppsala University, Uppsala, Sweden

Cristina Sylla Curricular Studies and Education Technology, University of Minho, Braga, Portugal

Daniel Tetteroo Department of Industrial Design, Eindhoven University of Technology, Eindhoven, Netherlands

Fons J. Verbeek Media Technology Group, Leiden Institute of Advanced Computer Science, Leiden University, Leiden, Netherlands

Gino Yu Associate Professor at Hong Kong Polytechnic University

Chapter 1
Entertaining the Whole World

Adrian David Cheok, Teresa Romão, Anton Nijholt and Gino Yu

Abstract Entertainment media are entertainment products and services that rely on digital technology. Mostly the digital entertainment industry is focused on the developed world such as USA, Europe, and Japan. However, due to the decreasing cost of computer and programming technologies, developing countries can greatly benefit from entertainment media in two ways: as creators and producers of games and entertainment for the global market and as a way to increase creativity and learning among developing world youth. In 2012, the international conference ACE 2012 or Advances in Computer Entertainment was held in Nepal to spark new frontiers of entertainment media in the developing world. The discussions and projects benefit the emerging world through digital entertainment. For example, youth in emerging markets can become creators as well as consumers of digital entertainment. They can distribute their work through apps and internet, and through media creativity benefit their country and economy. This book is a summary of some of the research projects and discussions which took place in Nepal.

1.1 Introduction

We define entertainment media as entertainment products and services that rely upon digital technology. These include traditional media that now use digital production processes such as movies, TV, computer animation, and music, as well as emerging

A. D. Cheok (✉)
Mixed Reality Lab, City University, London, UK
e-mail: adriancheok@mixedrealitylab.org

T. Romão
CITI, DI-Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa,
2829-516 Caparica, Portugal
e-mail: tir@fct.unl.pt

A. Nijholt
Department of Human Media Interaction, University of Twente,
Drienerlolaan 1, Enschede, Netherlands
e-mail: a.nijholt@utwente.nl

G. Yu
Associate Professor at Hong Kong Polytechnic University

A. D. Cheok et al. (eds.), *Entertaining the Whole World*,
Human–Computer Interaction Series, DOI 10.1007/978-1-4471-6446-3_1,

services for wireless and broadband, electronic toys, video games, edutainment, and location-based entertainment (ranging from PC game rooms to theme parks).

Digital entertainment media is unique in that its products and services are intimately tied to digital technology, which has been in a continuous state of innovation since its inception. Each new generation of integrated circuits has the potential to shake-up the landscape of market leaders, products and services that are possible, and boundaries between market segments. Arguably, digital technology innovation today is driven by entertainment applications. The need for faster, low-power processors, high bandwidth networks, and high-resolution displays are primarily for mass-entertainment applications.

Although digital entertainment relies heavily upon technology, it is equally dependent upon creative art, content, and design. It has been demonstrated time and time again (from web portals to broadband networks to electronic toys to video game consoles to digital audio formats) that state-of-the-art products and services will fail in the marketplace without compelling content or creative intellectual property (CIP).

1.2 Digital Entertainment Media Importance to the Developing World

The low cost of computing combined with low labor costs make the developing world ideal for developing new entertainment products and services. What is lacking, and what is required is the generation of artistic and creative intellectual property and imagineering. Youth in developing countries need to be given the skills to act as a catalyst and permeate creative intellectual property to companies and industries, as well as to make their own start-up companies. This will allow the huge potential of the entertainment media industry to be catalyzed from developing countries as an export market.

Digital games open up vast opportunities for future growth. Video game sales exceed US$ 20 billion worldwide[1] exceeding box office ticket sales for film. Computer animation is a US$ 25 billion-dollar industry[2] with more and more designs finding their ways into film, television, and multimedia. The market is expected to be bright due to the fact that according to the Interactive Digital Software Association, the average American gamer is 28. Older consumers tend to have more disposable income to spend on games than do teenagers. Increasing demand worldwide, high production costs in the US, Japan, and Europe, and the availability of new distribution channels (wireless, broadband, etc.), can allow developing countries to be major players in the US$ 45 billion world of digital entertainment.

The production of digital entertainment is extremely labor intensive. It provides high-paying jobs worldwide. It is very accessible (doesn't require extensive sciences

[1] http://www.theesa.com/facts/pdfs/esa_ef_2013.pdf.
[2] Roncarelli Report (2000 December). ISSN 1202 - 1156.

or language background). And the allure of digital entertainment makes it easy to motivate students, even those whom the education system has "written off". Students with minimum experience can acquire a two year Associate Degree that will allow them to contribute to society and earn a decent living doing something they enjoy.

Western designers create intellectual property for worldwide audiences. Developing countries have not been strong in this area. Most manufacturers there are reluctant to invest in activities that don't provide immediate returns. Thus they lack the resources for creative development. We need to help companies transition from original equipment manufacturing (OEM), to brand-ownership.

1.3 Benefits to Local Industry in Developing Countries

1. Create rewarding and exciting career opportunities for local university students in a new and promising field: Digital Entertainment is perfectly suited for developing countries environment. The local employment market would also receive huge benefits from the growth of such a new and promising industry. By providing training to local university students and equip them with the latest knowledge and understand on Entertainment, fresh local university graduates can immediately contribute to this booming area.
2. Through developing and transitioning leading-edge new media and human interface technology, developing countries will be part of this high impact global market.
3. Development of new technologies will act as a lighthouse for attracting foreign direct investment and encourage the presence of more multinationals in developing world.
4. New companies will be spun off as a result of the commercialization of new technology.
5. Increase private investment in research.
6. Infusion of talent in the region because the entertainment industry will become a magnet for attracting and retaining world-class students.

1.4 Conclusion

By entertaining the whole world, we allow the benefits of the huge digital entertainment industry to be felt in developing countries. This allows local developers with very little cost and equipment to develop games and apps to distribute on the global market. It also increases the creativity index of the youth which will further benefit the economy and the society.

Chapter 2
The Kathmandu Kids Entertainment Workshops

Yoram I. Chisik, Alissa N. Antle, Brian Birtles, Elena Márquez Segura and Cristina Sylla

Abstract The Kathmandu kids workshops at Advances in Computer Entertainment (ACE) brought together local children and leading entertainment media researchers from around the world in a daylong exploration of how children interact with and think about the latest innovations in computer entertainment and what these innovations or the lack thereof mean to their lives. The result was a mixture of surprise, play, inquiry and reflection. In this chapter, we describe the ideas behind the children workshops concept and the individual workshops themselves, the settings in which the workshops took place and the nature of the participants and the overall experience and outcome of the workshops.

Keywords Children · Participatory design · Games · Workshops · IC4D

2.1 Introduction

Designing for children is notoriously hard. Designing for children in developing countries is doubly hard as the physical distance between the developer and the target audience, financial constraints and other logistical difficulties make it almost impossible to employ the participatory and emphatic design practices that are the hall mark of a conscientious child-oriented design practice.

Since the 2012 Advances in Computer Entertainment (ACE) conference was held in Nepal, a country with severe infrastructure and development challenges,

Y. I. Chisik (✉)
University of Madeira Funchal, Portugal
e-mail: ychisik@gmail.com

A. N. Antle
School of Interactive Art & Technology, Simon Fraser University, Surrey, Canada

B. Birtles
Mozilla Japan, Tokyo, Japan

E. M. Segura
Department of Informatics and Media, Uppsala University, Uppsala, Sweden

C. Sylla
Curricular Studies and Education Technology, University of Minho, Braga, Portugal

A. D. Cheok et al. (eds.), *Entertaining the Whole World*,
Human–Computer Interaction Series, DOI 10.1007/978-1-4471-6446-3_2,

we wanted the conference to serve not only as a venue for the presentation of work and the sharing of ideas among researchers and media practitioners, but also to create an opportunity for attendees to interact with local children, and for local children to interact with the attendees.

The reasoning for this was twofold. First, games and media are not only a means of entertainment, but are also a means of empowerment by providing paths to new information and insights and by promoting creativity and experimentation through exploration and play. The presence in Nepal of leading researchers and practitioners in the field of entertainment technology provided a unique opportunity for children to go beyond playing with entertainment technology and explore ways of creating entertainment media and ways of expanding their own understanding of entertainment computing and its potential with visiting researchers and practitioners.

Second, we wanted to provide researchers and media practitioners with a glimpse into the perceptions and expectations of local children in the hope that this would act as a catalyst for further development of ideas and applications geared towards children in developing countries and children in general.

To achieve this goal we created the kids workshops, a collection of concurrent 2-h workshops conducted in local schools (away from the main conference venue) in which researchers from the ACE conference and local school children explored a particular piece of entertainment technology and a problem domain. Each of the individual workshops had its own agenda and objective so as to provide a broad spectrum of ideas and technologies.

2.2 The Schools

Nepal is a country of high variations and extreme discrepancies. This is reflected both in the topography of the land that spans the low lying valleys of the Terai region with an elevation as low as 67 m above sea level and extends to the Himalayan mountain range that peaks at the summit of Mount Everest 8848 m above sea level and in its demographics with a huge discrepancy between the rich and the poor and a quarter of the population living below the poverty line (World Bank 2013).

To account for this wide discrepancy we decided to run the workshops twice in one day, visiting a school at one end of the socio-economic spectrum in the morning, and a school at the other end of the socio-economic spectrum in the afternoon.

We started the day at the Ullens School, a private school offering well-equipped classrooms to students coming from well endowed families capable of paying the high fees charged by the school. We ended the day at the Shree Rudrayanee School, a government run school offering free public education in bare bones facilities to the general population. Both schools are located in the outskirts of Kathmandu (the capital city) and offer classes to children between the ages of 6–16.

Although the two schools are fairly close to one another, being separated by only 7 km of physical space, they are worlds apart in terms of the facilities they offer their students. The classrooms at the Ullens School are similar to those found in any

Fig. 2.1 A classroom at the Ullens School

developed country, they are well furnished and well lighted and some of them are also equipped with a projector. The classrooms at Rudrayanee consist of bare concrete units equipped with rudimentary benches, a blackboard, and no electricity supply. The only room at Rudrayanee with an electricity socket is the computer laboratory (Figs. 2.1 and 2.2).

A small sample[1] of the students at each school were asked to fill a short survey about their access to and use of computers, video games and mobile phones and as one would expect there marked differences between the two schools.

While all of the surveyed children in Ullens had computers at home and enjoyed Internet access both at home and in the school, only one child in Rudrayanee had a computer at home and none benefited from Internet access at home. Thus while most of the students at Ullens noted they spent between half and hour to four hours per day on a computer most of the ones in Rudrayanee were restricted to about an hour of computer usage per week at the school computer laboratory (composed of fairly old computers running windows XP) with occasional use of computers and the internet at a cyber café or during visits to relatives who owned a computer.

The section of the questionnaire concerned with game consoles revealed a deeper schism between the two schools. In Ullens 11 of the 14 children surveyed (80 %) noted they had game consoles at home with 6 of those having more than one type of console and reporting their friends and family being in a similar situation. In Rudrayanee, in contrast, only four children (33 %) noted they had a PlayStation at home, and none of their friends or relatives had any at their home (one child noted that one of the local children clubs had an Xbox).

Perhaps more telling was the terminology they used in response to the question "Do any of your friends/relatives/school etc. have a game console you can play?". While the Participants from Ullens were versed with all the latest technology listing

[1] In Rudrayanee a total of 12 students (8 females and 4 males) between the ages of 10 and 13 (median 13) completed the survey. In Ullens a total of 14 students (10 females and 4 males) between the ages of 13 and 14 (median 13) completed the survey.

Fig. 2.2 A classroom at the Shree Rudrayanee School

in great detail the model names of their game consoles and gadgets (Nintendo Wii, Galaxy Tab2, etc.), the participants from Rudrayanee listed traditional (physical) games such as chess boards, puzzle games and card games as the games they play with at school or when visiting friends and family.

Its only in the cell phone front that we see some similarity of access to technology, with all the participants in both schools reporting having access to cell phones via their parents (no specifics were asked about the type of phones or the nature of the access). However in Ullens, two of the children indicated they possessed their own cell phones.

2.3 The Workshops

From the international call published to solicit ideas for the workshops 5 proposals were selected and invited to conduct a workshop during the conference. The particulars of each of the five workshops are described below.

2.3.1 Dancing with the Oriboo

The Dancing with the Oriboo workshop organized by Elena Márquez Segura, and Annika Waern of Mobile Life at Stockholm University, and Jin Moen of Movinto Fun, explored aspects of technology-supported movement-based and social play, with two games designed for the Oriboo.

The Oriboo is a dance companion for children that feeds on movements detected by a 3-axis accelerometer, and reacts upon these movements with light via its LED-based eyes and small display, sound, and its own motion along a 60 cm leash. The prototype has been developed by Jin Moen and recently commercialized by Movinto Fun (Oriboo 2013). Different games have been designed and playtested over the last couple of years in order to address different movement qualities and social experience (Márquez Segura 2013a).

The organizers had a twofold objective. On one hand, they wanted to provide the children with a novel experience, a technology-based body game through which they could explore their body, their motion, the motion of others and the space that surrounds them. On the other hand, they wanted to use the workshop as an opportunity to gather insights into the play, playful behavior, social interaction, and movement qualities of the children, which would be used as a source of inspiration for designing movement based interactions for the Oriboo and other motion based game platforms.

To achieve this objective the organizers based the workshops around two games they had developed for the Oriboo, "Dance it" and "Make my Sound". They used these games as a basis to build up new games that used not only the technology as a design resource, but also the socio-spatial setting in which the games are played (Márquez Segura 2013b).

The first game "Dance it" is a goal-oriented single player game that keeps track and scores the movement of the player. The Oriboo marks interval times in which the child needs to perform a movement indicated by the Oriboo, of a repertoire of eight simple movements. The instructions regarding what movement to perform are provided both by the eyes of the Oriboo (pointing in different directions, e.g. right for "tug right", etc.) and by its small screen, where a small stick figure performing the movement is displayed, together with the name of the movement.

Scoring is based on whether the movements are performed accurately or not.

The second game, "Make My Sound", is purely exploratory with no predefined rules or goals. In this game, the Oriboo reacts with different music loops mapped to different movement qualities of the player.

Variations of the two games were played both individually and in groups. Individual play was meant to provide the children with their own time and space to discover and explore the technology and its basic games. Group play added to the games with new rules in terms of external restrictions and conditions (e.g. playing "Make My Sound" blindfolded, trying to make groups of players with the same sound), and different socio-spatial arrangements (e.g. playing a collaborative version of "Dance it" with one Oriboo shared within a group of children forming a line, passing it from the first on the line to the second. Or the competitive version of this, in which two groups placed in parallel, competing with one another) (Figs. 2.3 and 2.4).

Fig. 2.3 The Oriboo in Action at Ullens

Fig. 2.4 Introducing the Oriboos at Rudrayanee

2.3.2 Parapara Animation

The Parapara Animation workshop organized by Daisuke Akatsuka, Brian Birtles, and Satoko Yamaguchi of Mozilla Japan, explored the potential of stitching together hybrid digitally created animations as a story-telling medium. The organizers sought to see whether an animation movie could act as a catalyst in the evolution of its own storyline.

The workshop employed the Parapara application developed by the organizers and a large projection screen. Children were invited to draw their own designs using the Parapara application on the mobile devices provided. Once happy with their creation, children used the application to send their animations to a shared virtual canvas projected onto a screen where it was combined with animations created by other children to form a common story that unfolded on the screen as new animations were added (Figs. 2.5–2.6–2.7).

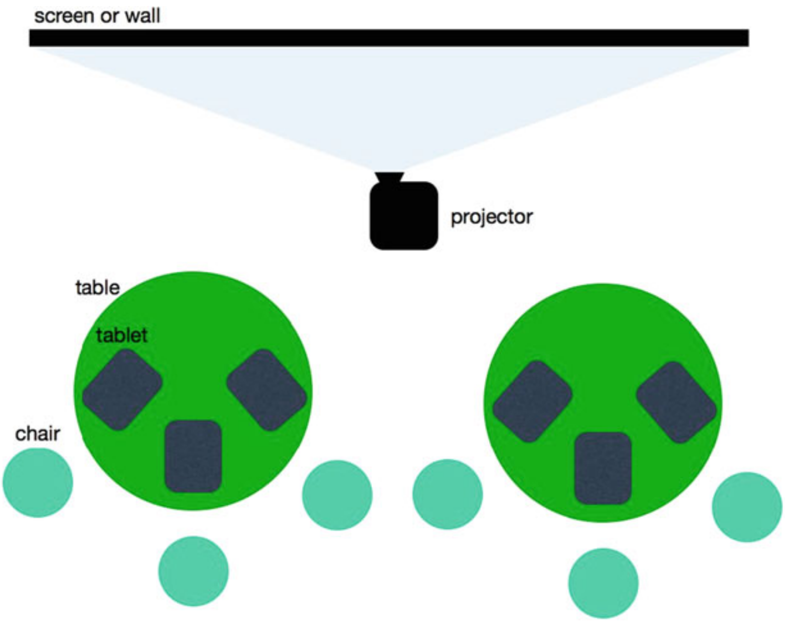


Fig. 2.5 Layout of the workshop

Fig. 2.6 Students at Ullens drawing an animation

2.3.3 Puppets Duets

The Puppets Duets workshop organized by Yoram Chisik, Monchu Chen and Clara Martins from the University of Madeira sought to explore whether it's possible to continue the narrative play of digital games when the electricity supply fails.

Fig. 2.7 Students at Rudrayanee with the canvas at the back

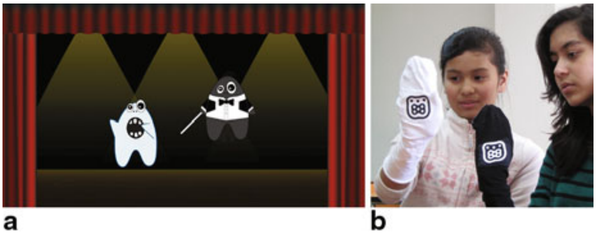


Fig. 2.8 The avatars (**a**) and the sock puppets (**b**)

The organizers developed a simple game consisting of a pair of sock puppets and their avatar alter egos (represented by a singer and a conductor) to examine how children relate to the puppets and the avatars, whether they can learn the rule set behind a game through a pure process of discovery (i. e. without being given the rules) and whether they would continue to play the game and re-enact the rules of the game when the power fails and thus the avatars vanish from the screen and all they are left with are the sock puppets and the set of rules they have learned (Fig. 2.8).

The game consisted of a simple set of mechanics. When the singer sock puppet opened his mouth the singer avatar started singing, and when the conductor puppet opened his mouth the conductor avatar waved his baton. In addition, if the conductor avatar waved his baton at the same time the singer avatar was singing the singer avatar changed his tune.

The game was governed by a set of two rules: The first rule was that the puppet (operated by a player) controls the avatar appearing on the screen. To enact this rule the player had to interact with the computer. The second rule was that the player/puppet/avatar control each other. To enact this rule the players had to interact with each other. Each play session started with the power supply on and thus a fully functioning computer and ended with a simulated power failure which disabled the computer and left the children holding the sock puppets in hand.

It was hoped that if the children can discover/learn these rules in the digital game (Fig. 2.9, left) they would be more likely to enact them when the electricity supply failed and the computer ceases to function (Fig. 2.9, right) and that the sock puppets coupled with the learned rules and a sense of play would provide an engaging (and hopefully an equally engaging) experience (Fig. 2.10).

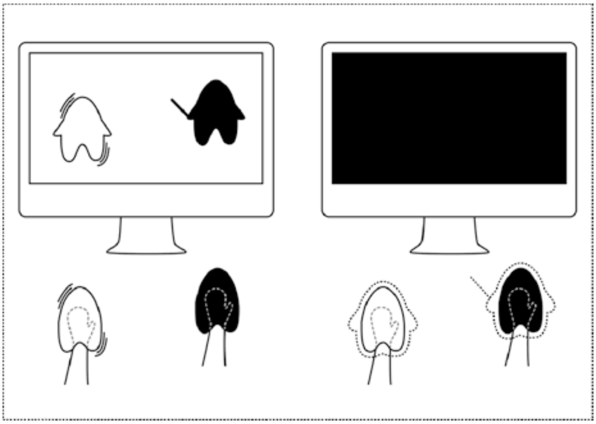


Fig. 2.9 Sock puppets, avatars and imaginary avatars

Fig. 2.10 No power play at Rudrayanee

2.3.4 The t-words

The t-words workshop organized by Cristina Sylla and Sérgio Gonçalves of the University of Minho and Valentina Nisi of the University of Madeira explored narrative creation from the oral perspective by presenting children with new possibilities through which they can express themselves and explore the nature of language composition.

t-words consists of a set of rectangular blocks that can be used to record and play audio, supporting a variety of language related activities such as creating rhymes, recording sounds, words or sentences, inventing and playing language games, exploring tongue twisters, or creating narratives. The system has two functions, one enables the children to record and store audio; the other enables them to play the recorded sounds. Children can record audio in one or more blocks depending on the proposed activities (Fig. 2.11).

Fig. 2.11 Children at Rudrayanee (*top*) and Ullens (*bottom*) recording audio in the t-words blocks

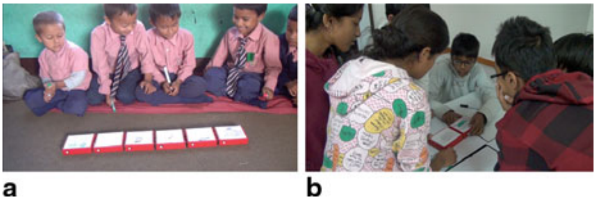


Fig. 2.12 Children at Rudrayanee (**a**) and Ullens (**b**) hearing a recorded sequence

Fig. 2.13 Children at Rudrayanee personalizing their blocks

To play the recorded audio, children just have to snap the blocks together—in which they have recorded their audio—the complete audio sequence begins playing from left to right (Fig. 2.12).

Reordering the blocks also changes the played audio sequence, allowing exploring different sound and speech combinations and eventually fostering reflection over the language. Children can also customize the blocks by drawing on top of their surface. The drawings can be wiped out and new ones can be drawn again (Fig. 2.13).

2.3.5 Creative Design Workshop

Involving children in developing countries in the design of interactive technologies can improve the likelihood that applications and products will address the challenges and needs faced by these children, their families and communities.

Alissa Antle and Allen Bevans who organized this workshop sought to elicit and capture value propositions about how some challenges and needs in urban Nepalese children's lives may be improved through edutainment-based interactive technology. Rather than impose their own values and perceptions on the problems faced by these children, the organizers supported the children to follow a creative design process that focused on the children's values and perceptions. They supported that the children to identify problems that interactive technology might be able to address.

The workshop was structured as a series of design activities. In each activity the children and the facilitators engaged in learning, group work, and discussing a particular element in a typical creative design process. The first activity centred around getting to know one another by discussing where everyone was from and how everyone's work or school days are shaped. This activity focused on setting the context for the rest of the design process. The second activity centred around identifying a need or problem that the children had either in their own lives or in the life of their family or community. The third activity centred around a show and tell of interactive technology on a variety of platforms ranging from a standard personal computer to web-based applications to mobile based and tablet applications. The goal of this activity was to introduce the capabilities and functionalities of different technologies that might be used as part of the solutions to problems identified in the previous phase. Finally the fourth activity involved synthesis of all of the ideas and information in the previous activities. The children worked in small groups with the facilitators to engage in an ideation activity. The goal of this activity was to frame a problem and ideate how inter-active technology might be used to enable or enhance the solution based on one challenge or need the children had identified in the second activity. The facilitator worked with each small group to help them capture, express and present the essence of their idea on how the challenge or need might be addressed. The children presented their ideas to the rest of their peers and the entire group discussed each idea. The result of the workshop was a series of value propositions created by the children. Each proposition included a short description of the context, problem, and potential technically mediated solutions.

The workshop was also designed to set the stage for a close working relationship between the research team and the child participants in terms of working together to further develop ideas about one or more ways that interactive technologies might improve these children's lives (Figs. 2.14 and 2.15).

2.4 The Workshop Experience

The kids workshops were set up with two aims in mind. The first was to create a venue through which local children could go beyond mere "playing" with technology, and explore concepts such as creativity, experience, and "cool" ways of creating entertainment media. This meant to expand their own understanding of entertainment computing and its potential with visiting researchers and entertainment media practitioners. The second aim was to provide the visiting researchers and entertainment

Fig. 2.14 Children at Rudrayanee exploring an iPad application

Fig. 2.15 Small group ideation phase at Ullens

media practitioners with a glimpse into the lives, perceptions and expectations (or lack thereof) of children in Nepal, with the hope that this glimpse would act as a catalyst to the development of new media or the initiation of new research work geared towards the needs of the local children in particular and children in developing countries in general.

Overall these aims were successfully met as the children got to explore new games and technologies, which brought about great pleasure and enjoyment. Researchers were also able to glance at the ways the children interacted with these games and technologies.

The socio-economic differences between the schools and the resultant differences in exposure to and use of digital technologies were a defining element in the ways through which the children interacted with the games and technologies. This influenced the ways in which the workshops panned out in each of the schools, sometimes in expected ways and sometimes in totally unexpected ways.

The research literature on technology use (Yardi and Bruckman 2012; Livingstone and Helsper 2007) suggests that higher exposure and access to technology leads to higher adoption and more openness to technology, as those familiar with it are more comfortable with its use. This was clearly visible in the Oriboo, t-words and creative design workshops where the children at Rudrayanee were much more cautious and hesitant with the devices they were given than the students at Ullens. Also, their focus was primarily on the novelty aspects of the devices and exploring their physical properties and affordances and what they could do with them (which is not surprising considering most of them had limited exposure to any kind of digital technology).

The students at Ullens moved from the initial curiosity phase (none had ever seen an Oriboo or a t-words device yet as these are not commercially available) in which they either explored the shape and functionality of the devices to something more complex.

In the Oriboo workshop this was illustrated by the kind of games children played. In the workshop plan, children would play single player games in which the rules were controlled by the device (Oriboo's in charge of the outcome of the game and the scores); multiplayer versions of these, in which the children kept count of their score and competed among them (a socially controlled outcome); multiplayer games in which the rules are controlled socially but the outcome is controlled by the device (e.g. a variation of "Dance it" in which a group of children shared one Oriboo, making a move and passing it to the next player, and then finally Oriboo saying who missed a movement); or the extension of the latter into a multiplayer competitive game, in which two groups of children competed to get the highest number of movements right. Children at Ullens played the whole span of games, whilst children at Rudrayanee mainly played simple single player games.

In the t-words workshop, the Ullens children were also very successful at taking full advantage of the t-words interface; they used the boxes to record sounds (e.g. imitating animals, recording information about themselves), to record Nepalese songs, or as a bit box. Some children improvised new instruments by using objects available in the classroom and the t-words boxes become jam session recording devices. Children snapped the recorded blocks together and changed their order playing with their compositions. Besides having fun by exploring the interface the children were also very interested in the technical functioning, asking to open of one of the t-words box, which they examined very thoroughly.

This phenomenon was also visible in the Puppets Duets workshop where the children at Ullens exhibited a greater degree of exuberance in their play with the puppets than the children at Rudrayanee.

In the Creative Design workshop, the children at Rudrayanee were deeply engaged with the technologies but needed more time to be able to think about how each might be used to solve problems. Several of the girls immediately identified the problem that girls rarely had access to email or the Internet but boys did. In this case, they were already familiar with the technology, and ideation came more easily. At Ullens, the children were more able to brainstorm technologically mediated solutions to problems they identified. However, again most solutions involved more familiar technologies including web and mobile applications (versus tablet).

However we suspect that although prior exposure to technology has a certain influence on the actions of the children the different styles of teaching employed by the two schools had a far greater impact on their behaviour. The Rudrayanee School follows a highly authoritarian and strict regimen while the Ullens School follows a more open and liberal approach. Furthermore, the level of English of the children at Rudrayanee was much lower than that of the children at Ullens, which meant we had to rely more on the teaching staff to act as mediators, which as a result had a dampening effect on the actions of the children. This was patently obvious during one of the play sessions in the Puppets Duets workshops where one of the boys who was clearly having fun while playing was scolded by one of the teachers for laughing out loud.

A surprising observation considering the fact that we expected to find differences between the schools due to the differences in socio-economic background and technology exposure was the lack of a huge difference when it came to exploring mechanisms and creating things using the technology.

In Parapara workshop, there were no observable differences between the two schools in terms of their use of the application or the impressiveness of the drawings they created. A similar observation was made in the Puppets Duets workshop where despite the fact that they were not given any information about the game, children in both schools were able to discover the mechanics and rule set of the game by themselves with the only difference being the creative ways in which they applied their newly acquired knowledge but as noted above this probably has more to do with the style of tuition of the school and therefore the freedom the children felt they had to express their creativity than any inherent difference in creativity and thought.

However, as mentioned above, in the case of children playing with the Oriboo and t-words, children in Rudrayanee enjoyed and explored more the physical attributes of the technology as well as the more simple games implemented in the device. They actually were overexcited about many of these games. This, together with the fact that the researchers were facing some language issues, made the researchers discard introducing the multiplayer games that were meant to be played after the initial phase of exploring the simple games (games constructed on top of these simple games and requiring of social control for rules and/or outcome). At Ullens, it was easier to move from this initial phase of discovering the games and physical device, to a phase of building socially on top of them. This might very well be a consequence of the different degree of excitement caused by a different degree of novelty effect or exposure to technology: children at Rudrayanee seemed to not get bored with the initial simple single player games, while we feel that children at Ullens would eventually have. On the other hand and in line with the other workshops, children of both schools seemed to grasp the simple games implemented in the Oriboo similarly. In terms of performance, it is difficult to say, since scores were not kept so that not to foster a focus on performance. They seemed though as if they were handling the games just fine at both schools.

Children in the Creative Design workshop at Ullens tended to focus on problem affecting their community and country (e.g. sanitation, health care, political corruption), whereas children at Rudrayanee tended to focus on more personal problems (e.g. access to the internet, girls having a lack of time to have access to computers in the community due to farm and house work compared to boys). This is likely a result of their socio-economic status and educational focus to some extent. In both cases, the researchers decided that the scale and nature of the problems identified were not suitable for further research studies under their areas of expertise (human computer interaction, tangible computing). The social issues identified by the Ullens children, such as sanitation and corruption, are not areas where HCI research can offer solutions without a larger team involving social scientists. The personal access issues identified by the Rudrayanee students are deeply rooted in a digital access divide not only between urban and more rural lifestyles but also between genders. Again, the researchers did not think that they could impact these issues through their HCI research. However, the children in both groups were exposed to the creative design process and the idea of using new forms of technology to mediate social and personal issues.

Moving from the experience of the children to the experience of the researchers and the catalytic effect the workshop had on their work we can conclude that the workshops have had the desired impact as all have sparked additional work mostly in the form of additional workshops and explorations. As a result of the workshop the Parapara animation software has come to be regarded as an educational tool rather than simply a technology showcase and has drawn keen interest from educators around the world with follow up workshops being conducted in London, Singapore, and Tokyo. Parapara is currently undergoing further development to support drawing styles and narrative evolutions discovered during the workshop. Similarly, the Puppets Duets workshop was followed by a workshop in Portugal to further explore the impact of socio-economic and cultural differences on children understanding and exploration of the game resulting in an academic publication (Chisik et al. 2013) and continued development efforts. The Oriboo workshop was also followed by European workshops conducted in Stockholm and Seville yielding wealth of data yet to be analysed and acted upon. Also, a video was published in the HRI 2013 conference (Márquez Segura et al. 2013b) and the material of the workshop was used to illustrate the researchers' design approach to body games in a video preview of a paper presented at CHI 2013 (Márquez Segura et al. 2013a). A revised version of t-words incorporating insights gleaned from the Nepal workshop was showcased in the Human Factors in Computing Systems (CHI 2013) conference (Sylla et al. 2013) and will serve as the basis for field trials to be conducted in Portugal. Finally, Alissa Antle of the Creative Design workshop continued her travels in Nepal and conducted an interview and brainstorming session with a councilor working at Nepal House Society in the city of Pokahara. Together, they identified a value proposition around using simple biofeedback-based tablet games to help teachers and councilors teach children living in poverty self-regulation[2].

[2] More details on this project can be found at http://www.antle.iat.sfu.ca/TabletGames.

2.5 Conclusions

The aim of the kids workshops was to extend the reach of the conference beyond the halls of the conference centre and into the classrooms and playground frequented by the youngest echelons of the digital media public in the hope that the culture and idea clash would yield new insights and fresh developments. In this we were partially successful. On one hand we succeeded in bringing fun and enjoyment to a group of children and exposed them to technologies they do not see on an everyday basis. On the other hand, the short duration of the workshops and the language difficulties experienced in one school limited the type of activities that could be carried out in the workshops and thus limited the extent of the creative explorations that could be pursued either by the researchers and the children themselves. However, this made us think.

Another downside was that the workshop ended up being a one-time affair with no continuation of activities or a continued engagement with the participating schools. On the positive side, the workshops lead to a number of follow up studies in other countries and to continued work on some of the projects which will provide new entertainment and education possibilities and hopefully will trickle in some way back to Nepal and the participating schools.

Plans are already under way for the next kids workshops in the upcoming ACE conference in which the organizers intend to push the boundaries even further by distributing technology kits via the conference web site and enabling numerous schools around the world to take part as a way of providing a more meaningful and longer lasting connection between the schools, the conference and the attending researchers and practitioners.

Acknowledgments First and foremost we would like to express our outmost thanks and extreme gratitude to all the children and teachers who participated in the study for playing our games and sharing their insights and thoughts with us. Last but by no means least we would also like to thank Ishwor Hamal of Edupro Nepal and Veronika Halupka and Yongsoon Choi of Keio University in Japan for the logistical help and support they provided before, during and after the workshops.

References

Chisik, Y., Chen, M., & Corriea Martins, C. (2013). A tale of two puppets, two avatars and two countries. In *Proceedings of INTERACT 2013 14th IFIP TC 13 International Conference*, Cape Town, South Africa, 2–6 September 2013.

Livingstone, S., & Helsper, E. (2007). Gradations in digital inclusion: Children, young people and the digital divide. *New Media & Society, 9*(4), 671–696.

Márquez Segura, E., Waern, A., Moen, J., & Johansson, C. (2013a). The design space of body games: Technological, physical, and social design. In *Proceedings of the 2013 ACM Annual Conference on Human Factors in Computing Systems (CHI'13)*, 3365–3374. New York: ACM.

Márquez Segura, E., Moen, J., Waern, A., & Onco Orduna, A. (2013b). The Oriboos going to Nepal: A story of playful encounters. In *Proceedings of the 8th ACM/IEEE International Conference on Human–Robot Interaction (HRI'13)*, 411–412. Piscataway: IEEE Press.

Oriboo. (2013). http://www.oriboo.com. Accessed 23 May 2013.
Sylla, S., Gonçalves, S., Branco, P., & Coutinho, C. (2013). Peter piper picked a peck of pickled peppers: an interface for playful language exploration. In CHI' 13 *Extended Abstracts on Human Factors in Computing Systems (CHI EA'13)*, 3127–3130. New York, NY: ACM.
World Bank. 2013. World Development Indicators, Nepal. http://data.worldbank.org/country/Nepal. Accessed 23 May 2013.
Yardi, S., & Bruckman, A. (2012). Income, race, and class: exploring socioeconomic differences in family technology use. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI'12)*, 3041–3050. New York: ACM.

Chapter 3
Digital Pop Kids

Ichiya Nakamura

Abstract This chapter aims at describing what is going on in the digital society and what I am doing in order to create the future of the digital society as my project from the point of view of a producer and an activist, to entertain the whole world.

Keywords Digital · Pop culture · Children · Creativity · Learning

3.1 Changing Digital Society

The Workshop Collection is an annual festival that fosters kids' digital creativity and is held at Keio University, Japan. There are about one hundred workshops that allow kids to create animation, music, digital newspaper, game, etc.

Recently, more than 100,000 children came to participate in the workshops. I believe that this is the world's biggest event concerned with kids' creativity. My mission is to provide opportunities to design and to use technology to all related people, such as artists, performers, teachers, IT industry, entertainment industry, parents, and children. I am the representative of this event, and this is one of my public activities.

I. Nakamura (✉)
Keio Media Design, Keio University, Tokyo, Japan
e-mail: ichiya@kmd.keio.ac.jp

A. D. Cheok et al. (eds.), *Entertaining the Whole World*,
Human–Computer Interaction Series, DOI 10.1007/978-1-4471-6446-3_3,

This is the application “tap*rap transformation” for children’s learning, which my group just created and that is now being sold on the App-store and the Android market. Children can learn words by touching and exploring what comes up on the tablet. This application also allows you to create your own characters, and thus stimulates children’s creativity. This is application converges entertainment and learning. I am also privately developing this kind of digital content.

More than 30 years ago I formed a punk rock band called “Shonen Knife”. I served as their director and also played instruments supporting them. Shonen Knife showed that everyone could create and play punk rock on the world stage even though they are from the Far East.

However, I gave up music understanding that my mission was not to be a creator but a producer and a supporter for creative people. I then joined the Japanese government and created IT policy for 14 years.

In order to create a society and the environment for talented creative people, I made policies supporting digital technology, creative activity, and digital business.

After graduating from the government, I spent 4 years as a Visiting Professor at MIT Media Laboratory. My main project was to establish a research center focusing on children and their creativity called “MIT Okawa Center”. Then I moved to Stanford

University, where I spent 4 years as director of the Japan Center and finally joined Keio University 6 years ago.

While I was at the MIT, I also worked with SEGA on developing the TV game console "Dreamcast" and the robot pet "Pooch". Dreamcast was the first game machine that embedded internet connectivity. Pooch could communicate with users with its small intelligence. They both aimed at digital connection and the ubiquitous computing society. Both are still under construction.

What our team aimed at was to change computers into friends. Computers were always either my teachers or my children. Computers taught me a lot of things like a teacher. However, when I let my computer work, I had to command it one by one, accurately, like I did to my child. So, we wanted to chat with him, laugh with him, and play with him.

Today he is becoming my friend. He introduces many friends to me through social network services (SNS), and he also responds to my obscure voice with applications for smart phones like Siri. After Nintendo launched the "Family Computer" in 1983, which enabled people everywhere on earth to play with visual images, a lot of media other than TVs and telephones were developed. In Japan, these were called "new-media", and they were basically developments of analog hardware dreaming of an "advanced information society".

Ten years later, in the early 1990s, the "multi-media" boom happened. A movement where various media were converted into digital devices represented by PCs, mobile phones and the digital information highway called "the internet".

Then, various kinds of "information products"—entertainment products, copyright Materials—were also unified into a unique notion termed "content", and became highlighted to be a hot issue.

But now, we are entering a new stage. Over the last few years, new media trends have been spreading over in three dimensions, (1) multi-screen, (2) cloud network, and (3) social service.

1. Device: Multi screen has come. The fourth media after TV, PC, and cell phone—including smart phone, tablet PC, eBook reader, digital signage, smart TV, etc.—is in our hands.
2. Network: Nationwide digital TV network is being established and broadband networks are spreading. Both have been already achieved in Japan in 2011.
3. Service: SNS is drastically growing. Once it's said, "content is king", but in Japan content business has stagnated and SNS gets traffic and money instead.

Content is now used as a catalyst for communication on SNS, and SNS is becoming the main stage for information business.

Three elements that form up media—device, network and service—are shifting to the next stage.

3.2 Digital Reality

A huge disaster hit Japan in 2011.

I watched the tsunami in real time on TV.

The real visual image was taken from above. Just after the tsunami, when I visited the hit area, I realized that the image shown on the display was not real. What I got there, at the real place, was the smell. It was the strange smell what I had never experienced. That is the reality.

Information is most essential and important. Everyone can survive from a tsunami, only if adequate information such as "run away!" is delivered and shared. Breakwater, zoning, and building codes are not secure. The point is how to design a city where information can easily be shared.

In 1995, Japan experienced another big earthquake in the western part. The earthquake interrupted the landline telephone system, but cell phones were working well, because cell phone users were still small in numbers those days. Internet users were even much fewer.

In the 2011 disaster cell phones didn't work at all. Networks were already overcrowded with all the users in the country. Instead, the Internet, especially social media played an active and important role.

However, will the Internet work well when such a big disaster comes again in the future?

TCP/IP was developed imagining a nuclear war threatening all human beings, as a type of connection that would never be cut no matter what happened, and unfortunately this time, the earthquake proved it working.

However, communication was character based and person-to-person based. After everyone has started using the internet to deliver motion pictures, and after everything around us got connected and started communicating with each other, the internet may blow up. Visual communication and machine-to-machine communication needs a new network architecture.

Now, a next generation network should be planned, taking into consideration the enemies named earthquake, tsunami, and nuclear power stations.

On September 11 in 2001, I drove my car from Boston to NYC for an appointment with a startup company early in the morning. At the entrance of Manhattan, I was stopped by the police screaming something that I could not understand. The car radio was also shouting but I could not understand. As soon as I watched CNN at a coffee shop on my way back to Boston, I understood what's going on.

What I witnessed there was a clash of high technologies of the last century, jet planes and skyscrapers. Aeronautical technology and high-rise architecture, things designed to make people happy were used as weapons for terror and destruction.

I made telephone calls to my friends in Tokyo and Kyoto, all of who had watched the real scenes of the second airplane hitting the building on TV. My friends in the US didn't watch it because people in the east coast including me were commuting to their offices and schools and the west coast were sleeping because of the 3 h time gap.

The "real time character" of the disaster was much stronger in Asia.

Twenty-five years ago, in Nintendo days, we dreamt of the advanced information society where all the people could connect with each other and could watch everything visually. Those days, the government of Japan advocated that world peace would come true if all the people on the earth could understand each other.

Now it is achieved. We can watch everything on TV in real time via satellites and optic fiber networks. But the dream has not become true. We got to know each other better, which made our difference clearer, and which caused new friction.

In the nineteenth and twentieth centuries, the engine of the society was war and competition, battles among nations and battles among companies. Nowadays digitalization causes new battles. Could this be the engine of this century? Modern wars are connected through new media. World War Two was recorded on film, Vietnam was watched on TV, Falkland was relayed with satellites, Gulf was simulated like a TV game, and Iraq was the first war after the internet.

After September 11, the Internet community in the world tried to stop the war.

The antiwar movement quickly spread over on to the virtual space. However, it was not successful. One and a half years later, the war started in Iraq. In the war, the same digital technology was used as a weapon. GPS enabled pinpoint bombs and wearable computers enabled soldiers to kill people more efficiently. What we developed is used for both peace and war. The direction digital technology goes is determined by its users. "Digital" reached that stage in the beginning of this century.

3.3 Digital Kids' Power

The TIME magazine selects the person of the year in the end of every year. In 2001, they conducted a public Internet questionnaire survey in Japan. The second rank was Osama bin Ladin, but the amazing thing was the first ranked person Mr. Masashi Tashiro, a Japanese comedian who was not famous in the wider world. He was accused of being a Peeping Tom that year, which became small gossip in Japan.

Young people in the Internet community were responsible for this mischief. They voted for the TIME ranking writing the name Mr. Masashi Tashiro. TIME was confused and deleted the page. It was a funny incident, but it showed a serious shift in power. It means that the established analog media was defeated by young, naughty, far eastern, anonymous, but connected users.
Asian digital kids started to provide information to the world.

In the beginning of this century, in Japan and Korea, teenage girls were already reading and writing with their thumbs and uploading their messages and photos with mobile phones. That could not be seen even in western countries. Asian digital kids have been active.

My young assistant was good at drawing pictures. In 2005, I introduced her to an Internet community, and there she got a chance to draw Manga about a strange cat maid on a commercial website. A publisher found her and published the Manga book as her debut work, which soon became a smash hit, and she suddenly became a millionaire.

Now many entertainment companies ask me, "please introduce me to her next Manga", "let's hold an event for the cat", "allow us to develop character goods and Anime of the cat". . . . Today, I am her assistant. That's what the Internet made possible.

In the end of 2006, the person of the year in TIME magazine was "YOU". A mirror was attached on the surface of the magazine, and a photo of a PC was surrounded the mirror. It described that each reader, yourself in the mirror, gained power through IT. Yes, 2006 was the year of the "Web 2.0".

That was what Japanese naughty kids had pointed out by voting for Mr. Tashiro 5 years before. Five years were necessary for TIME to recognize what was going on in the world.

Digitalization is changing the world rapidly from the bottom, even though it may be difficult to see from an analog and established stage.

According to a research by Technorati in 2007, among all the blogs in the world, the most used language was Japanese. Japanese occupied 37 % and exceeded English (36 %). This must have been caused by teenaged mobile phone users. Even Japanese adults didn't recognize this situation. Without clearly recognizing, we must be heading for a society where everyone on earth uploads something every minute.

The struggle of how to construct a digital society is still going on.

In Egypt, networked people removed the political administration in 2011. In NYC and London, networked people demonstrated disturbance in 2012. On the other hand, some nations are eager to control people, trying to regulate the Internet society.

Hatsune Miku won the first prize in a vote for the musician of the London Olympic game's opening ceremony. She was born to two special parents. One is technology called "Vocaloid" and the other is the design as an anime character.

The more important point is that she grew up in the SNS named Nico Nico Douga in Japan. Many people wrote songs for her, and composed music for her. Many played music, danced, sang, showed performance, and uploaded them to Nico Nico Douga. Many adults and children participated in any possible way they could so that Hatsune Miku grew up to become a superstar in the world.

3.4 Digital Kids Project

One of my projects is called "Digital Kids", which is focusing on giving children technology and the chance to develop their creativity and express what they want to.

Just 10 years ago, I established an NPO (Non Profit Organiation) called "CANVAS" and have been working with the industry, academia, schools, governments, artists, parents, and children. Two thousand workshops were provided to children throughout the world.

The goal of this project is to enable every child on the earth to create Anime and to compose music with digital technology.

For example, in the clay anime workshop held in Tokyo University, they created their own characters, made scenarios, shot photos, edited on PCs, recorded sounds, and rather more important is that they showed their Anime (animation) to their families, friends, teachers, etc. and got feedback from them. Through workshops, they learn how to use devices, how to entertain visually, and how to manage copyrights.

The Photo Manga workshop using mobile phones was held in Tokyo and Paris supported by the UNESCO. Children created cartoons by taking four pictures and sent them out by mobile phones.

Here is one photo Manga made by a girl from Paris.

1. A lovely girl,
2. She loves walking,
3. She loves sweets,
4. She loves kisses.

It was a fantastic piece of art, but as the story was written in French, I only sent photos to Tokyo and held another workshop with Tokyo kids. I asked them to make their own story using these photos.

The amazing thing was that almost all the kids in Tokyo made similar stories from the same sequence of photos.

(1) A suspicious person, (2) was prowling, (3) and set up bombs in a sweets shop, (4) and her lip was blown off! Baaaan!!

Tokyo Manga versus Paris high art?

The same technology and the same devices were used. But the result showed totally different expressions and contents. It depends on the culture, history, communication style, etc. That is what I expected them to share. Once we had a workshop in a local village in Cambodia. It was an Anime creation workshop, but it was not as easy as usual, because we did not have enough electricity, and more over, the children had never seen Anime before. We first had to share the idea what Anime is. However, they managed to create their photo Anime under that environment. In similar ways, workshops were also held in Brazil, Italy, and Japan. In the end, they all made a collaboration Anime together.

Every country, every village, every child on earth has its own beautiful culture. It can be empowered by digital technology.

Let’s think about your town. At a digital newspaper workshop, children research with the Internet, and go out into the town with pens, notebooks, digital cameras to make interviews, discuss each other, and make digital newspapers. That is a convergence of digital and analog and virtual and real. The balance between them is the important point.

In Autumn 2012, our team worked with Google in order to see smiles of children in the northern part of Japan, where the earthquake and tsunami hit 1 year before. A programming workshop was provided that enabled children to create their own games. The software we used for programming was Scratch, developed at the MIT Media Laboratory.

In this way, we are providing workshops in universities, kindergartens, commercial centers, wherever, mainly in Japan, but also in China, Korea, Thailand, Paris, Bologna, San Francisco, Sao Paolo, and more.

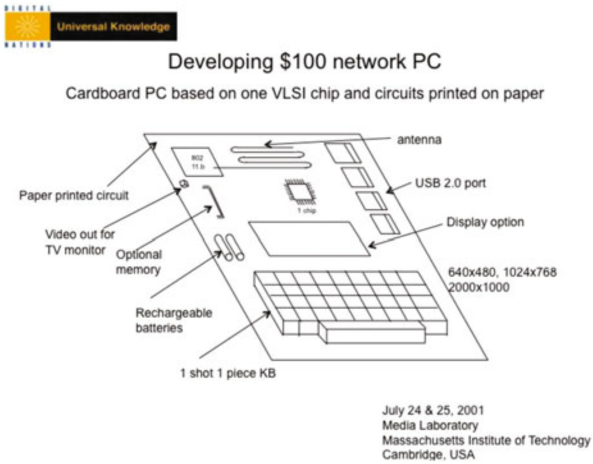
3.5 Digital Learning Project

In order to expand kids activities to the core education in schools, a new project for accelerating digitalization of education started 2 years ago in Japan. An association "Digital Textbook and Teaching" (DiTT) was formed up with more than hundred companies including Apple, Microsoft, Intel, Qualcomm, LEGO, SONY, NEC, etc. that aims at giving digital learning environment to all children—one PC per child, broadband network, and digital textbooks.

So far, this activity focuses on Japan, because Japan is still behind many countries in the field of digital education even though its broadband network environment is at the top level in the world.

http://japanese.engadget.com/2008/10/19/olpc/

Uruguay already delivered the Internet PCs to all domestic children in 2009. What they have in their hands are $ 100 PCs developed by the MIT Media Laboratory. The $ 100 PCs of the One Laptop PC project, led by the founder of Media Laboratory, Dr Nicholas Negroponte, are said to be used by more than one million children in the world.



Here is its first blue print, drawn by Dr Kay Nishi and myself, in 2001. Just after we made a presentation to MIT, they started this as a big policy project talking with the US government and many governments in the world.

I gave the same presentation to the government of Japan in the same year, but I was kicked out then by the bureaucracy of my own country. It may show that a 10 years' gap has existed between Japan and other countries like the USA. To change the recognition of digital technology in my own country is another mission of mine.

We are developing digital textbooks, applications, tablet PCs, cloud network services, etc. for schools. We are also leading experiments for digital learning, working with local governments and many schools. We are also in steady consultation with the government and politicians so that a new legal structure suitable for digital education including copyright issue can be developed.

Changing the educational system needs a long time. I will continue these kinds of public activities, but at the same time, I am afraid that there is not so much time left. Thus I decided to start making private creations. My newest challenge is to create digital picture books for kids, as learning materials.

My group is now developing new types of digital materials for kids' learning—applications for smart phones and tablets establishing the studio "Digital Ehon, corp."

"EMAKIMON" is based on the old Japanese style picture scroll. A mother and a child can read and play together making their own story. You can also draw your own cat and egg, characters you play with.

We also provide workshops using this material. We concentrate on making materials that allow you to create your own characters and stories so that you can join the digital world.

"tap*rap Shiritori". Shiritori is Japanese for "word chain game". Each time you touch the panel, sounds and sand gather at the point, and then become words and pictures.

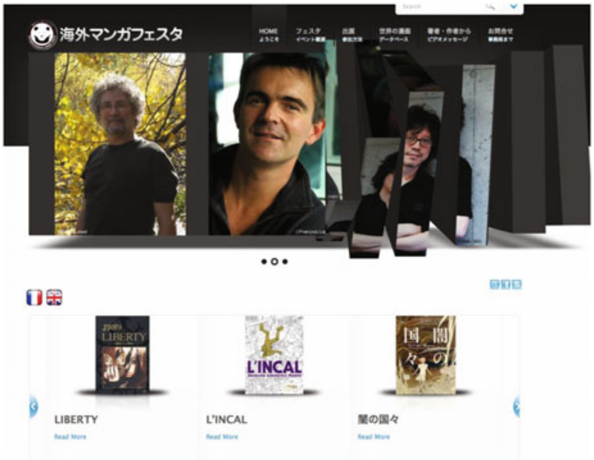
The only form of input is tapping. The most primitive and simple interface will stimulate users language acquisition. Its advanced model, the "tap*rap Photo Shiritori" application is a tool that enables you to make your own Shiritori game. You can take photos and record your sounds, and then you can play with those materials.

One of my most favorite museums, Museum of Fine Arts Boston's exhibition was held in 2012 in Japan, and the main item was the dragon painted by Shohaku in 1763. That was its first exhibition to the public. Our team made an application with which you can modify and create your own dragon face.

Our project is focusing on giving this kind of entertainment to children so that they can play, communicate and share with other people, rather than just watch content.

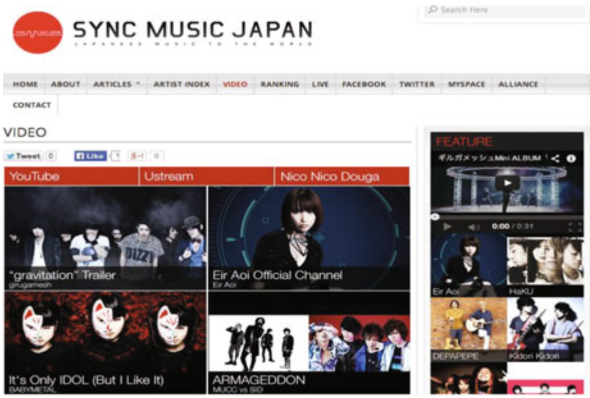
3.6 Pop Power and the Future

My third mission is to empower contemporary culture using digital technology. Japanese comic books, Manga are getting popular in the world, and they want to become digital.



Currently, I have been working with Manga publishers to develop an international Manga market using digital technology. At the same time, we hold a big event, the "International Manga Festa" every autumn in Tokyo inviting famous Manga artists and producers so that a worlds' Manga platform can be created.

With regard to film, we collaborate with "the Okinawa International Film Festival", gather short comedy films from all over the world, and introduce them to the world.



Promoting Japanese pop music information is also going on working with music industry.

My laboratory is running the website and data base "SYNC MUSIC JAPAN" that one thousand five hundred J-Pop bands, (that means almost all the famous pop musicians in Japan), participate in.

My project currently concentrates on Japanese local pop culture. However, of course, digital technology empowers every local culture on earth, the important thing, I believe, is to recognize what kind of culture you have in your hand, and to find out how to activate it with the help of digital technology.

What I am concerned about is whether we are imagining the future enough. I hear that small-sized mpeg4 video of 70 years length, needs ten terabytes of storage capacity.

Now, terabyte holding HDDs cost only five hundred US dollars. Let's embed a camera in every baby's head so that they can shoot what they see look at in their daily lives, while they are awake, say, 70 years. It only costs around 500 US dollars each.

You can accumulate them all, connect them all, share them all, and modify them all. You will get a big parallel virtual visual space other than this real world. Then, what is going to happen? I don't have an answer. My imagination stops there. It's beyond my imagination. The point is that technology is already in my hand, products are already in my hand, but the imagination is neither in my hand nor in my mind.

In 2005, Mr. Eric Schmidt at Google said that all the amount of information in the world was five Exabyte and that Google had already input 1 % of them into their database. He added that 300 more years were needed to input all data into the database.

I thought that it would be possible, and that they would achieve it. But I couldn't imagine what would happen after that. We still may not imagine what three centuries after are going to be like.


EPLA IERONIMI

Last year, I visited Mainz, Germany, the hometown of Johannes Gutenberg. The typography technology he invented in the fifteenth century made people begin reading books and contemplate a lot, which led to a complete change of science, technology, and social structure. Three centuries later, the industrial revolution, and democratic revolution took place.

Do you think that Gutenberg imagined that his invention would change the whole world three centuries later? How about you?

Information technology, bio technology, nano technology, financial technology, globalization, we are now living in an age of unlimited potential for innovation.

Can you imagine what these technologies will bring about in the distant future?

Now, it is your big chance to imagine the future with your technology, and it is your chance to realize what you imagine with your technology.

Chapter 4
Fostering Learning and Behavior Change Through Computer Entertainment

Teresa Romão

Abstract Entertainment is closely related with fun, positive feelings and emotions. It doesn't have to be only fun and in most cases it need not be, but it is desirable that entertainment is always fun. By invoking positive emotions, entertainment can be exploited to promote learning, creative thinking and behavior change. Entertaining games that invoke positive emotions, guide players towards relevant goals and provide them with the appropriate messages and knowledge have the potential to encourage behavior changes.

This chapter presents and discusses several game prototypes built to foster users awareness, learning and behavior change. Most of these prototypes are related with environmental sustainability, as it is a relevant matter affecting the whole world, and rely on persuasive technology and entertainment techniques to provide users with the appropriate messages and experiences that stimulate them to take pro-environmental actions in the real world.

Keywords Behavior changes · Contextual awareness · Persuasive technology · Games · Education

4.1 Introduction

Entertainment technology has been undergoing a remarkable development in the last decade. Commercial off the shelf technology (such as Kinect (2013) and Arduino (2013)) enable the rapid and affordable creation of innovative entertainment applications with natural user interfaces that look much more real and rewarding.

Entertainment presumes the idea of pleasure, amusement and fun and it is supposed to hold the attention and interest of people. Entertainment is defined by the Oxford Dictionary of English (2003) as the action of providing or being provided with amusement or enjoyment. To entertain also means to engage, to keep people occupied and to capture their attention and thoughts. This can be achieved through many creative techniques and with different purposes in mind.

T. Romão (✉)
CITI, DI-Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa,
2829-516 Caparica, Portugal
e-mail: tir@fct.unl.pt

A. D. Cheok et al. (eds.), *Entertaining the Whole World*,
Human–Computer Interaction Series, DOI 10.1007/978-1-4471-6446-3_4,

The verb play is also closely related with entertainment. Play is more than fun as stated by Stuart Brown (2008; Brown and Vaughan 2010), who advocates that play is deeply involved with human development and intelligence and affirms the importance and need for healthy play throughout the human life cycle. While playing, children use their senses to find out how things work and they can experiment by themselves without fear. Playing is a powerful way to learn. It promotes curiosity, creativity, self-esteem and social interaction since childhood.

As stated by Donald Norman (2004), positive affect arouses curiosity, engages creativity, and makes the brain into an effective learning organism. Research works in the field of psychology have shown that happiness facilitates creative thinking and complex problem solving (Ashby et al. 1999). Entertainment mechanisms can be used to invoke positive emotions and consequently be exploited to promote education, social relationships and behavior changes, as well as to increase productivity.

In recent years, modern society has evolved in many aspects, but people still lack routines and behaviors that support and help the environment. Environmental sustainability involves efforts such as monitoring the physical world's state and informing individuals' personal choices in consumption and behavior (Woodruff and Mankoff 2009). Our aim is to study the creation and use of educational and persuasive contextual-aware applications that, through users awareness concerning environmental problems, encourage them to adopt more appropriate behaviors in order to solve these problems and contribute to environmental sustainability.

This chapter presents and discusses several game prototypes built to foster user awareness, learning and behavior change mostly concerning environmental sustainability, as it is a relevant matter affecting the whole world. Some of these prototypes were developed in the scope of project DEAP (Developing Environmental Awareness with Persuasive systems) and rely on persuasive technology and entertainment techniques to provide the users with the appropriate messages and experiences that stimulate them to take action in the real world.

4.2 Technologies for Behavior Change

Persuasive technology purposefully applies psychological principles of persuasion (such as credibility, trust, reciprocity or authority) to interactive media, aiming at changing users' attitudes and behaviors (Kort et al. 2007). The term captology was coined by BJ Fogg, and is derived from computers as persuasive technology (Fogg 2003). It focuses on the design, research, and analysis of interactive computing products created to change people's attitudes and behaviors. The collection of influence strategies is wide, ranging from Cialdini (2007) six strategies to more than 100 (Rhoads 2007). It is clear that these influence strategies can be used as powerful tools to increase the effectiveness of persuasive systems.

When applied to mobile applications, persuasive technology can have a stronger persuasive effect, due to the just-in-time interaction ability (to intervene at the right moments) (Fogg 2003). Eckles and Fogg (2007) also mention that mobile phones are an excellent persuasion tool, which can very well be the most important platform for persuasion in the next years, for three reasons: people love mobile phones, they are always with them and they have a wide range of features.

Contextual awareness, namely the ability to detect and react to both the users' actions and the changes in the environment, is a key feature of mobile applications. It considerably enhances the user experience by providing seamless and continuous access to the appropriate services and data. Schmidt (2008) mentions that the users' perception of the surrounding environment is determinant to allow them to have smart behaviors when using a context-aware application.

Moreover, individuals have some tendency to exhibit social proof behaviors inside their groups (Rhoads 2007), thus promoting convenient behaviors in a social network may have a contagious effect. In 2007, Facebook launched Facebook Platform, which allowed developers to create applications for the millions of people registered in the social network. This started a new phenomenon, which Fogg calls "Mass Interpersonal Persuasion" (MIP) (Fogg 2008). MIP brings together the power of interpersonal persuasion with the reach of mass media, by creating applications that allow people to interact and cooperate on a non-personal level, allowing them to reach a massive number of people.

Games may influence players to take action through game play, as described by Ian Bogost in his theory on how videogames make arguments and influence players (Bogost 2007). Games not only deliver messages, but also simulate experiences, and may become rhetorical tools for persuading players.

Behavior changing games combine game design elements, influence strategies and persuasive technology along with the power of communities to motivate people to accomplish challenging tasks. They use the power of games, networks and data to help and encourage people to produce meaningful changes in their behaviors. Behavior changing games have been applied within several contexts, such as healthcare (de Oliveira et al. 2010), education (Bogost 2007; Fogg 2003) and environmental sustainability (Froehlich et al. 2009; Gustafsson et al. 2009; Reeves et al. 2011).

Most behavior change games include typical game design mechanisms: setting goals, tracking progress, rewarding and receiving support. Players need to complete tasks in order to achieve goals and get the corresponding rewards and recognition. Game progress is tracked by asking players to perform virtual tasks, self-reporting or automatic collecting data through sensors. Players are acknowledged and rewarded with points, badges, virtual goods and sometimes real life prizes. Rankings are used to allow players to compare their performance with their friends or other players, which encourage a beneficial sense of competition. Many behavior change games encourage people to share their performance and achievements with their social networks to foster collaboration, competition and peer-pressure.

4.3 Playing to Save Energy

Decreasing energy consumption is an important goal for environmental sustainability. Each one of us can contribute to reduce domestic energy consumptions and consequently CO_2 emissions. Small individual actions may seem insignificant, but together everyone's efforts can have a great impact on the environment. It has been a challenge to find ways of educating people to follow better attitudes towards energy savings. Results show that technology-enabled consumption feedback can promote awareness and lead to energy savings (Woodruff and Mankoff 2009) and some research work and applications have been developed. Power Agent (Bang et al. 2007) is a mobile pervasive game for teenagers, designed to influence their everyday activities and electricity usage patterns in the household. The underlying design idea is to let players (one for each house) compete in teams (cooperate with their families) and learn hands-on how to save energy in their homes. Power Explorer (Gustafsson et al. 2009), builds on the previous research on Power Agent and uses a similar technological set-up, but focuses on real-time feedback. The game design teaches the players about the consumption of their devices and encourages them to adopt good habits.

To experiment and evaluate how games can entertain people and motivate behavior changes, we followed two approaches with different goals: MAID which aim at using players' free time in public spaces, such as shopping centers or waiting rooms, to both motivate and educate them towards home energy saving behaviors; and LEY, a pervasive-based serious game to help people understand household energy usage and to persuade them to change negative energy consumption habits. The mechanics of this game are based on real-time domestic energy consumption information, presenting a collaborative-competitive approach.

4.3.1 MAID

MAID (Motion-based Ambient Interactive Display) (Salvador et al. 2012) is a game, deployed on an interactive public ambient display, driven to motivate behavior changes regarding domestic energy consumption, through a persuasive interface based on gesture recognition technology. The main objective of MAID is to instruct (or remind) users about simple procedures to save energy, showing them how easy it is to have a huge impact on the environment by taking simple actions in their daily lives. Our approach is based on the assumption that a change in behavior requires both motivation to act, as well as knowledge of what to do. According to Fogg (2009), behavior changes can be achieved through the conciliation of three main factors: motivation, ability and trigger. Thus, our design exposes several common inappropriate behaviors that must be noticed and corrected by the players through a public display. During the game, players can explore the different rooms of a house, where they have to find out what is wrong and perform the correct actions to save energy, using similar gestures to the ones they would use in the real world to achieve the same goals (Fig. 4.1). Actions that can be taken to reduce energy consumption include turning lights off, unplugging standby equipment, as well as replacing traditional light bulbs with low-energy ones. The objective of the game is to save as much energy as possible, solving all the situations presented by the different game scenarios. Each situation is associated with a different electronic equipment that, when misused, can decrease the home energy efficiency.

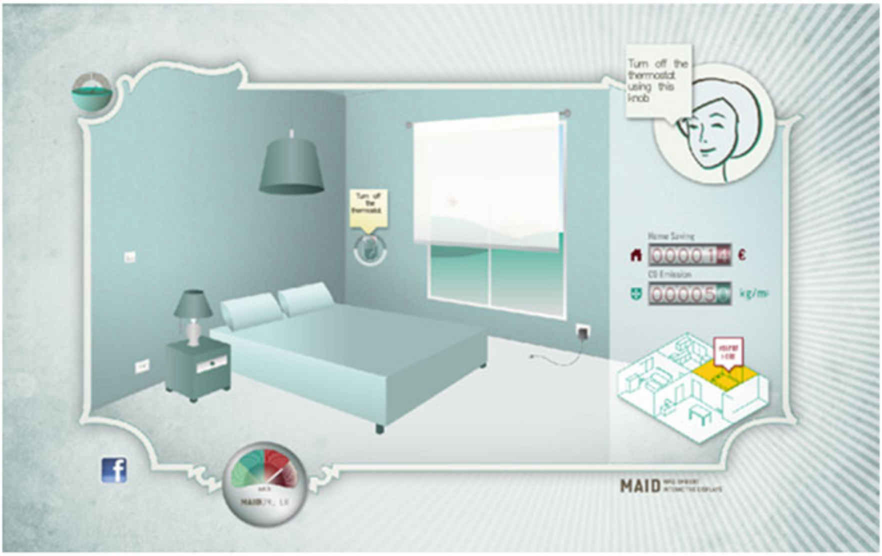


Fig. 4.1 MAID's main interface

The interaction with the public display is performed by hand gestures similar to the ones required to perform the corresponding action in real life (ex: pushing or pulling hand motions are used for objects' manipulation, such as pulling a power adapter from a wall socket or tapping a light switch), so players can learn and rehearsal these actions and may easily recall them later (Fig. 4.2). Additionally, to make players aware of the consequences of their actions, the system provides feedback (visual and audio) regarding the costs saved and the quantity of CO_2 emissions avoided when performing a specific action (Fig. 4.1). To have a more impressive effect and to emphasize how individual actions can have a significant contribution to the global achievements, feedback is based on what would be saved or avoided if everyone in the country would take a certain action.

Hand gestures were chosen to avoid the need for any additional device, as well as to allow players to perform actions as similar as possible to the real ones. A public display allows for a broader dissemination of a message, since besides the user directly interacting with it, all members of the audience can receive the output from the public display.

MAID is implemented in C++, using OpenGL technology for graphics processing, following a highly modular and configurable development strategy and allowing gameplay scripting. It can also be connected to a Facebook application, which allows users to share their experiences and increase the exposure of the project. The Kinect for Xbox 360 by Microsoft (Kinect 2013) is used for gesture recognition.

MAID was deployed on a large event for teenagers, an open day at our University Campus attended by 6000 high-school students. During this event, a user study was conducted with twenty six users aged 15–28 (average of 17.5) (Salvador et al. 2012).

Fig. 4.2 User interacting with MAID

The majority of participants liked to use MAID and found it easy to learn and to use. They considered the feedback and the information provided by the application useful and they were willing to use MAID in public spaces. Most importantly, 50 % of the participants reported that they were motivated by MAID to implement the given suggestions. So, MAID seems to have a persuasive effect and may potentially influence people to change.

Observations revealed that users had fun while using MAID and their friends, in the audience, were commenting and giving suggestions. In general, participants considered the gestures natural and appropriate to mimic the real actions, as well as easy to perform. A few users reported that the hand gesture interface became tiring after a few minutes of interaction. Applications like MAID should not be used for a long time and users must be able to accomplish the game objectives in a few minutes.

4.3.2 LEY

LEY (Less energy Empowers You) is as a persuasive pervasive-based serious game approach to help people understand domestic energy usage and change their habits (Madeira et al. 2011). The mechanics of the game are based on real-time domestic energy consumption data, collected by smart energy monitor devices.

Current version of LEY was developed for Android mobile phones. The LEY's user interface presents an avatar of the user's house, which is the main game character (Fig. 4.3). In the beginning of the game, a profile is assigned to the avatar. This has to be defined according to some conditions, such as the house typology, appliances connected and their average number by room, the number of inhabitants, and last year's consumption. The profile permits that houses with different typologies compete against each other. The first week's consumption values will be used to help sharpen the profile.

LEY presents a single competition mode, Status View mode, where the application can monitor the user's house instant consumption, current energy category and total

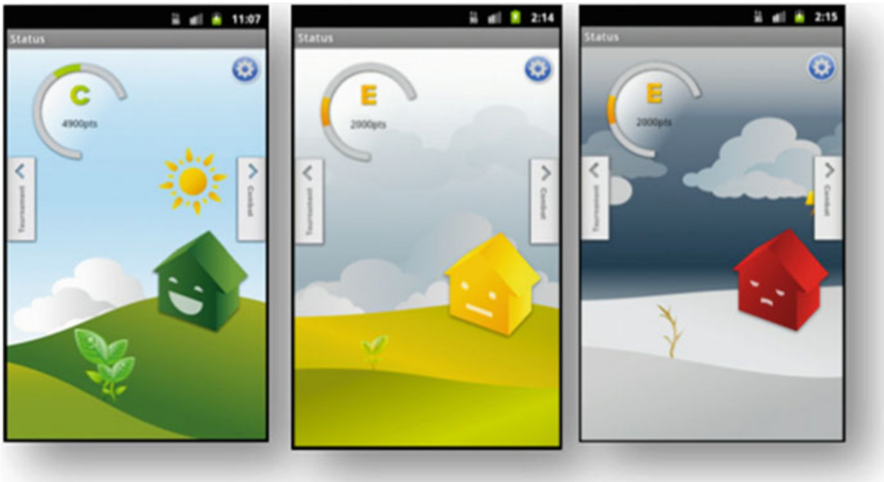


Fig. 4.3 LEY interface

score; and two multi-player modes, the combats and tournaments. The combat mode allows users to enter into a one-on-one competition, while tournaments provide competition for more than two users.

The user's challenge is always to bring his house to the best consumption level and to obtain the best possible score over time. The total score is calculated according to the real energy consumption values and the competitions' results. The avatar mood is green if the consumption is below the usual mean value of the current period (yellow and red are obvious alternatives) (Fig. 4.3). A notification service is executed if abnormal consumption values appear or when the user should be notified in competition situations. In combat mode, a user can challenge another user. An environmental sustainability-based quiz will be launched to each one of the "fighters", which will receive points according to the result. The tournament competition can be organized by a player that invites others to participate for a pre-defined period of time.

At the end of each month, persuasive information related with the energy consumption results is shown to the users. Another important functionality is the avatar interaction with the player, showing its satisfaction level about the player's real-time consumption actions. It presents the quizzes, shows negative results and appears in wakening-up functions when occur, for instance, the aforementioned abnormal energy consumption values.

LEY consists of three main components: the sensor platform, the supporting web-based information system and the mobile game app (Madeira et al. 2011). For the sensor platform, we use the Current Cost EnviR wireless home real-time energy monitor, but others can be used. We use the Pachube web services platform (now Cosm (2013)) to make sensors' data available, in real-time, for the mobile game. The game server and information system (IS) are implemented in MySQL, PHP and Java technologies, based on the Spring MVC platform.

A personalization mechanism, provided by an external web service, has been explored to enhance LEY effectiveness, helping people to better understand domestic energy usage in order to change potential negative habits and potentiate the positive ones to a whole new level (Madeira et al. 2012).

4.4 Rethinking Your Attitude on the Move

As referred by Eckles and Fogg (2007), mobile phones are an excellent persuasion tool, since they became ubiquitous smart objects that most people carry with them everywhere. In this section, we present some mobile games designed to foster environmental awareness.

4.4.1 Gaea

Gaea is a persuasive location-based multiplayer mobile game, which prompts people to recycle virtual objects within a geographical area (Centieiro et al. 2011). Gaea was created with the goals of instructing, informing and persuading users to recycle their wastes. We also intend to reach a large number of people simultaneously, to promote entertainment and social engagement, as well as to encourage the contact with nature and the performance of physical exercise. Thus, we decided to combine mobile devices (allowing players to freely move around) with a public display (allowing audience awareness and players' social engagement).

Gaea was designed to be played in any open-air space. Players have to move around and use their mobile phone to locate and collect virtual garbage spread within their surroundings. These virtual objects are linked to geographic coordinates and players need to physically go there in order to pick them up. Once grabbed, players need to bring it near the public display, and place it into the right virtual recycle bin. Virtual recycle bins are displayed for selection on the mobile device only when users turn their mobile phones towards the public display (Fig. 4.4). If the object is placed in the right container, the player receives, on the mobile phone, useful environmental information (in addition to the corresponding points) that can help him answer a quiz displayed in the public display, for all players, at the end of the game. The purposes of forcing players to bring the virtual objects near the public display are (1) to replicate the real recycling process, and (2) to stimulate communication between participants and the audience. The final quiz motivates users to pay attention to the information provided on their mobile phones when they correctly recycle an object. The audience can follow the game progress through the public display.

At the end of the activity, the classification of the various players, based on their performance, is presented in the public display and it can be also shared via social network Facebook. In order to advertise Gaea and disseminate environmental information, we used Facebook Connect so that users could login to Gaea with their

Fig. 4.4 Selecting the virtual recycling bin

Facebook accounts, and easily share their experience and accomplishments through this social network, by posting them on their Wall. This allows users to spread the word in an easy and powerful way that would be impossible otherwise.

In the various events where Gaea was set up, players arduously competed to recycle the largest number of objects (which made them run across the game area) and to achieve the best possible score in the quiz.

A team version of Gaea was also developed. When playing the team version, users must register in one of the three possible teams and each team is in charge of picking up one type of waste (paper, plastic/metal, or glass). Gaea turns into a both collaborative and competitive social activity that persuades a group of people to cooperate towards a common goal. By stimulating social and collaborative activities Gaea may influence people to have the same kind of behavior in their daily lives.

To give users a more immersive and game-like experience, it was decided not to use Google Maps (or any other web mapping service application) to show the objects and users' locations, both on the mobile phones and on the public display. Instead, a custom map was designed specifically for this activity (Fig. 4.5).

Gaea is based upon a client-server architecture and it was developed, in Objective C, for iOS. The client application runs on iPhones and iPads, exploiting the GPS, compass and accelerometer components. The public display is connected to a computer running the server application, waiting for requests from the client mobile devices.

Gaea was deployed on a large event for teenagers, an open day at our University Campus attended by 7000 high-school students. During this event, a user study was

a b

Fig. 4.5 Dynamic local map: **a** mobile phone interface and **b** public display interface

conducted with thirty seven users aged 16–28 (average of 17.2) (Centieiro et al. 2011). Besides the initial players, some members of the audience asked to participate. The Facebook Connect feature was a success, substantially increasing the views of DEAP project Facebook page during the week after the event, due to the experiences that users posted on their Walls.

Based on the results of the tests, it is possible to conclude that Gaea managed to convey the intended message. Everyone considered the addressed topics relevant, and stated that Gaea increased their awareness about recycling. The users' motivation to recycle after using Gaea also increased slightly, as stated by the players.

Also, the quiz phase made it possible to instruct and inform users and audience about the consequences and gains of recycling, subtly persuading them to change their attitudes and behaviors towards recycling, according to the results from the questionnaire.

4.4.2 eVision

eVision (Santos 2013) is a persuasive mobile game designed to change people's attitudes or behaviors towards environment in a fun and entertaining way, through the use of mobile devices, augmented reality and persuasive technology. It was conceived to be an iPhone application, which works like an environmental scanner, allowing users to exploit their mobile devices to detect and gather information regarding air quality and environmental threats around their current geographical position.

The main objectives of eVision are to: inform users about the environmental threats in their surroundings and their consequences for the environment; encourage them to change their behavior towards the environment; offer digital rewards for completing pro-environment tasks; create a bond between the users and the virtual character to make them more receptive to his advices and suggestions and to enable data sharing through social networks.

Fig. 4.6 Detecting and cleaning environmental threats: *1* detection, *2* cleaning, *3* overlaying of the environmental threat

The eVision virtual character, Snowkin, invites users to participate in a game activity that consists in using their mobile device to detect and clean environmental threats in their vicinity, such as cars, airplanes and factories. Detection is automatically achieved by eVision as the user moves his mobile phone and points around. Once an environmental threat is detected, the player should clean it by using his finger to rub the mobile phone display over the detected threat (Fig. 4.6), which will then be automatically overlaid with pro-environmental objects (e.g., overlaying a car with a bicycle).

When completing each activity, users are awarded with points and green leaves (eVision's virtual currency), as well as with environmental information regarding the corresponding threat. eVision's green leaves can then be spent to buy items, in the in-game store, to customize the Snowkin. Positive reinforcement techniques are also used to keep the user engaged. This aspect is very important and it is achieved with the assistance of Snowkin by establishing motivating and pro-environmental dialogues every time the users clean a threat.

eVision was implemented using Apple's Xcode IDE (Integrated Development Environment) in Objective-C language. The image processing module was developed using the OpenCV library compiled for iOS 5.1. For the Facebook integration it was used the proper Facebook mobile API designed for iOS with minor refinements.

eVision current implementation allows users to detect different pollution sources: cars, airplanes and factories. Knowing the static location of factories, GPS was used to identify factories in the users surroundings. Image detection methods were investigated in order to detect the dynamic position of cars and airplanes during eVision's game activity. Using the OpenCV library (2013), the airplane detection method was designed based on contour detection and analysis. It worked quite well on a clean sky. For vehicle detection, recognition of cars' registration plates was used. These methods for recognition of dynamic threats still need optimization, however given the eVision's modular software architecture, it is easy to replace the current image recognition algorithms by more precise ones.

Figure 4.7a illustrates the eVision's main menu interface, where the users can navigate through all the features of the application. The Scanner mode is the eVision's main feature, leading the users to the core game activity, where they can inspect their surroundings and gather information regarding environmental threats. Snowkin is always present, guiding the users through the game, encouraging them to play and to help the environment, as well as congratulating the users for their achievements.

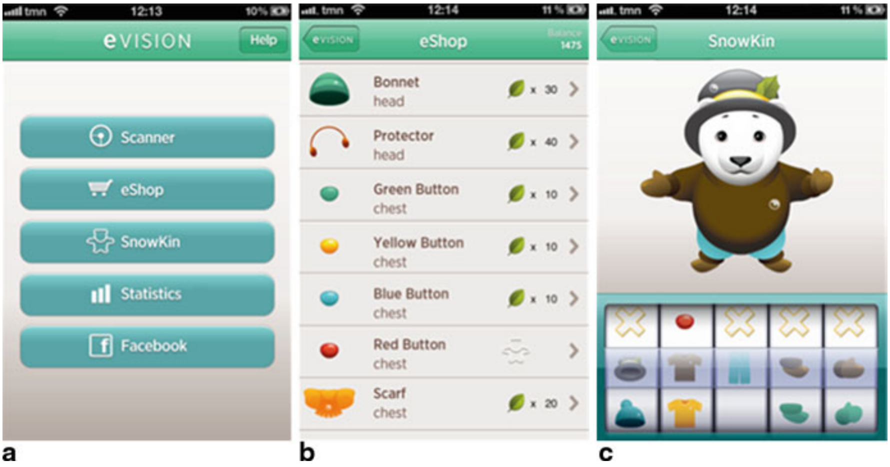


Fig. 4.7 eVision: **a** main menu. **b** e-shop and **c** Snowkin customization

Besides being informed about the environment in their surroundings and the consequences of their action towards the environment, users can also visit the e-shop (Fig. 4.7b) and spend the green leaves they earned to buy different items to customize Snowkin (Fig. 4.7c), view the statistics of the game and post they achievements in Facebook. The commitment and time the user puts on building Snowkin's appearance makes him closer to Snowkin and more likely to follow the character's advices and recommendations regarding the environment, thus being persuaded by the application.

eVision's usability and impact tests were performed with a group of thirty participants (50 % male) aged 18–56 year old (mean = 30.9). Results from the first test were very positive. Participants found eVision easy to learn and to use. The Snowkin character had a particular strong impact, driving the participants to keep scoring, so they could buy more items to customize the virtual character. About 55 % of participants considered that the use of the application contributed to increase their awareness regarding environmental issues, demonstrating the persuasive potential of the eVision.

The impact tests were carried out, with the same participants, one month after the usability tests, to better evaluate the persuasive effect of eVision and to check if it still holds sometime after the first eVision experience. Participants agreed that eVision played an important role in alerting them to Earth's sustainability problems and they also reported that their experience with eVision influenced their daily life decisions. Participants felt that Snowkin's dialogues and information were still relevant to them a month after the experience.

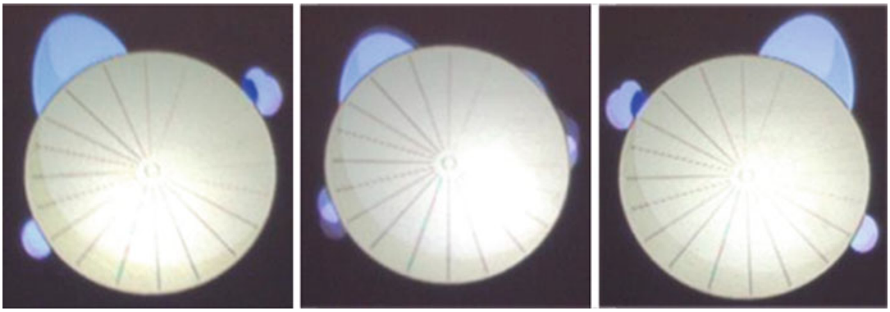


Fig. 4.8 Projected image of the Imaginary Friend while walking along with the user

4.4.3 The Imaginary Friend

The system implements the metaphor of the imaginary friend that walks along with the user (Fig. 4.8; Reis and Correia 2011, 2014). When the user stops and looks down his friend is there looking back at him (Fig. 4.9a). The Imaginary Friend is projected on the floor using a pico projector attached to the user's backpack shoulder strap (Fig. 4.9b). The projector is connected to a mobile phone that runs the interactive application. The user also wears a bracelet with an electrodermal activity sensor. This sensor is used to measure the arousal of the user. Arousal corresponds to a change in conductance at the surface of the skin due to an external or internal stimuli experienced by the user (Dawson et al. 2000). The sensor is connected, with wires, to a PLUX device (PLUX 2013) that transmits the data, via bluetooth, to the mobile phone. The PLUX device can be attached to a belt, placed inside a pocket or inside the backpack. The mobile phone is connected to the pico projector, in order to project the Imaginary Friend on the floor. The mobile phone accelerometer is used to detect if the user is standing or walking.

When there is a significant increase or decrease in the arousal, the external or internal stimuli behind that change might have caused an alteration in the emotion the user is feeling. To discover what emotion the user is feeling, the Imaginary Friend will pose a question and present several emotion tags from which the users needs to choose one. The phone beeps and vibrates to warn the user that the Imaginary Friend is posing a question. After the user selects an emotion tag, an emotion cookie, with the same color as the selected emotional tag, is left on the ground. The Imaginary Friend collects the user's emotions for future reference in a jar. The user can also visualize, in a map, the places where the Imaginary Friend collected each emotion cookie. It may help the user to follow his emotional history.

The Imaginary Friend can be adapted for several behavior change games, where it can have the role of the users' conscience (Talking Cricket metaphor), informing and persuading the users to take specific actions when a certain contextual situation is detected. This way, the Imaginary Friend works as a persuasive friendly agent trusted by the user.

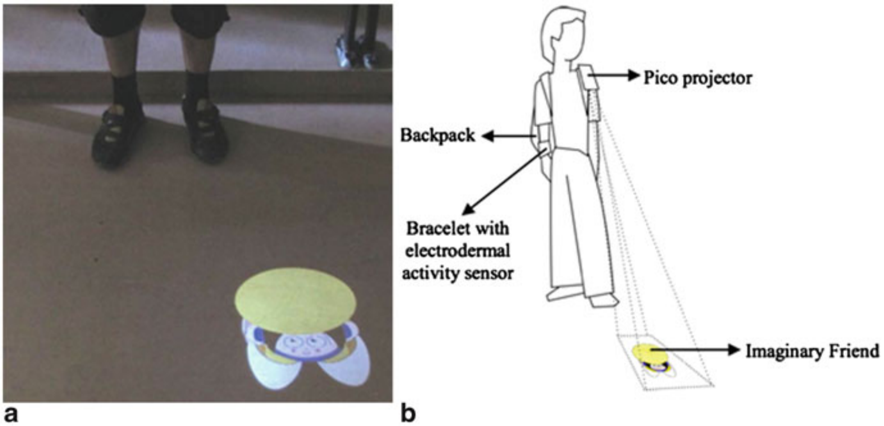


Fig. 4.9 **a** Projected image of the Imaginary Friend while the user is standing still and **b** user with the Imaginary Friend

4.5 Engaging Children

Children are our future, so it is important to assure they grow up healthy, skillful, knowledgeable and happy. Entertainment can support their learning activities, promoting curiosity, creativity, self-esteem and social interaction.

ACE (Advances in Computer Entertainment Conference) has now an extra focus on children through the Kids Workshops (Chisik et al. 2013) that promote the engagement between both researchers and industry practitioners and groups of youth children with the aim of exploring concepts, such as creativity, user experience and learning, and "cool" ways of creating entertainment media, as well as new ways of expanding children's understanding of entertainment computing and its potential. During ACE 2012 in Nepal, Kids Workshops provided an amazing, successful and rewarding experience both for researchers and local children. Researchers had the opportunity to work with a considerable number of curious, interested and eager to learn youth children from a developing country with a different culture and inspect new designs and requirements for their entertainment media, as well evaluate novel concepts and applications. Local children had a change to experiment new technologies, create their own applications and interact with researchers from different countries and cultures. Considering our observations and the feedback from researchers and the children involved in the workshops, it was a very productive and memorable experience for both.

In our research work, we consider children as one of our target groups. Based on many research works, that have been done in the areas of educational software and children interaction, we present below some of our developments aiming at educating and changing children behaviors.

Fig. 4.10 A child using Smart Bins

4.5.1 Smart Bins

Smart Bins was designed as an educational game to encourage recycling activities (Lobo et al. 2009a). It comprises an augmented recycling bin, composed by three containers (blue, yellow and green), able to detect if users place the objects to be recycled in the correct container (Fig. 4.10). Smart Bins is also able to communicate simple messages right on the appropriate time according to the users' actions. Mascots were created to guide the users throughout the entire game, providing them with useful stimuli. The mascots, resembling humanized recycling containers, are displayed on a screen above the recycling bin and convey persuasive messages to the children, bringing "life" and "intelligence" to Smart Bins.

Smart Bins works as follows. When no one is close to the system, the display shows a video about recycling. As soon as a child approaches the augmented recycling bin (detected by an infrared sensors), the application reacts and one of the recycling bin mascots tells the children how to play the game and start recycling.

To play Smart Bins, children have to identify themselves to the system showing the camera a card with a Data Matrix code. This allows the system to provide them with personalized messages. After that, they can start recycling and they have to place a set of objects in the recycling containers, aiming at selecting the correct container for each object. A Data Matrix image is attached to each object to identify the type of container in which the object should be placed (green, yellow, or blue). Thus, to identify an object the user has to pass the object in front of the camera and then place it in the recycling container.

Each container has an infrared sensor, thus whenever an object is put inside a container, the object is detected and stimuli are provided to the children telling them whether the object was placed in the right container. The choice of the correct recycling container triggers a congratulating message together with audio to reinforce the success of the user's action. Otherwise, when children fail to place an object in the correct recycling container, Smart Bins mascots get sad and encourage them to do it better with the next object. The game ends either when the user fails to correctly recycle more than three objects, after the recycling of a predefined number of objects or after a predefined time period. Besides the score and feedback about objects correctly or incorrectly recycled, the game also provides interesting facts about recycling.

Smart Bins was created with a framework developed for the creation of context-sensitive persuasive applications (Lobo et al. 2009b). The framework allows the authoring of persuasive smart environments producing the appropriate feedback to the users based on different sensors spread throughout the environment to capture contextual information.

Eight and nine year old children evaluated Smart Bins in two user tests sessions. The second session was carried out one month after the first one with the same participants (with one exception only) and game setting. While the first test had a special focus on the usability evaluation of the application, the second test was directed towards the persuasion effects of Smart Bins, focusing on the effect of the game in the children's behavior towards recycling. Children were interviewed before using Smart Bins, they were observed while testing it, and they were interviewed again after playing with it. Although being based on a questionnaire, interviews provide a closer interaction with the children, allowing for a more feasible evaluation of their opinions and feelings.

During the first users' tests, from our observation, the game seemed very entertaining and all children but one (who wasn't sure) wanted to repeat the experience. Fourteen (out of seventeen) players wanted to see Smart Bins available in other places. Nevertheless, they all agreed that they would like to have Smart Bins at home. Thirteen interviewees said they had learned about recycling with this experience and four of them said they had not. Finally, the children said they felt that they would recycle more after experiencing Smart Bins.

In the second tests, we intended to analyze how users felt about recycling, assessing if there were any changes in their attitude towards recycling. Nine (out of sixteen) participants said they had recycled more after their first experience with Smart Bins, six said they didn't and one said that he had done a little more. Only one participant answered that he didn't talk to anyone about the game, but the other fifteen did mention the experience to their families and friends. All children were really excited to play the game again. They all agreed that they had learned about recycling. They all felt they would recycle more if they had the game at home or at school and finally, eleven users said they would recycle more after these experiences while the remaining five were not sure.

In conclusion, Smart Bins seems to be easy to use and the children' opinions make us believe that they became aware of recycling activities and benefits, and at least part of them will be more concerned about this matter.

4.5.2 Ecosystem Room

An enhanced version of the framework mentioned above was used to create the Ecosystem Room, which is a tangible game system that intends to raise children awareness regarding how ecosystems work, as well as the impact of our actions on the environment, aiming at changing their behaviors towards the environment (Romão et al. 2012). The application focuses on the different threats that can affect the environment, such as pollution, deforestation, illegal hunting.

The Ecosystem Room is installed in a room. Upon entering the Ecosystem Room entrance hall, the user is faced with a projection screen, which shows a movie about the different ecosystems, their components and some of the threats that can affect them (e.g., poaching, deforestation, pollution, urbanization, endangered species, etc.). While the user is watching the movie, a video camera, placed at the top of the screen, captures user's images and sends them to the face recognition module, for user identification. Note that the user data (e.g., name and picture) must be previously inserted in the database. This allows the personalization of the application with the purpose of enhancing the persuasive effect. After being identified, the user is encouraged to proceed to the next room (the interaction room), through audio instructions (with custom messages).

Upon entering the interaction room, the user is faced with a central interactive table where all the game action takes place (Fig. 4.11). Tangible objects are used to interact with the table. These objects are identified by Data Matrix patterns detected by a camera. By using tangible objects, the child can select, one of five movies, each one of them related to a different possible threat to ecosystems, or immediately start the adventure game to save the Earth. When the child selects a movie, she watches it, returning to the previous menu when it ends. When the child selects to start the adventure, she is encouraged to save various ecosystems in the world. For each continent there is a different threat, and the children should save all the continents, in order to complete and win the game. With that purpose in mind, the user should start by selecting a continent, placing the corresponding tangible object in the centre of the interactive table. Then he is presented with three questions that focus on the threat corresponding to a typical ecosystem of the selected continent. To save this continent, the user must correctly answer to at least two of these three questions. When the user fails, he is always encouraged to try again, so he can have new learning opportunities.

The Ecosystem Room was tested with thirty children, who were all very enthusiastic while playing the game. The children were asked several questions regarding the environmental issues mentioned in the game, before and after playing the game. Their answers were substantially more correct after playing Ecosystem Room, which indicates that children also acquired some knowledge about the topics of the game.

This work also allowed us to explore the use of interactive tables to teach environmental concepts and motivate children's behavior changes by offering them a concrete platform for learning and awareness through interaction with physical objects.

Two versions of the Ecosystem Room, which only differ in the user interface, were developed. In addition to the tangible interface version, another version with

Fig. 4.11 A child interacting with the interactive table

a traditional GUI, operated with a mouse, was created. For each physical object in the tangible interface system, there is a corresponding object (icon) on the GUI that instead of being placed on the table, as in the tangible interface system, is dragged into the centre of the playing area using the mouse. To exploit this later interface, a computer with the appropriate interaction device (mouse) replaced the table. The users' preference for the tangible interface was notorious. Some children even suggested the actual dual purpose of the interactive table: as a physical object (furniture) to support their study activities, and as an intelligent tutor.

4.5.3 T-Games

Knowledge is an essential component of behavior change, because it allows us to estimate the probable consequences and outcomes of our choices and actions. Games are typically played by children for entertaining and learning purposes, but they can also be created by children, for children. We followed a Learning-by-Teaching approach in which children are given the instructor's role and we developed T-Games (Tangible Games), an authoring tool that allows children to use tangible objects for input when creating their own quiz-type games (Mendes and Romão 2011). While using T-Games, children play the role of the teacher who creates tests and challenges for their students. While creating their own games children need to explore scholar subjects, in order to produce the questions and possible answers, which will compose the game content. In this way, they feel empowered and responsible for creating a game appreciated by their colleagues and they strive to achieve their goals.

Fig. 4.12 Children using T-Games to create an educational game

T-Games allow the children to create games based on the structure of the "Game of life", with an additional rule: in some places of the game board where players can land, they have to answer a multiple-choice question. Instead of using a typical computer to create their games, children have to interact with a tangible table (a magic table), using small cubes with markers that represent objects and actions (Fig. 4.12). The idea of children creating their own application scenarios with physical objects appeared from the notion that they are more familiar with constructing spaces using their own toys, which they are used to do from the moment they have the necessary dexterity.

Before starting to use T-Games to create a game, children have to design their games and prepare the materials they will need. This way, they have to do some research on the topics regarding the questions and answers they will include in the game. Building a game to be played by other colleagues seemed to motivate them to learn about those topics. After this step, children start to use T-Games where they have to perform four different main tasks in order to define: a contextual story for the game, a virtual character, a scenario for the game (board configuration) and all the questions and respective four possible answers through the use of tangible markers, a microphone and a keyboard. Markers are square pieces of wood with a picture on the topside and an amoeba-like fiducial on the bottom side.

The T-Games starts with a presentation made by the magician (T-Game character) who guides and helps the children during the whole game creation process. The contextual story is a recorded audio file that will be played at the start of the game. The magician asks the children to use the microphone to record the story of the game. The children use a marker to start the record, a microphone to record the story and another marker to stop recording. To select the character that will be the star of the game, children use the corresponding marker. There is a marker representing each one of the possible characters. Children can then use several markers to define the character attributes (e.g., clothes, hair). After that, children need to select the game board configuration, placing the corresponding marker on the table. Next, children must define the question/answers. Each question is recorded in an audio file (like the initial game story). Children are prompted to enter the possible answers with the keyboard (the first one entered corresponds to the right answer). The game is then ready to be played.

User tests were performed in order to evaluate the usability of the T-Games authoring application and the children motivation to use it, as well as to perceive if children's motivation to create their own games engages them into learning more about their scholar subject. The prototype was tested with 10 children, aged between 8 and 10, divided in five pairs.

Surprisingly, most groups spent more time reading the scholar books, choosing a game story and debating about the possible questions and answers than, actually, using T-Games to create the game. The goal of creating a game, motivated children to learn, so they could formulate the questions and find the correct answer, as well as the remaining options. Children were very enthusiastic about the preparation of the game and voluntary put considerable effort in learning the topics related to the questions that will be part of the game.

T-Games were easy to learn and to use by the children involved in the users studies. The keyboard data input, however, presented some problems, since it took children a longer time to create the game elements that required this type of input (answers) and they often asked the team members for help with the text input. However long it took, they didn't seem to care, which led to the conviction that they were really having fun. Children even suggested the use of letter markers for text input. According the users studies, T-Games is a game authoring tool for children with a great potential to encourage them to learn and engage in social activities that can be directed to promote behavior changes.

4.6 Conclusions

Entertainment technology can be combined with persuasive technology to produce applications that engage people in desired activities and promote behavior changes. This chapter presents and discusses several game prototypes built to foster users awareness, learning and behavior change. Most of these prototypes are related with environmental sustainability, as it is a relevant matter affecting the whole world. They rely on entertaining and persuasive technologies combined with mobile computing, contextual awareness techniques, or novel interaction methods. The use of typical game design mechanisms, such as setting goals, tracking progress, rewarding and providing support, seems to guide and keep the users engaged in the desired activities. Several approaches were explored: mobility and contextual awareness allow the detection and reaction to both the users' actions and the changes in the environment and enable just-in-time interaction; novel interaction methods and devices (such as gesture and tangible interfaces) promote users engagement with the applications; social interaction fosters collaboration, competition, peer-pressure, and dissemination of knowledge.

These techniques were also applied to support and engage children in learning activities, promoting curiosity, creativity, self-esteem and social interaction.

The interactive systems presented in this chapter revealed a great potential to engage users, raise awareness and encourage behavior change. Although the results were positive, evaluating behavior changes is always a complex and time-consuming task that requires assessing user behavior through time. Thus, further tests will be performed with a larger number of users, allowing them to use the applications for a longer period of time to better evaluate the persuasive power of the developed applications.

Acknowledgements This work was funded by Fundação para a Ciência e Tecnologia (FCT/MEC), Portugal, in the scope of project DEAP (PTDC/AAC-AMB/104834/2008) and by CITI/DI/FCT/UNL (PEst-OE/EEI/UI0527/2011). The author also wishes to thank the IMG-CITI/FCT/UNL team for their contribution and support.

References

Arduino (2013). http://www.arduino.cc/. Accessed March 2013.

Ashby, F. G., Isen, A. M., & Turken, A. U. (1999). A neuropsychological theory of positive affect and its influence on cognition. *Psychological Review, 106,* 529–550.

Bang, M., Gustafsson, A., & Katzeff, C. (2007). Promoting new patterns in household energy consumption with pervasive learning games. Proceedings of Persuasive 2007, Palo Alto, USA, 26–27 April 2007 (vol. 4744, pp. 55–63). LNCS. Heidelberg: Springer.

Bogost, I. (2007). *Persuasive games: The expressive power of videogames*. Cambridge: MIT Press.

Brown S. (2008). TED talk: Play is more than fun, May 2008. http://www.ted.com/talks/lang/en/stuart_brown_says_play_is_more_than_fun_it_s_vital.html. Accessed March 2013.

Brown, S., & Vaughan, C. (2010). *Play: How it shapes the brain, opens the Imagination, and invigorates the soul*. New York: Avery Trade.

Centieiro, P., Romão T., & Dias, A. E. (2011). A location-based multiplayer mobile game to encourage pro-environmental behaviors. Proceedings of International Conference on Advances in Computer Entertainment Technology (ACE 2011), Lisbon, Portugal, 8–11 November, Issue 31.

Chisik, Y., Chen, M., & Martins, M. C. C. (2013). Puppets duets in [E]ngaging Major, Op. 33. In: Seventh International Conference on Tangible, Embedded and Embodied Interaction (TEI 2013) Barcelona, Spain, 10–13 February. Works in progress.

Cialdini, R. (2007). *Influence—The psychology of persuasion*. New York: Harper Collins Publishers.

Cosm. (2013). https://cosm.com/. Accessed March 2013.

Dawson, M., Schell, A., & Filion, D. (2000). The electrodermal system. In J. Cacioppo, L. Tassinary, & G. Berntson (Eds.)*, Handbook of psychophysiology* (pp. 200–223). Cambridge: Cambridge University Press.

de Oliveira, R., Cherubini, M., & Oliver, N. (2010). MoviPill: Improving medication compliance for elders using a mobile persuasive social game. Proceedings of UbiComp 2010, Copenhagen, Demark, 26–29 Sept 2010 (pp. 251–260). ACM.

Eckles, D., & Fogg, B. J. (2007). The future of persuasion is mobile. In *Mobile persuasion: 20 perspectives on the future of behavior change* (pp. 5–11). Stanford: Stanford Captology Media.

Fogg, B. J. (2003). *Persuasive technology: Using computers to change what we think and do*. San Francisco: Morgan Kaufmann.

Fogg, B. J. (2008). Mass interpersonal persuasion: An early view of a new phenomenon. Proceedings of third International Conference on Persuasive Technology, Oulu, Finland, 4–6 June 2008 (pp. 23–34), Persuasive '08. Heidelberg: Springer.

Fogg, B. (2009). A behavior model for persuasive design. Proceedings of the Fourth International Conference on Persuasive Technology, Claremont, USA, 26–29 April 2009 (vol. 40, pp. 1–7).

Froehlich, J., Dillahunt, T., Klasnja, P., Mankoff, J., Consolvo, S., Harrison, B., & Landay, J. (2009). UbiGreen: Investigating a mobile tool for tracking and supporting green transportation habits. Proceedings of CHI ans, Boston, USA, 4–9 April 2009 (pp. 1043–1052). New York: ACM Press.

Gustafsson, A., Bang, M., & Svahn, M. (2009). Power Explorer: A casual game style for encouraging long term behavior change among teenagers. Proceedings of ACE 2009, Athens, Greece, 29–31 October 2009 (pp. 182–189). New York: ACM.

Kinect. (2013). http://www.xbox.com/en-US/kinect. Accessed March 2013.

Kort, Y., Ijsselsteijn, W., Millden C., & Eggen, B. (2007). Preface. Proceedings of Second International Conference on Persuasive Technology, Palo Alto, USA, 26–27 April 2007. Persuasive '07. Heidelberg: Springer.

Lobo, P., Romão T., Dias, A., & Danado, J. (2009a). Smart bins: An educational game to encourage recycling activities. Proceedings of IADIS International Conference Interfaces and Human Computer Interaction Carvoeiro, Portugal, 20–22 June 2009 (pp. 155–162). IHCI '09. Portugal: IADIS Press.

Lobo, P., Romão, T., Dias, A. E., & Danado, J.C. (2009b). A framework to develop persuasive smart environments. Proceedings of Third European Conference on Ambient Intelligence (AMI 2009), Salzburg, Austria, 18–21 November 2009, pp. 225–234.

Madeira, R., Silva, A., Santos, C., Teixeira B., Romão, T., Dias, A. E., & Correia N. (2011). LEY!: Persuasive pervasive gaming on domestic energy consumption-awareness. Proceedings of International Conference on Advances in Computer Entertainment Technology (ACE 2011), Lisbon, Portugal, 8–11 November 2011, Issue 72.

Madeira, R., Vieira, A., & Correia, N. (2012). Personalization of an energy awareness pervasive game. Proceedings of 14th ACM International Conference on Ubiquitous Computing (UbiComp 2012), Pittsburgh, USA, 5–8 September 2012, pp. 619–620.

Mendes, L., & Romão, T. (2011). Children as teachers: A tangible approach. Proceedings of International Conference on Advances in Computer Entertainment Technology (ACE 2011), Lisbon, Portugal, 8–11 November 2011, Issue 12.

Norman, D. (2004). *Emotional design: Why we love (or hate) everyday things*. New York: Basic Books.

OpenCV. Open Source Computer Vision. (2013). http://opencv.org/. Accessed on March 2013.

Oxford Dicionary of English (2003). Second Edition, Oxford University Press, p. 579.

PLUX. (2013). http://plux.info. Accessed March 2013.

Reeves, B., Cummings, J. J., & Anderson, D. (2011). Leveraging the engagement of games to change energy behavior. Gamification Workshop at CHI 2011, Seatle, USA, 31 March–5 April 2001.

Reis, S., & Correia, N. (2011). An imaginary friend that connects with the user's emotions. Proceedings of Int. Conf. on Advances in Computer Entertainment Technology (ACE 2011), Lisbon, Portugal, 8–11 November 2011, Issue 1.

Reis, S., & Correia, N. (2014). Casual games with a pervasive twist. *Entertainment Computing, 5*(2), 115–125.

Rhoads, K. (2007). How many influence, persuasion, compliance tactics & strategies are there? http://www.workingpsychology.com/numbertactics.html. Accessed March 2013.

Romão, T., Almeida, M., & Centieiro, P. (2012). A framework for developing tangible educational applications. Proceedings of IADIS International Conference Interfaces and Human Computer Interaction (IHCI 2012), Lisbon, Portugal, 21–23 July 2012, pp. 157–164.

Salvador, R., Romão, T, & Centieiro, P. (2012). A gesture interface game for energy consumption awareness. Proceedings of ACE 2012, Kathmandu, Nepal, 3–5 November 2012, pp. 352–367.

Santos, B. (2013). Changing environmental behaviors through smartphone-based augmented experiences. Master Thesis, Faculdade de Ciências e Tecnologia/Universidade Nova de Lisboa, Portugal.

Schmidt, A. (2008). Context-aware communication and interaction. MobileHCI 2008 Tutorials, Amsterdam, Holland, 2–5 September 2008.

Woodruff, A., & Mankoff, J. (2009). Environmental sustainability. *IEEE Pervasive Computing, 8*(1), 18–21.

Chapter 5
Yellow is Mine!: Designing Interactive Playgrounds Based on Traditional Childrens Play

Daniel Tetteroo, Dennis Reidsma, Betsy van Dijk and Anton Nijholt

Abstract This paper presents a novel method for interactive playground design, based on traditional children's play. This method combines the rich interaction possibilities of computer games with the physical and open-ended aspects of traditional children's games. The method is explored through the development of a prototype interactive playground that has been implemented and evaluated.

Keywords Interactive playgrounds · Children · Traditional play · Emergent play · HCI

5.1 Introduction

Many governments pursue health care programs that promote a healthier youth. Still, children are unlikely to give up computer time in favor of outdoor play (Jansen et al. 2010). Sturm et al. suggest that this tendency might be countered by the development of interactive playgrounds, consisting of "one or more interactive objects that use advanced technology to react to the interaction with children and actively encourage them to play" (Sturm et al. 2008). They possess the rich interaction possibilities from computer games as well as the physical and social aspects of traditional outdoor play. Being an *environment for play*, rather than a *game*, they do not force strict rules upon the players, but provide possibilities for the children to define their own emergent game play (Reidsma et al. 2012). This form of "open-ended" play benefits children in

D. Tetteroo (✉)
Department of Industrial Design, Eindhoven University of Technology,
Den Dolech 2, Eindhoven, Netherlands
e-mail: d.tetteroo@tue.nl

D. Reidsma · B. van Dijk · A. Nijholt
Department of Human Media Interaction, University of Twente,
Drienerlolaan 1, Enschede, Netherlands
e-mail: d.reidsma@utwente.nl

B. van Dijk
e-mail: e.m.a.g.vandijk@utwente.nl

A. Nijholt
e-mail: a.nijholt@utwente.nl

A. D. Cheok et al. (eds.), *Entertaining the Whole World*,
Human–Computer Interaction Series, DOI 10.1007/978-1-4471-6446-3_5,

many aspects of their development, such as social skills, problem solving, creativity, and a better understanding of the physical world (Rogers ans Price 2004; Bekker et al. 2008).

Although it is clear *in principle* that interactive technology can be used to facilitate emergent games and play, it remains challenging to design them in such a way as to actively leverage the open ended aspects that are so obviously present in traditional playground play. This chapter presents a design method for developing interactive playgrounds that should combine the interactivity of modern computer games and the open-endedness of traditional outdoor play, by systematically basing the design of these playgrounds on elements of traditional children's play. In addition, we present a playground that we implemented using this method, focused on social and physical activation of the children playing in it.

5.2 Interactive Playgrounds: Environments for Pervasive and Emergent Game Play

As Seitinger et al. wrote, *"the increasing availability of technologies for outdoor interaction"* would cause *"digitally enhanced equipment to be incorporated into playgrounds in the near future"* (Seitinger et al. 2006). This vision has become reality in numerous interactive playgrounds in different (research) projects. In this section, we discuss a few aspects of interactive playgrounds that are central to our own work.

5.2.1 Pervasive Gaming

Interactive playgrounds are typically **pervasive gaming** environments: *"an emerging genre in which traditional, real-world games are augmented with computing functionality, or, depending on the perspective, purely virtual computer entertainment is brought back to the real world"* (Magerkurth et al. 2005). Pervasive gaming inherently involves interaction with and within the physical (real world) environment. For example, in *Camelot* (Verhaegh et al. 2006), players collect *virtual* resources in various parts of the play space to earn physical building blocks to build a castle. In *Save the safe* (Soute et al. 2009), guards and burglars each try to get hold of a (virtual) key that unlocks a safe. Players wear a belt with a wireless communication unit, a vibration motor and some LED's. The virtual key is transferred from player to player by approaching within a certain distance; key possession is indicated by vibration of the belt. As Soute and Markopoulos noted, pervasive games should make minimal use of hand-held displays, as such devices do not go together with wildly running around; hence, they call this type of game *Head Up Games* (HUGs) (Soute and Markopoulos 2007; Soute et al. 2009).

5.2.2 Emergent Game Play

Interactive playgrounds also lend themselves well to **emergent game play**. Emergent games have been defined by Nijholt et al. as: "*games that are not really predefined by the designer, nor explicitly present as a game in the environment. Rather, the environment may simply afford many kinds of playful interaction to its inhabitants*" (Nijholt et al. 2009). The game play and rules *emerge* from the interaction between humans and their environment.

Because emergent games are not predefined, they do not necessarily have an explicit goal. In such a sense, emergent gaming should be related to the more spontaneous concept of *play*. This does not mean that emergent games are entirely without goals. Play can have many intrinsic (social, biological, . . .) goals which extend beyond the limits of the act itself (Huizinga 1950). Furthermore, users of emergent systems can be challenged to form their own (short or mid term) goals through open-ended play (Rogers and Price 2004; Hopma et al. 2009; Seitinger 2006; Reidsma et al. 2012). Morrison et al. discuss that *"a successful open-ended interactive environment is one that promotes or requires exploratory behaviour from the participants"*. Also, the output from the environment should arouse curiosity and require investigation to 'figure out' how it works (Morrison et al. 2011).

An early example of emergent game play in a digitally enhanced environment is *Dancing In The Streets* (Palmer and Popat 2008). This installation consists of a top-down projection onto a public space that is monitored by an infra-red (IR) camera. The IR camera detects the movement and actions of the users, which are then translated into a visual response of the system in the projection. The projections themselves do not have explicit goals and do not define the rules of the game. The explicit goal of this installation is to seduce passers-by to interact with the installation in a playful manner. However, the users can, and apparently do, create their own emergent games through the interaction with the installation and each other.

5.2.3 Technology for Interactive Playgrounds

The technology that can be used for building interactive playgrounds is virtually unlimited. One of the first outdoor playground implementations incorporating interactive technology was the *Playware* playground. It consisted of tiles containing sensors, LED's and/or loudspeakers, plus processing capabilities to allow one to configure multiple tiles into different games (Lund et al. 2005). The *Interactive Pathway* (see Fig. 5.1) is a railway like construction consisting of two wooden beams with a series of narrow pressure-sensitive mats connecting them (Seitinger et al. 2006). On the wooden beams, "spinning tops" were placed, hand crafted by the children themselves. When a child steps on a mat, a motor causes one of the spinning tops to rotate. Evaluation showed that these quite simple interactions led to a wide range of open-ended play behaviour from the children.

Fig. 5.1 The interactive slide (*left*) and the interactive pathway (*right*)

Later interactive playground projects have often been based on the projection of interactive graphics on the environment, in combination with camera input (mostly reacting to location and gross motion of participants). In the *Interactive Slide* (see Fig. 5.1), a display is projected on a large, inflatable slide (2009). The projection area is monitored by an IR camera, which allows for interactivity between the slide's users and the projection. The games designed by Wyeth et al. (2011a, 2011b), the Dancing in the Streets project (Palmer and Popat 2008), and many other playgrounds, similarily use projections of responsive visualisations to generate interaction with users. Other projects are focused around tangible playground objects. For example, the *Swinxsbee* was developed as a shared play object to allow for new types of games (Jansen and Bekker 2009): evaluation showed that using a shared play object increased social interaction amongst children (games that require a lot of physical activity, however, might suffer a negative influence on the amount of social interaction). *Flash-Poles* (Sturm et al. 2008; Bekker et al. 2007) are interactive poles, placed on a fixed position on a field, meant for flexibly developing many different simple game concepts. User tests indicated that such games were successful in stimulating both cooperative and competitive physical play amongst children. The authors touch on an important paradoxical issue in the design of installations for open-ended play: The interactive behaviour of the objects needs to be understandable for the children, but too many and too specific rules limit the possibilities for open-ended play. *Space Explorers* are a new category of autonomously moving playground props that allow children to explore the space around them in a playful manner (Seitinger 2006). The prototype consists of a ball which moves around autonomously in a space, while interacting with the children present in the space. Children keep interacting with the ball as it moves around the space, such that they gradually discover the space around them. This shows there is potential for such playground props as mediating objects between a child and its play setting.

5.3 Project Goals

The previous section shows that there has been extensive research on the development and evaluation of interactive playgrounds. However, the *design process* for interactive playgrounds is a topic that has received relatively little attention so far and has thus remained rather ad-hoc.

Our vision of an ideal interactive playground features the best of two worlds: the open-endedness, social interaction and physical exercise found in traditional outdoor play, and the exciting and virtually limitless interaction possibilities provided in modern computer games. It should actively stimulate the development of children's physical, social and creative skills, without forcing game specific rules upon them (i.e. emergent gaming).

Although goals like these have been addressed in previous work, a structured method to proceed from these goals towards the design and implementation of an interactive playground that fulfils them has been lacking so far. We aim to fill the gap between these high-level goals and the very specific user-system interactions that form an interactive playground. We believe that such a structured approach not only helps to meet these goals, but also simplifies the design process.

The project focuses on children in the age group between 8 and 12 years old. These children are able to perform advanced physical activities, define games rules and socially interact with each other (Del Alamo 2004, p. 226; Schenk-Danzinger 1977, p. 251–252). Furthermore, they are capable of actively taking part in evaluations involving group discussions and interviews.

5.4 A Taxonomy for Playground Play

Our goal was to design an intelligent, interactive playground, based on elements of *traditional children's (outdoor) play*. In order to design our interactive playground using elements of traditional children's play, we need a taxonomy to describe these elements in a structured way. For this, we draw from related work in interaction design, we introduce the idea of *Gamespace* in playgrounds, and finally elaborate our taxonomy based on an analysis of many types of traditional playground play.

5.4.1 Play, Games, and Playgrounds

Huizinga, in the book *Homo Ludens*, argues that it is almost impossible to capture the properties of *play* in a single definition. Because the act of play does not necessarily have a goal and is by definition not bound to rules, almost any act could be considered an act of play (Huizinga 1950). Games are a more formalized and strict form of play. "*The game has a beginning, a middle, and a quantifiable outcome at the end. The game takes place in a precisely defined physical and temporal space of play. Either*

Fig. 5.2 Examples of traditional children's games: playing with marbles, running the hoop and the skip rope. (Cornelisz 1837, pgs. 3/33/36)

the children are playing Tic-Tac-Toe or they are not" (Salen and Zimmerman 2003, p. 25). Open-ended play can evolve into a game over time, as players try to enforce certain play behaviour by defining rules and limitations.

Children's games often require few attributes, consisting of little more than some simple toys, the players themselves and their creativity (Soute et al. 2009). They often require physical activity and can be played with basic materials which can be carried along (hoop, ball, stick). Finally, the rules of such games are often few and simple, adaptable by the players themselves. Whether a stick is to be used for hitting, drawing or waving is up to the children inventing their game. The simple rules make the games very accessible and easy to understand for anyone eager to join a game, and make it easy to adapt a game by replacing, removing or adding a rule. It also makes it easy to convey these games from generation to generation. Sometimes, simple games—made-up by children themselves—can even have a higher appeal to them than more complex and predefined games (Bekker et al. 2008, Fig. 5.2).

Although play is potentially always and everywhere possible (Wigley 1998), most societies know the concept of *playground* as an environment specifically designated for play. The space may contain one or more playground artefacts. Traditional playground artefacts do not offer feedback and do not actively interact with the user. For example, a slide is often a rigid wooden structure which just 'sits' there in a playground. However, its presence within the playground allows for a number of ways to interact with it (climbing up the slide, sliding downwards, hiding beneath the slide), and children, when incorporating the artefact in their play, may assign any meaning to it when it fits their current play.

5.4.2 Elements From Related Work in Interaction Design

Soute et al. (2009) and Sturm et al. (2008) address a number of key issues for the successful design of Head Up Games and intelligent, interactive playgrounds of open-ended play:

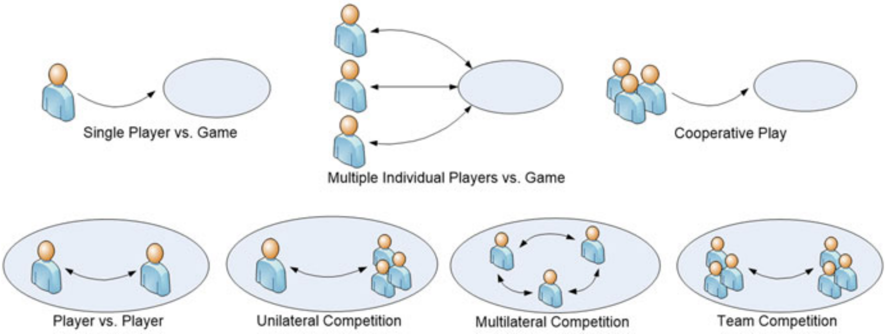


Fig. 5.3 The player interaction patterns from (Fullerton et al. 2004, p. 46)

A **Physical activity**: a playground should allow for physical activities such as running and climbing.

B **Social interaction**: playgrounds should not only provide a possibility for physical development, but also for social interaction between the children. One way to provide possibilities for social interaction, is to facilitate different player interaction patterns. A more detailed view on this issue is provided by Fullerton et al. (2004, p. 46). They defined seven different player interaction patterns (see Fig. 5.3) that describe the interaction between the players and the interactive system. Social interaction between the players could be enhanced by facilitating competitive or cooperative play.

C **Simplicity**: children need to be able to use the playground straight away.

D **Flexible and adaptable rules**: this issue does not, or in a lesser sense, apply to the development of an interactive playground aimed at open-ended play. Predefined rules should not be part of a playground designed as an environment for open-ended play. However, players might still create their own rules within the interactive playground.

E **Challenge**: the playground should be interesting and challenging to both novice and experienced playground visitors.

F **Goals**: providing goals to the children can help to keep up the challenge of the playground and keeps it interesting for a longer period of time. However, when we want children to come up with games by themselves it seems a mistake to provide them with goals. After all, the essence of open-ended play is that players themselves invent their own games, including corresponding goals. Still, it remains important to provide children with the *possibility* to define their own goals.

G **Feedback**: naturally, an interactive playground should provide feedback, as it is an interactive system. The feedback provided should be clear and understandable by the children, to show them that their actions and intends have been understood by the system.

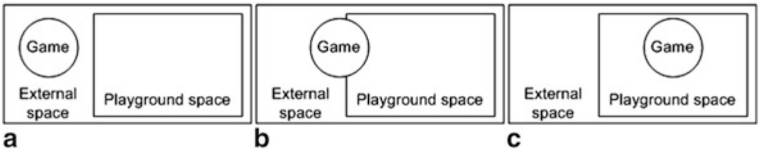


Fig. 5.4 Gamespace levels. **a** Fully external **b** Partially contained **c** Fully contained

H **Fun**: many pervasive games have an educational goal, which seldom makes it fun to repeatedly play those games. Playgrounds should primarily focus on a fun experience, such that children will keep returning to them.

5.4.3 Gamespace

We introduce *Gamespace* as a one-dimensional measure defining to which degree an act of play, or a game, is related to the play-environment or playground in which it occurs. We define gamespace (see Fig. 5.4) on a continuous scale on which three global levels can be defined, independent of the level of "open-endedness" exhibited by the playground play:

- *Fully external*: the playground is irrelevant to the game, except as the location where it takes place. For example, children throw a ball back and forth without looking at, or making use of what is in the playground.
- *Partially contained*: the game is not mainly dependent on the playground, but incorporates elements of the playground. For example, the children play cops and robbers, and use the climbing frame as the robbers' home base.
- *Fully contained*: the game takes place entirely within the playground. For example, the children are swinging or using the seesaw.

We aim to merge traditional children's play and modern computer gaming into an interactive playground. Ideally, a passer-by would see children playing together, and only with a closer look would discover that the playground is technologically enhanced. In a similar fashion, the children playing on the playground would incorporate elements of the interactive playground in their play, but would not let the digital enhancements overshadow their play. Ideally, the games played within the playground would be *partially contained*. They should be stimulated and facilitated by the playground, but not be fully dependent on it. Partially contained play is open-ended, but supported by and enhanced through the play environment. It fits exactly in between the two worlds of traditional children's play (which is usually open-ended, but limited in its interactivity) and computer gaming (which usually provides rich interaction, but is often rule-bound).

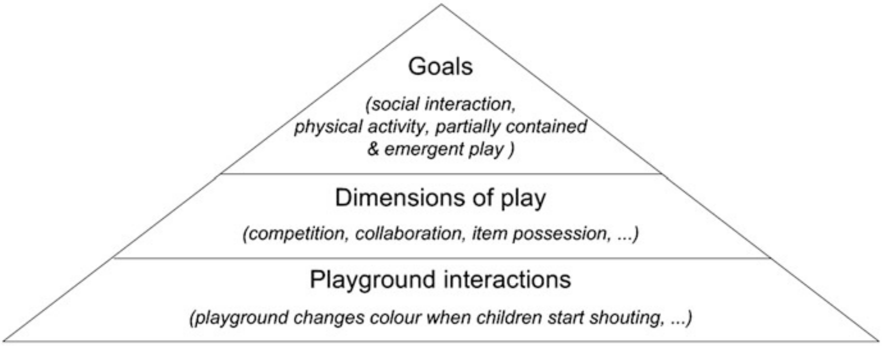


Fig. 5.5 Playground interaction design levels

5.4.4 A Design Taxonomy for Playgrounds

Based on the key issues described above, we define our taxonomy in three layers (see Fig. 5.5). The **top level** concerns our main goals: we want to develop playgrounds that (1) encourage social interaction, (2) encourage physical interaction, (3) lead to *partially contained* play, and (4) support emergent game play.

At the other end of the spectrum, the **bottom level** of our taxonomy is made up of a set of single specific interaction patterns between children and the (enhanced) playground. An example of a single interaction is the playground responding to shouting children by changing the colour of the playground's surface, or a little robot following the player that is the most quiet.

To bridge the gap, we analysed a large number of traditional outdoor children's games. From this analysis we constructed a set of 20 *dimensions* that are key to the analysed games and make up the **intermediate level** of our taxonomy. On the one hand, incorporating these dimensions in a playground supports our top level goals. On the other hand, it is feasible to derive specific interaction patterns for these dimensions, in a way that is abstract enough to allow for emergent game play in which the children themselves determine the rules and the meaning of the specific interaction methods.

1. **Player interaction pattern**: the dominant player interaction pattern (according to Fullerton et al. (2004) associated with the game. This dimension has a strong relation with key issue B (social interaction).
2. **Physical skills**: the amount of physical activity involved in the game. This is a higher level dimension, directly related to key issue A.
3. **Social skills**: the amount of social activity, through conversation or other forms of communication, involved in the game. This is a higher level dimension, directly related to key issue B.
4. **Creative skills**: the amount of creativity involved in the game. Somewhat related to key issue E, as greater challenge often stimulates creativity.

5. **Tactical skills**: the extent to which tactics can be applied to the game. In other words, whether players can plan for attaining a particular goal. Related to key issues E and F.
6. **Is finite?**: whether the game is limited by some intrinsic rule or condition. Is part of key issue F. At a first glance, this dimension seems to be incompatible with our goal of creating a play environment that supports emergent play. After all, we don't want to impose pre-defined rules on the children's play. Rather than imposing pre-defined goals, one can design system wide state changes. E.g., changing the overall visual theme at specific time intervals, or in response to certain triggers. Such a system wide change *can* be interpreted by the children as a state change of the whole game play—i.e., the end of a game, or the start of a new level or phase.
7. **Has goal?**: whether the game has a concrete and defined goal. Directly related to key issue F. In a similar fashion as the previous dimension, one should not incorporate explicit goals into the design of an interactive playground supporting emergent play behaviour. However, one can design interactions that allow players to set their own goals, for example by introducing system responses that the players might interpret as a consequence of their actions (sounds, animations, ...). Players are then free to interpret these consequences as rewards or punishments, Take for example a playground that plays a sound when a player steps on a particular tile. In this case, a player's goal could be to step on as many of these tiles as possible, but equally well a player could try to avoid stepping on any of these tiles.
8. **Is competitive?**: whether competition plays a role in the game. This is a dimension which is strongly related to dimension 1, because competition is only possible in non-cooperative player interaction patterns. Is listed separately because of its importance in many games. Non-competitive games are either collaborative, or individually played games.
9. **Single/multiplayer**: whether the game can or needs to be played by multiple players. Is part of dimension 1. This dimension bears an obvious link to one of our goals (social interaction), since preventing multiplayer use of the playground could lead to a lack of social interaction. At the same time, interactions can be designed such that a playground does not respond to actions of more than one player. This could cause play behaviour to become single player, but equally well it could be cause for competitive play (i.e. who 'owns' the playground?).
10. **Amount of space required**: the amount of space required for the game, ranging from low (a few square meters) and medium (size of a playground) to high (area of a residential block). Related to key issue A, since the amount of space available can severely influence the amount of physical activity that is possible within a playground.
11. **Element of chasing?**: whether chasing other players is a factor in the game. Is situated between dimensions 1 and 2.
12. **Player's visibility is essential part of the game?**: whether the visibility of a player can have a determining influence on the outcome of the game.

13. **Promotion/degradation system**: whether the game contains a promotion/degradation mechanism. That is, whether players can achieve a higher (social) status or ranking through playing the game. This dimension is related to both key issue B and F, as a promotion/degradation mechanism creates social hierarchy and allows for goal setting (attaining the highest 'level'). Note that interactions that are based on this dimension should not strive to make a player's status explicit (e.g. showing points). However, a playground could be designed such that players bear different (virtual) features (e.g. different colours assigned to players). Players can then attribute these feature differences to a player's status, and strive to obtain an equal set of features for themselves.
14. **Player can be 'game over'**: whether a player can lose or not win the game. Loosely associated with key issue F.
15. **Time limit**: whether the game is strictly limited in time. Is a specific case of dimension 6.
16. **Sound plays a role**: whether sound plays (or can play) a determining role in the game.
17. **Physical contact between players required**: whether players need to touch, hit, kick, etc. each other. A specific case of dimension 2.
18. **Requires extra (physical) items**: whether the game needs any physical objects such as a ball or rope. Play environments that allow players to bring in their own physical objects and are able to incorporate these objects in their interactive behaviour, could provide an opportunity for emergent play. Incorporating physical objects might also increase the amount of partially contained play, since the focus of the play might shift to the objects themselves, rather than the playground *per se*.
19. **Shared/individual items**: whether there are item(s) required for the game that are shared amongst all players, or 'owned' by individual players. Item possession may become a matter of 'status' and hence a goal (see next dimension), thereby leading to social interaction and physical chasing/running around. To achieve this, the system needs to (a) contain items that (b) can be 'attached' to someone.
20. **Item possession is a (sub)goal?**: whether the possession of an item is a goal of the game itself. Is a specific case of dimensions 7 and 19.

The dimensions that are listed here, form a bridge between the high-level, abstract goals and concrete interactions implementing these goals. These dimensions are abstractions of the interactions that are found in the games that have been analysed. Such dimensions provide a valuable tool for designing for open-ended play in interactive, intelligent playgrounds.

5.5 A Novel Approach to Interactive Playground Design

Although a lot is known about key issues for interactive playgrounds through evaluation studies of various prototypes (cf. the sections above), a fully structured method leading from a playground concept to interactions for a working prototype is still lacking. This section aims to fill this gap by introducing a novel approach for interactive playground design that results in a tight integration of traditional children's play and modern computer gaming, by systematically using the dimensions introduced above for generating and improving interaction methods.

5.5.1 Concepts

The method starts with *Concept Generation*. This phase aims to arrive at an overall 'story concept' that will drive the design (Schell et al. 2008, p. 49–53). First, a number of candidate 'story concepts' are described. Out of these, one concept is selected for further development, choosing on the basis of suitability for open-ended play: the concept must be concrete enough to be able to derive possible interactions from it, but it should not be so concrete as to block the children from evolving their own play in the playground. For example, a story concept might centre on "make a playground that is like a giant complex machine with moving parts", or "make a playground inhabited by many creatures".

5.5.2 Interaction Methods

The story concept sketches the rough contours along which we can design the playground's interactions. The second phase is to *develop single Interactions* that children can have with the playground. For each of the 20 *dimensions* determined earlier, a single interaction possibility is designed. An interaction may be related to more than one dimension, but at least we make sure that every dimension is related to at least one interaction. For example, an interaction, related to dimension 16 (see 5.4.4), might be "If you step on a spinning gear in the machine, it will start making a noise".

5.5.3 Systematic Variation on Interaction Methods

The third step in the design process is one of *Systematic Variation*. In this phase, every interaction developed during the previous phase is analysed along all 20 dimensions. Wherever possible, a new interaction is derived by adding the dimension if it was not yet present in the interaction, or by inverting the role of the dimension, if it was. Taking the example from 5.5.2, an interaction resulting from this phase could be "If you and at least one other player step on a spinning gear in the machine, it will start making a noise". While the interaction bears a clear link to the original, it has been extended with a social component (dimension 3, see 5.4.4).

By structurally creating varied instances of the initial set of interactions, this phase adds yet more structure to the design and yields a vastly more extensive set of interactions. The extended set of interactions will have a better coverage of the various dimensions, and therefore of the four abstract goals.

5.5.4 Selection

The final step in the design process is the *Selection* of interactions which will be implemented. Because the previous phase will tend to create numerous contradicting and opposing interactions, selection is not a trivial task. Criteria to guide the selection process, besides practical reasons of feasibility, are: (1) Which dimensions are covered by the selected interaction methods? (2) Do the chosen interactions form a balanced system? If there are, for example, mechanics for introducing new (virtual) objects into the playground, there should be mechanics for reducing their amount as well, to avoid clutter.

5.6 Case Study

Using the design approach summarized above, we developed an interactive playground and evaluated it in a user study with 19 children.

5.6.1 Concept Generation

The initial story concept was as follows:[1]):

> The playground contains an ecosystem that is populated with a range of strange shapes. Players can interact with shapes on both the level of the ecosystem, as well as with individual shapes, and shapes can interact with their peers.

5.6.2 Interaction Generation

An initial set of 20 interaction methods (at least one for each dimension) was derived from the initial story concept. An example interaction is shown in Fig. 5.6 (IM2). This interaction describes that physical contact between two players triggers the 'birth' of a new shape. This interaction has been designed to satisfy the need to cover dimension 1 (Player interaction pattern). In this case, the envisioned player interaction pattern for this interaction is one of collaborative play.

Another example interaction is shown in Fig. 5.7 (IM16). It describes that the tail of shapes that follows player B will break once another player runs across it. Naturally, it provides an element of competition and has potential influence on a player's status.

[1] cf. http://hmi.ewi.utwente.nl/showcase/anemone-emergententertainment/.

IM22. **Initial situation:** Two or more players with a ball within the playground
Action performed: Two players let their balls touch for a moment
System reaction: Tails of both players switch owners
Rationale: Competitive element as opposed to original (2)
Variation on: 2

Fig. 5.6 IM22 is a variation on IM2; collaboration becomes competition

IM47. **Initial situation:** Players A and B (both with ball) within the playground
Action performed: A runs fast over B's tail
System reaction: An extra shape is added to B´s tail
Rationale: Element of collaboration, social skills, physical exercise, opposite of original interaction (16)
Variation on: 16

Fig. 5.7 IM46 and IM47 are variations on IM16; IM46 adds a tactical element to the original interaction, while IM47 turns the originally competitive interaction into a collaborative one

Both of the described interactions cover more than just a single dimension. Still, all dimensions that have been listed before, have been covered by at least one interaction within the case study.

5.6.3 Systematic Variation

Systematic variation of the initial set of 20 interaction methods resulted in 32 additional interactions. Full details can be found in (Tetteroo 2010); we only mention some examples of variation. The variation in Fig. 5.6 (IM22) shows a different system response compared to the original interaction: the players' tails switch owners, causing collaborative play to become competitive play. As the example shows, inverting the result of an interaction can lead to completely new dynamics.

Two other examples of variation are shown in Fig. 5.7. Where the original interaction provides a means for competition, the variation of IM46 creates an additional, tactical layer. In essence, the result is equal to that of the original interaction. However, a player now has to plan his actions more carefully, adding a tactical component to the original interaction. Another variation of the original interaction is given by IM47. Instead of competition, the variation fosters collaboration and social skills. If players collaborate, at least one of them might benefit from their interaction. If both players would want to profit from their interaction, they have to negotiate return-of-favor; this is where the players' social skills are addressed.

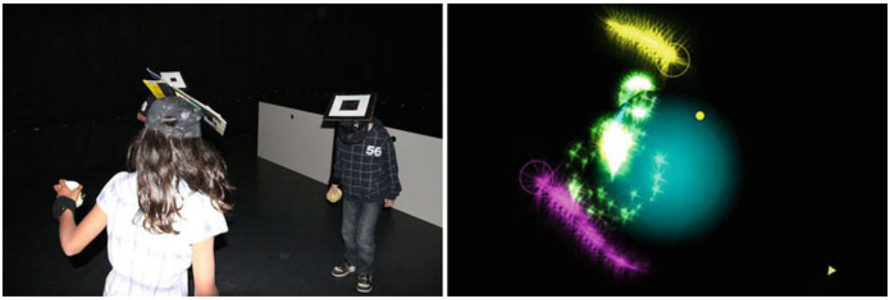


Fig. 5.8 The interactive playground

5.6.4 Selection

Of the 52 interactions resulting from systematic variation, 13 were implemented in our playground. The playground interactions are centered around shapes that normally lead a life floating around the playground freely, but which can be captured by players who chase them. Captured shapes follow a player in a tail, but can also be stolen by other players that chase the tail for a while. Players can create new shapes by standing together, and destroy each others' shapes by running through another player's tail. Each player can, by shaking a ball (s)he carries, create a pool of poisonous venom that destroys other players' shapes. All of these actions influence a player's status, which is expressed by the size of a circle projected around them (Fig. 5.8).

5.6.5 Implementation

The interactive playground described in the previous sections has been implemented in the SmartXP laboratory of the University of Twente. This laboratory consists of a large hall with rigging equipment which can be raised or lowered. The technical implementation of the interactive playground favoured a relatively dark environment, so we created a dark 'cubicle' by using black curtains. The floor area of the cubicle was 6 x 6 m, its height 4 m.

5.6.5.1 Hardware

The playground was implemented with a—for these kind of projects typical— setup consisting of a projector and an infrared camera. The top-down projection made it possible to display a virtual world on the playground floor. The players' positions were tracked by the infrared camera, filming reflective markers mounted on the children's heads. Both the players and small foam balls which were handed out to them, were equipped with Sun SPOT sensors (Tetteroo 2005).

5.6.5.2 Software

The incoming video data of the playground was continuously analysed by using the ParleVision software[2]. The output of the analysis was the position of the various players within the playground. Acceleration data from the Sun SPOTs within the foam balls and those attached to the players' wrests were compared, to determine when a ball is shaken and by whom. All input was processed by a Java application which generated the visual output for the playground by using the JMonkey 3D library[3]. The software adjusted the behaviour of the shapes and items within the virtual playground according to the designed and chosen interactions.

5.7 Evaluation

The described playground had been designed to feature possibilities for social interaction as well as physical play. Additionally, we aimed at providing a play environment that would stimulate play that is partly-contained contained in the playground's gamespace (see 5.4.3). The goal of this evaluation was to explore the feasibility of using the proposed design method for creating such an interactive play environment. This evaluation should thus be regarded as an exploration of the proposed design method, rather than a validation.

5.7.1 Methods

5.7.1.1 Experimental Design

The evaluation consisted of sessions lasting approximately one hour, in which groups of children would be invited to play in the playground. The group sizes that participated in the evaluation varied from two up to four children. For the comfort of the children involved, the group sizes were adjusted to their age, and wherever possible friends were clustered into a single group (Markopoulos et al. 2008).

Every evaluation session started with an explanation of experiment's procedure to the children, and time to answer questions concerning the experiment. Nothing however was told to the children about the interaction possibilities of the playground. Then they were equipped with a marker for the playground's tracking system, a Sun SPOT sensor and a sensor equipped ball. A first 10-min exploration phase gave the children the possibility to explore the playground and its interactions by themselves. After the initial phase, the children were called back from the playground, to receive an explanation about some key interactions that were possible within the playground. Then, a second 20-min phase was started to identify whether playground behaviour

[2] http://hmi.ewi.utwente.nl/showcases/parlevision.
[3] http://www.jmonkeyengine.com.

changed significantly once the children were explained about some of the possible interactions. The interactions that were explained to the children, were:

1. Each player within the playground is followed by a coloured circle.
2. Shapes in the playground flee when players become more active.
3. Shapes can be caught by following them for a short period.
4. By standing with at least two players in the middle of the playground, a ‘nutritious well’ can be activated that sparks the creation of additional shapes.
5. By shaking a players ball, that player would receive a ‘guardian creature’.

After the second play-phase, a debriefing interview was conducted with each participating group. These interviews were conducted group-wise, to create a more natural context for children to be interviewed in (Eder and Fingerson 2002).

5.7.1.2 Measures

A modified version of the OPOS observation scheme (Bakker et al. 2008) was used to record observations along the main goals defined in Sect. 5.4.4 (physical activity, gamespace & social interaction). Additionally, a system-log was kept that recorded when an interaction was triggered by one of the children, what interaction was triggered, and who triggered the interaction. The log was kept to be able to link player behaviour to system events (such as triggering of interactions). No separate analysis was performed on the log data, since the evaluation’s goal was to investigate player behaviour rather than system behaviour. The fact that an interaction had been triggered would not imply that this interaction had actually influenced the children’s play, for example because the results of the interaction were not noticed by the players. Finally, semi-structured group interviews were conducted to collect data about the children’s awareness of the interaction possibilities, their general experience of being in the playground, as well as remarks for improvements.

5.7.1.3 Data Gathering Process

All playground sessions were video-taped with two synchronized infra-red video cameras, filming the playground from two different angles and covering the entire playground space. All videos have subsequently been coded with the OPOS observation scheme. Annotations have been performed group-wise during all sessions. That is, if three players from a group were running around wildly and one player was standing still, the *physical activity* tier for that instance would be labelled *intense physical activity*.

5.7.1.4 Demography

Nineteen children (10 male, 9 female) from three daycare centres in the region of Enschede, The Netherlands, have participated in the evaluation. Their age varied between 6 and 11 (Mdn = 8, SD = 1.57).

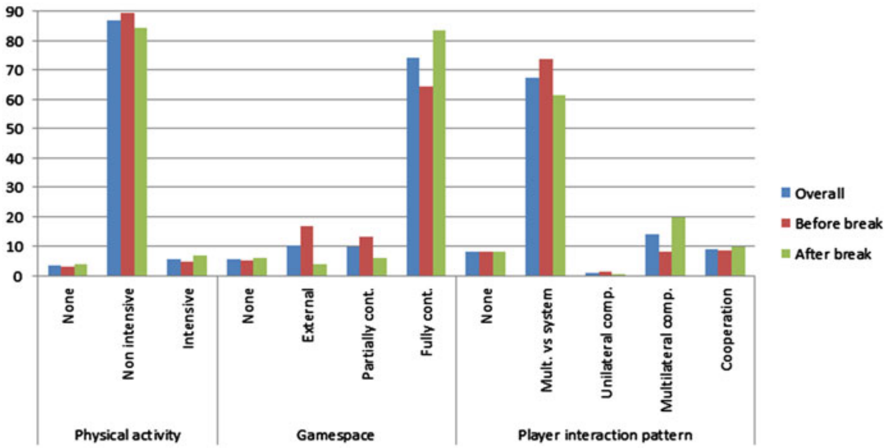


Fig. 5.9 Observations collected with the modified OPOS observation scheme. (Average number of instances per session)

5.7.2 Results

5.7.2.1 Gamespace

Most instances of play that were observed during the evaluation, were strongly related to the children's presence in the playground (fully-contained, see Fig. 5.9, M = 74.07, SD = 26.137). Examples of play that was observed are:

- *steal-the-shapes*: children would steal shapes from other players to get a longer tail of shapes.
- *scare-the-monster*: children would try to scare away the predator shape that sometimes appeared within the playground.
- *switch tails*: children would try to steal each other's circle and tail. Sometimes they would steal a circle for its colour, sometimes for its size or tail length, sometimes just because it annoyed the other players.

In most sessions play became increasingly contained in the playground's gamespace *after* the mid-session break. Before the break, players from these sessions played many games outside the playground's gamespace (for example: throwing a ball). Once the interactions had been explained to the children during the break, they started to explore these interactions such that the level of fully-contained play increased (non-significant; $t(6) = -1.520$, $p = 0.179$).

Partially contained games (such as chasing another player with the 'added benefit' of gaining his shapes) were observed rather infrequently (M = 9.86, SD = 10.918), and mostly only at the end of an evaluation session.

A final interesting observation on the amount of containment in the children's play, is that the games played sometimes gradually moved in their level of gamespace.

For example, sometimes play starting as *fully external* (e.g. parading around the playground) gradually converted into *partially contained* play (e.g. chasing a player with a particularly coloured circle).

5.7.2.2 Physical Play

During most sessions the physical activity of the children was at a non-intensive level (M = 86.93, SD = 13.931). Although children would occasionally perform intense activities (M = 5.79, SD = 8.64) such as running, jumping and sliding, the most observed behaviour included non-intensive activities such as walking, throwing and shaking. Passive behaviour, involving no physical activity was observed only rarely (M = 3.57, SD = 3.797).

5.7.2.3 Social Interaction

In all sessions, the most frequent observed player interaction pattern was *multiple individual players versus game* (Fullerton et al. 2004) (M = 67.5, SD = 15.426). In other words, players would spend most of their time within the playground interacting with the playground itself, instead of with other players. Note that this does not imply a lack of communication between the players. Typical player behaviour for these situations included walking around the playground and discovering new interaction possibilities, while making remarks about things happening in the playground's visualisation. These remarks were often not directed to anyone in particular, but would nonetheless sometimes cause responses from other players. The social nature of the play that was observed in the before-break and after-break sessions showed a significant difference. Competitive and cooperative play behaviour increased significantly when comparing the before-break observations (M = 16.86, SD = 9.263) with the after-break observations (M = 29.57, SD = 5.028); $t(6) = -5.156$, $p = 0.002$.

5.7.2.4 Concluding Group Interviews

Concluding interviews with the children indicated that they were very fond of the interactive playground and were willing to give up computer gaming time to play in the playground.

5.7.3 Discussion

The evaluation has shown that through the design method described earlier, an interactive environment was created that elicited playful behaviour by children participating in this evaluation. It has also highlighted difficulties that arise when designing for open-ended play, such as ensuring that the interactions that a playground offers do not entirely determine the playful activities taking place in the playground. The relative abundance of fully-contained play that was observed during this evaluation might have been caused by the novelty of the playground, which incited children to first focus on exploration of the playground's possibilities. It is however likely that other factors, such as the physical setup of the playground, had a larger impact on the play behaviour exhibited by the children. This means that the design of interactions should consider more than just the playful quality of an interaction as such, by incorporating the relation between the interaction and the context in which it is being deployed in.

Another factor that could have been of influence on the behaviour exhibited by the children during the evaluation is that, although their participation was voluntary, it was also planned for. In other words, it remains unknown what effect the playground would have had on their behaviour if it had been placed in an environment more natural to the children (e.g. their school). Interesting questions remain, such as: What is the effect of passers-by on the play behaviour? What external objects would children bring into the playground and incorporate in their play? To which extend does the playground actually seduce passers-by to start playing?

Finally, the design method that has been presented in this chapter features 20 dimensions of play that can be considered in the design of an interactive playground. Since these dimensions originate from an analysis of a large, albeit limited set of traditional children's games, it is possible that with an even more extensive analysis more dimensions could be identified. However, it is questionable whether such an extension would lead to 'better' interactive playground design, since the dimensions should be considered a design tool, rather than a prescriptive list.

5.8 Conclusions & Recommendations

This chapter presented a novel and systematic design method for interactive playgrounds based on traditional children's play. Through systematic analysis of a large number of traditional children's games, a set of 20 dimensions that form the essence of these traditional games have been distilled. These dimensions allow the designer to concretise high-level project goals (such as stimulating social interaction, and physical, partially contained and emergent play) into individual interactions that make up the core of an interactive playground.

To explore the proposed design method, an example playground was designed, implemented and evaluated in a user study with 19 children. The results indicate that the proposed design approach can influence the type of play occurring within a playground, but that other factors (such as playground size and novelty) may play an important role as well. Nevertheless, the proposed design method helps bridging the gap between an interactive playground's abstract goals, and concrete interactions that influence play behaviour.

Acknowledgements This project has been made possible by support from the Dutch national program COMMIT, and by the friendly collaborators from the daycare centres who participated in the user tests. This chapter is a revised and extended version of a paper presented at the International Conference for Intelligent Technologies for Interactive Entertainment 2011 in Genua, Italy.

References

Bekker, M., van den Hoven, E., Peters, P., & Hemmink, B.K. (2007). *Stimulating children's physical play through interactive games: Two exploratory case studies*. Proceedings of IDC '07, pp. 163–164. ACM, New York, NY, USA. doi:http://doi.acm.org/10.1145/1297277.1297313.

Bakker, S., Markopoulos, P., & de Kort, Y. (2008). OPOS: An observation scheme for evaluating head-up play. In NordiCHI'08, pp. 33–42. doi:http://doi.acm.org/10.1145/1463160.1463165.

Bekker, T., Sturm, J., Wesselink, R., Groenendaal, B., & Eggen, B. (2008). *Interactive play objects and the effects of open-ended play on social interaction and fun*. Proceedings of ACE '08, pp. 389–392. ACM, New York, NY, USA. doi:http://doi.acm.org/10.1145/1501750.1501841.

Cornelisz, J. H. (1837). Kinderspelen, in leerzame gedichtjes. Amsterdam: Ten Brink en De Vries.

Del Alamo, M. R. (2004). *Design for fun: Playgrounds*. Spain: Links International

Eder, D., Fingerson, L. (2002). Interviewing children and adolescents In J. Gubrium & J. A. Holsetin (Eds.), *Handbook of interview research* (vol. 1). Thousand Oaks: Sage.

Fullerton, T., Swain, C., Hoffman, S. (2004). *Game design workshop: Designing, prototyping, and playtesting games*. Waltham, Massachusetts: Focal Press.

Hopma, E., Bekker, T., Sturm, J. (2009). Interactive play objects: The influence of multimodal output on open-ended play. In A. Nijholt, D. Reidsma, & H. Hondorp (Eds.) *Intelligent Technologies for Interactive Entertainment* (vol. 9, pp. 78–89). Berlin Heidelberg: Springer. http://dx.doi.org/10.1007/978-3-642-02315-6_8 (LNICST).

Huizinga, J. (1955). *Homo ludens: A study of the play-element in culture*. Boston: Beacon Press.

Jansen, M., & Bekker, T. (2009). Swinxsbee: A shared interactive play object to stimulate children's social play behaviour and physical exercise. Proceedings INTETAIN'09, LNICST, pp. 90–101. Springer. http://dx.doi.org/10.1007/978-3-642-02315-6_9.

Jansen, W., Mackenbach, J. P., van Zwanenburg, E. J., & Brug, J. (2010). Weight status, energy-balance behaviours and intentions in 9-12-year-old inner-city children. *Journal of Human Nutrition and Dietetics, 23*(1), 85–96. http://dx.doi.org/10.1111/j.1365-277X.2009.01027.x.

Lund, H. H., Klitbo, T., & Jessen, C. (2005). Playware technology for physically activating play. *Artificial Life and Robotics, 9*(4), 165–174. http://dx.doi.org/10.1007/s10015-005-0350-z.

Magerkurth, C., Cheok, A. D., Mandryk, R. L., & Nilsen, T. (2005) Pervasive games: Bringing computer entertainment back to the real world. *Computational Entertainment, 3*(3), 4–4. doi:http://doi.acm.org/10.1145/1077246.1077257.

Markopoulos, P., Read, J. C., MacFarlane, S., Hoysniemi, J. (2008). *Evaluating interactive products with and for children*. San Francisco: Morgan Kaufman publishers-imprint of Elsevier

Morrison, A., Viller, S., & Mitchell, P. (2011). *Open-ended art environments motivate participation*. Proceedings of the 8th international conference on advances in computer entertainment technology, ACE '11, pp. 45:1–45:8. ACM, New York, NY, USA. http://doi.acm.org/10.1145/2071423.2071479. http://doi.acm.org/10.1145/2071423.2071479

Nijholt, A., Reidsma, D., & Poppe, R. W. (2009). *Games and entertainment in Ambient intelligence environments* (pp. 393–413). Burlington: Academic Press.

Palmer, S., & Popat, S. (2008). Dancing in the streets. *Interactions, 15*(3), 55–59. doi:10.1145/1353782.1353797

Reidsma, D., Tetteroo, D., Nijholt, A. (2012) Making ambient spaces into playgrounds. In A. Spink, F. Grieco, O. E. Krips, L. W. S. Loijens, L. P. J. J. Noldus, & P. H. Zimmerman (Eds.), In *Proceedings of 8th international conference on methods and techniques in behavioral research, measuring behavior 2012, Utrecht* (pp. 79–81). Wageningen: Noldus Information Technology

Rogers, Y., & Price, S. (2004). Extending and augmenting scientific enquiry through pervasive learning environments.. *Children Youth and Environments, 14*(2), 67-83.

Salen, K., & Zimmerman, E. (2003). *Rules of play: Game design fundamentals*. Cambridge, Massachusetts: MIT Press

Schell, J. (2008). *The art of game design: A book of lenses*. Burlington: Morgan Kaufmann.

Schenk-Danzinger, L. (1977). *Entwicklungspsychologie*. Wien: Österreichischer Bundesverlag.

Seitinger, S. (2006). *Animated props for responsive playspaces. Masters's thesis in Media Arts and Sciences*. Massachusetts Institute of Technology

Seitinger, S., Sylvan, E., Zuckerman, O., Popovic, M., & Zuckerman, O. (2006). A new playground experience: Going digital? In CHI'06 (pp. 303–308). doi:10.1145/1125451.1125520.

Soler-Adillon, J., Ferrer, J., & Parés, N. (2009). A novel approach to interactive playgrounds: The interactive slide project. Proceedings of IDC'09, pp. 131–139. ACM, New York, NY, USA. doi:http://doi.acm.org/10.1145/1551788.1551811.

Soute, I., & Markopoulos, P. (2007). *Head up games: The games of the future will look more like the games of the past*. In Human-Computer Interaction—INTERACT 2007, pp. 404–407. http://dx.doi.org/10.1007/978-3-540-74800-7_35.

Soute, I., Kaptein, M., & Markopoulos, P. (2009). *Evaluating outdoor play for children: Virtual vs. tangible game objects in pervasive games*. Proceedings of IDC'09 pp. 250–253. ACM New York, NY, USA.

Soute, I., Markopoulos, P., & Magielse, R. (2009). Head up games: Combining the best of both worlds by merging traditional and digital play. Personal and Ubiquitous Computers 14, 435–444. http://dx.doi.org/10.1007/s00779-009-0265-0.

Sturm, J., Bekker, T., Groenendaal, B., Wesselink, R., & Eggen, B. (2008). Key issues for the successful design of an intelligent, interactive playground. Proceedings of IDC '08, pp. 258–265. ACM, New York, NY, USA. doi:http://doi.acm.org/10.1145/1463689.1463764.

Sun Microsystems Inc. (2005). Sun spot system: Turning vision into reality. Technical White Paper on Sun SPOTs

Tetteroo, D. (2010). *Design of an interactive playground based on traditional childrens play. Masters's thesis in human media interaction*. University of Twente

Verhaegh, J., Soute, I., Kessels, A., & Markopoulos, P. (2006). On the design of camelot, an outdoor game for children. IDC '06: Proceedings of the 2006 conference on interaction design and children, pp. 9–16. ACM, New York, NY, USA. doi:http://doi.acm.org/10.1145/1139073.1139082.

Wigley, M. (1998). Constant's New Babylon: The hyper-architecture of desire. 010 Publishers, Rotterdam.

Wyeth, P., Johnson, D., Sweetser, P. (2011a). Motivating whole body gaming for people with intellectual disability. Proceedings of 4th international workshop on whole body interaction at the conference on advances in computer entertainment

Wyeth, P., Summerville, J., Adkins, B. (2011b) Stomp: An interactive platform for people with intellectual disabilities. Proceedings advances in computer entertainment.

Chapter 6
Embedded Smarthouse Bathroom Entertainment Systems for Improving Quality of Life

Shigeyuki Hirai

Abstract The phrase "Smarthouse to improve the smartness of a human's daily life" has two meanings. One is to improve individual smartness, which represents the Quality of Life (QoL); the other is to improve social smartness, which includes human communications and social consumptions. This chapter primarily describes entertainment systems that can be embedded particularly in the bathrooms of smarthouses and used by humans in everyday life to improve QoL. The systems include "Bathonify," a sonification system that reflects the bathing states and vital signs of the bather; "TubTouch," a bathtub entertainment system that uses embedded touch sensors and a projector to control various equipment and systems; and "Bathcratch," a DJ scratching music system that is operated by rubbing and touching the bathtub. Even though these systems are based on Japanese bathing culture and style, they provide advances in the pleasures of everyday life. In addition, these embedded systems and their techniques provide advances in computer entertainment platforms that can be extended to various places and situations.

Keywords Smarthouse · Bathroom · Embedded sensors · Interactive sonification · Media arts

6.1 Introduction

Food, clothing, and shelter (housing) are essential for the survival of human beings, and thus, research has been actively underway in these areas. With network-enabled household appliances now a reality, ubiquitous computing (Weiser 1991) research to enhance the convenience and comfort of everyday life in the home, resulting in the term "Smarthouse," is also actively being conducted (Mason et al. 1983; Kidd et al. 1999; Intille et al. 2005; Ruyter et al. 2005; Ueda and Yamazaki 2007; Siio et al. 2010; Hirai and Ueda 2011). Some of the research being conducted is focused on entertainment aspects and includes various ideas and systems for enjoying everyday life. To date, most of the research has focused on the living room and kitchen, where

S. Hirai (✉)
Faculty of Computer Science and Engineering Kyoto Sangyo University, Kyoto, Japan
e-mail: hirai@cse.kyoto-su.ac.jp

A. D. Cheok et al. (eds.), *Entertaining the Whole World,*
Human–Computer Interaction Series, DOI 10.1007/978-1-4471-6446-3_6,

electrical appliances are easily installed. In contrast, it is difficult to equip the bathroom to become a computing environment because the sharp changes in temperature and humidity that occur there make installation of equipment difficult. Despite this difficulty, however, a Japanese bathroom may have a variety of electronic equipment such as a heater/dryer unit in the ceiling, an external water heater, equipment for remotely controlling bathroom temperature, water temperature, and water quantity, and a speakerphone between the bathroom and the kitchen. Further, we are beginning to see other value-added amenities and equipment such as TV and audio systems, lights with dimmers, Jacuzzis, and mist generators in bathrooms. Thus, the bathroom can now be viewed as another space to bring various ubiquitous computing technologies and to enhance the everyday act of bathing so that it is more entertaining even though the equipment may depend on the Japanese bathing culture and the style of the home.

This chapter discusses a number of systems in terms of their entertainment and practical applications for the Japanese-style bathroom that are controlled via various embedded sensors. The first system discussed is Bathonify (Hirai et al. 2004), an interactive sonification system that reflects a bather's actions and vital signs while in the bathtub using an external water heater and embedded ECG sensors in the bathtub. It uses sonified sounds and music to create an amenity space in the bathroom that bathers can enjoy and other family members in the home can utilize to listen and monitor the bather's state, actions, and vital signs in real time. The next system discussed is TubTouch (Sakakibara et al. 2013; Hirai et al. 2013), which uses embedded capacitive touch sensors to convert the edge of the bathtub into a user interface. TubTouch can operate various types of bathroom equipment and also enables all age groups, from children to elderly people, to have access to a variety of entertaining applications while bathing. The final system discussed is Bathcratch (Hirai et al. 2012), which utilizes an embedded piezo sensor to enable bathers to play a DJ scratching music entertainment system by rubbing the edge of the bathtub. Works related to these three systems, their practicability as regards bathroom facilities, common grounds of all the systems, interactivity of each system, and improvements brought to Quality of Life (QoL) are subsequently discussed.

6.2 Bathonify: Sonification System to Reflect Bather's Motion and Vital Signs

6.2.1 Concept Underlying Bathonify

The goal of Bathonify (Hirai et al. 2004) is to create an amenity space that is both unobtrusive and enjoyable, and which can thus facilitate novel bath systems based on ubiquitous computing. The idea is to use bathwater as a natural ambient medium and express the state of the water through sound. The Bathonify system sonifies the changes in water level and ripples on the surface of the water as interactive sounds (sound effects and music) utilizing a water pressure sensor equipped in an external water heater. In this system, bathwater coupled with sound enables a new level of active interaction.

To further expand the expression of sound during quiet bathing (minimal movement), this system takes account of the bather's vital signs. For everyday computing, it is important for this system to show health management information such as the bather's physiological and psychological states and to keep the bather informed of those states. To collect vital signs, the system utilizes a hidden interface that unobtrusively measures these states when the bather is submerged, without attaching any sensors to the body. In addition, the system processes the sound made by vital signs such as breathing changes and heartbeats even in a quiet bathing state (no movement). One condition to keep in mind is that heartbeats tend to rise as the bathing period lengthens because of water pressure and heat stress on the body. The Bathonify system uses this tendency to correlate the music tempo with the beating of the heart. The bather can thus be aware of his/her health and changing body state through the tempo of the music.

This novel bathing environment enables a bather to experience auditory pleasure as well as monitor vital signs in an unobtrusive manner. However, it must be kept in mind that sound design is one of the most important factors in the seamless coupling of functionality and ambient media.

6.2.2 System Overview and Design

Figure 6.1 gives an overview of the Bathonify system along with the embedded features described in the previous section. The information and technology required for each feature are described below.

6.2.2.1 Measuring Movement Information

In the Bathonify system, a water pressure sensor embedded in a fully-automatic bathwater heater measures the movement of water inside the bathtub. This sensor only checks the water level periodically; thus, it is idle most of the time. By continuously measuring the water pressure, we can measure changes in the water level as well as monitor water surface ripples and dynamic pressure changes in the bathwater. This type of sensor is already present in bathing equipment and is very safe against electric shock in watery environments. The sensor itself resides inside the water heater, which provides a hidden interface out of the bather's view. We consider that a bather can influence water movement in the following ways:

1. Stir the water in the bathtub to eliminate temperature differences.
2. Ladle water from a wash bowl or a bucket (small movement).
3. Become submerged in the bathwater (resulting in the water level rising).
4. Move arms around in the bathtub.
5. Exit the bathtub (resulting in the water level lowering).

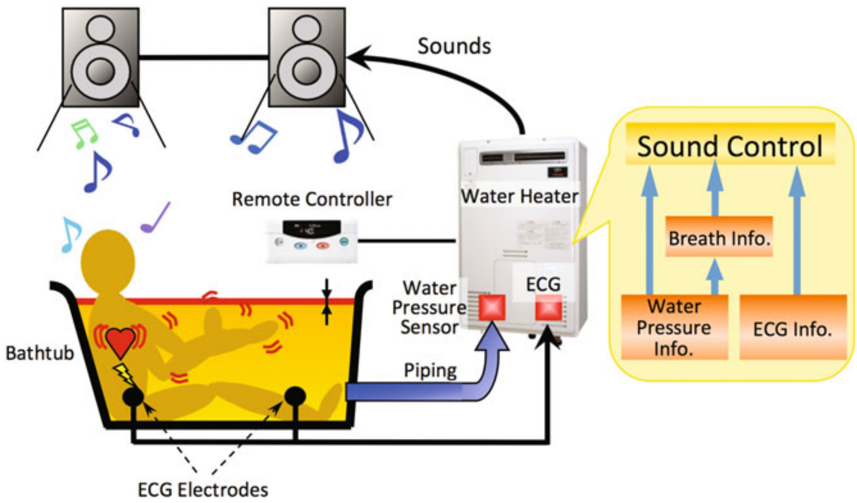


Fig. 6.1 Overview of the Bathonify system

Figure 6.2 shows the output data from a water pressure sensor (model KH0578-30 by Hamamatsu Photonics) for an actual bather based on the movements described above. The measurement data for a water heater contains circuit noise that has a higher frequency than both bather movements and water movements in the bathtub. As a result, the noise can easily be eliminated with a low-pass filter. A comparison of Figs. 6.2a and b shows that stirring the water strongly causes a large change in the pressure of the water. Figure 6.2c shows how the water pressure slowly rises as the bather enters the bath, starting from the feet and submerging the body up to the shoulders. Conversely, Fig. 6.2f shows how the water pressure is suddenly lowered as the bather rapidly exits the bath. Figure 6.2e shows that the pressure changes only a little compared to when the water is strongly stirred without a bather in the bathtub. This difference may be because the sensor cannot easily detect large stirring motions on the surface, and thus changes in water pressure, when a bather is in close proximity to the opening of the hot water supply. These measurement results draw attention to the importance of considering differences in ripple amplitude when a bathtub is occupied and unoccupied.

6.2.2.2 Measuring Vital Signs

We use the water pressure sensor to take breathing measurements. The act of breathing causes the water level to fluctuate by a few millimeters in a bathtub. Therefore, the sensor extracts information about each breath from variations in the water level. Preparatory tests showed that low-pass filter processing with a cutoff at 0.35 to 0.4 Hz gives virtually the same results as a specialized breathing measurement instrument (model AE-280 S by Minato Medical Science). Figure 6.3 compares the water volume

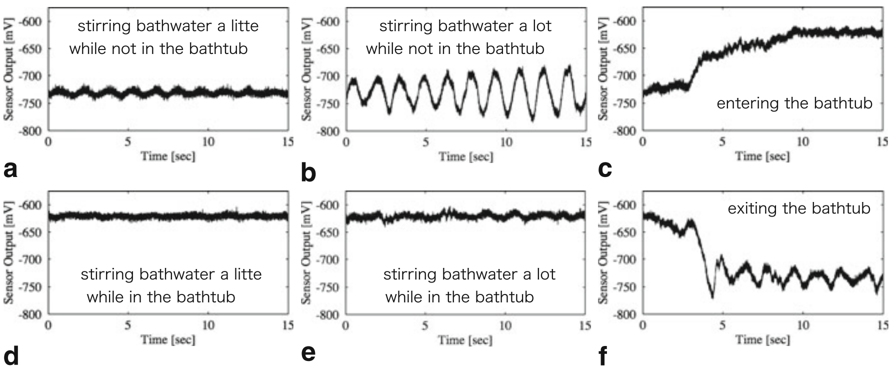


Fig. 6.2 Water pressure sensor output for each situation

to the respiration volume. The upper of Fig. 6.3 shows a graph of conversion values for the bathtub volume (including breathing volume) after low-pass filter processing of the water level values with the cutoff set at 0.35 Hz. From these values we can extract a breathing curve using low-pass filter processing and couple the breathing depth information with sound control. However, this processing only works when a person is bathing. If the water surface undulates a lot, the sensor will extract other information in addition to the breathing component. Consequently, breathing processing is limited to relatively mild undulations on the surface of the water.

This system also measures heartbeats in real time while bathing. The bathtub is a conventional bathtub with small electrodes, which provide a contactless method to measure heartbeats when a bather enters the bathtub, attached to its sidewalls. The heartbeat measurement circuit eliminates noise and samples an amplified waveform at 8 bit/kHz using an RS-232 C connection. Figure 6.4 shows an actual electrocardiogram (ECG) waveform from a bather bathing in a bathtub.

6.2.2.3 Extracting and Processing Control Information

From the movement information and vital signs, we extract the parameters and events needed to perform sound control processing. To control the type of sound, volume, and production conditions, the following states and parameters are used: entering the bath, exiting the bath, amplitude of water surface ripple, instantaneous heartbeat based on R waves, R wave height, and T wave height. To control sound production timing, events to detect triggers for R waves and T waves are used, and trigger signals for water surface ripples above a threshold value are also used. Pretreatment functions for measurement data are primarily handled by the microprocessor of the water heater unit. However, if the water heater is connected to the Internet through a home LAN, the water heater can send the measurement data to external processors for pre- and post-processing.

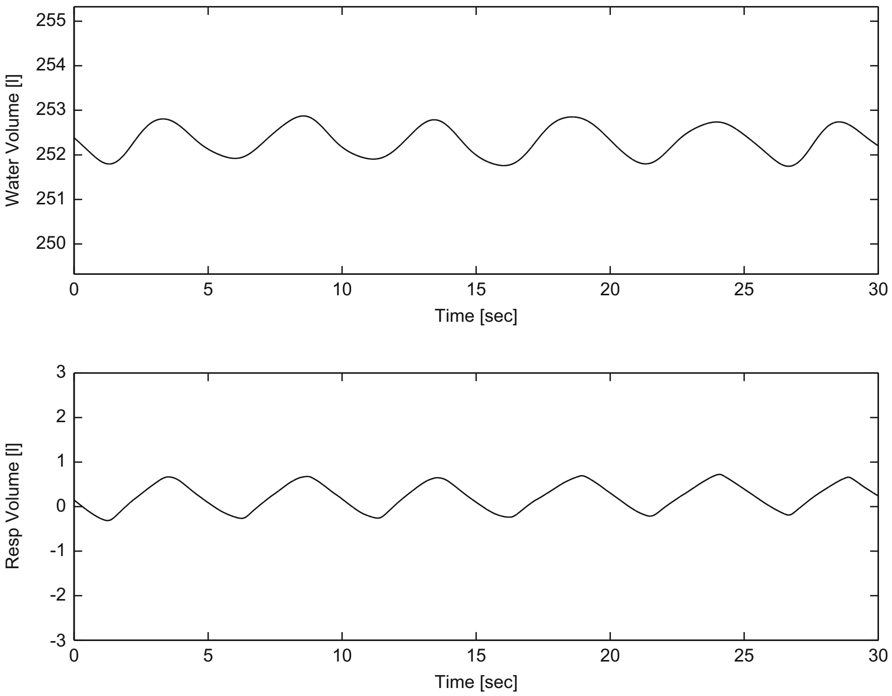


Fig. 6.3 Comparison of respiration curves (*Upper*) by water pressure, (*Lower*) flowmeter

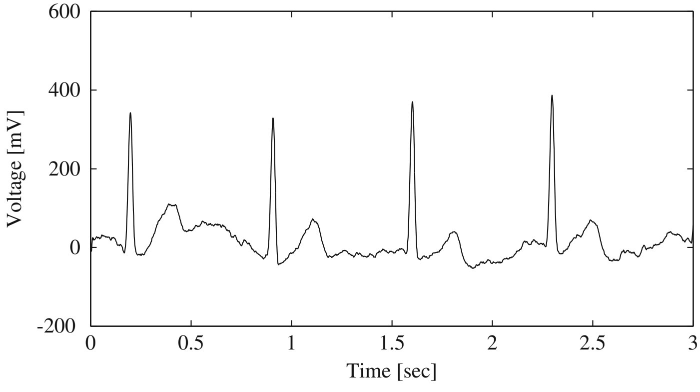


Fig. 6.4 ECG measured in a bathtub

6.2.2.4 Sound Control

The sound controller uses parameters and events obtained from processing to extract control information. Settings are coupled with parameter and event information for output sound such as audio and MIDI data. These settings, including the processing used to play or generate sounds, are collectively called a sound set. Only one type of sound set can be configured at a time. However, the bather can switch between various sound sets using the remote controller. A sound set is designed as an expression of the bathing state. Thus, it is possible to design sets for a variety of bathing spaces. The sound controller is processed either inside the water heater unit or by an external processor over a network. The generated sounds are played in the bathroom via an audio speaker located in the bathroom or in remote environments via networks.

6.2.2.5 Bathonify Remote Controller

In addition to the displays for water temperature and settings, Bathonify requires additional displays in the bathroom for sound on/off, sound setting changes, volume adjustment, operation information, system state, vital signs, and sound set images.

6.2.3 Software Components

This section describes the software components and the sound design of Bathonify. Figure 6.5 shows a schematic of the Max/MSP. The software operates as a sensing processor for the extraction and processing of sound control information, A/D control of water pressure output, and serial communication control from the ECG measurement unit. Max/MSP configures each sound set as a sub-patch (subprogram), which is then imported by the sound processor. If multiple sound sets are used, the sound processing module can switch between them.

6.2.3.1 Sensing Module

Max/MSP samples the water pressure sensor output at 200 Hz and divides the data into bathing movement information and breathing component extraction information for processing. There are three types of bathing movement information: Entering/exiting state (Bathing: 1. Not bathing: 0.), amplitude value (level change over fixed time), and excess amplitude trigger (above the amplitude threshold). Moving average processing is used to eliminate the noise from the output voltage of the water pressure sensor. Sensor output characteristics are then translated into water level in the bathtub. The water level value is used to judge whether the bathtub is occupied. The bathing state is output as one of two variables (occupied or not occupied). To make this determination, the average water level when the bath is not occupied is used as the standard water level and a certain value above this level is set as the threshold. If the water level is continuously above the threshold over a fixed period of time, the processor judges the bathing state as occupied. If, however, the water level is below the threshold over a fixed period of time, the processor judges the bathing state as not occupied. The threshold for this system is 20 mm above the

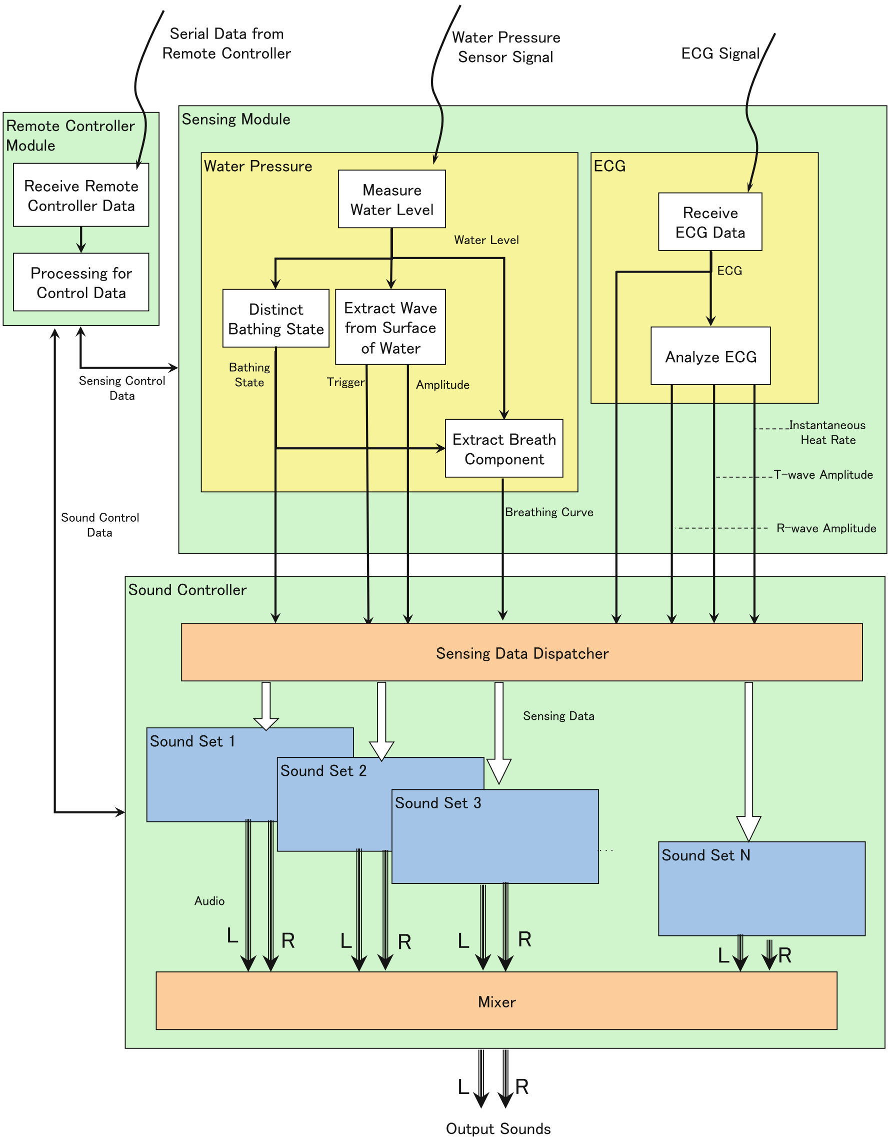


Fig. 6.5 Schematic of the software modules

standard water level. If the water level exceeds the standard value, the processor activates after a fixed time of 0.8 s. We verified the 20 mm value for the shape of the bathtub used in this system. However, a bathtub with a smaller volume would experience larger water level changes and surface ripples, necessitating the setting of a higher threshold. If the fixed time threshold of 0.8 s is set shorter, the processor makes incorrect judgments on large water surface ripples. On the other hand, if the threshold is set longer, the sound that starts based on the trigger that detects when a person is entering the bath would be awkwardly late. We therefore determined that 0.8 sec is an appropriate time. The amplitude value is set for a time level of 1.5 s. The processor will activate an excess amplitude trigger if the amplitude for 0.8 sec of moving time is above the threshold. However, the trigger only activates during bathing. This threshold is related to how easily sound plays based on the trigger; so it can be adjusted by the user.

The breathing component and bathing movement information are processed simultaneously. Water pressure data are then converted into water level data by applying a low-pass filter with a cutoff frequency of 0.35 Hz. The data are subsequently converted again using the bathtub volume and a breathing curve that shows changes in breathing volume outputted. This breathing curve is then passed to the sound controller. For the heartbeat, the measurement circuit outputs an ECG signal, which is sent to the computer over the RS-232 C interface. The ECG waveforms are output directly to the sound processor, which detects R waves and T waves and outputs height values for each of these waveforms as event signals used for timing control. When the processor detects R waves, it finds the instantaneous heartbeat from the interval between the R waves (time interval between the current R and previous R waves).

6.2.3.2 Sound Controller Module

The sound processor sends the control signal received from the sensing part to the sound set (Max-patch). The previous sound set sent from the control signal can be changed as required using the bathtub remote controller and the mixer can adjust the sound volume before the sound is output to the speaker. The Max-patches (programs) arrange the data input port that receives control information and the sound data output port. They have an integrated input/output interface, which makes it is easy to switch between sound sets.

6.2.4 Sound Design

In our prototype system, we prepared two different sound sets to verify that they could be switched when it was being used.

6.2.4.1 Sound Set 1

We designed Sound Set 1 to be similar to Soundscape (Schafer 1993) with an underlying sound of gentle waves lapping a tropical seashore in the evening. The lapping wave sound is mapped so that its volume can be changed using amplitude values. When the bathwater is stirred strongly, the lapping wave sound increases. Different amplitude values are produced for stirring of the water when the bath is occupied and for when it is not occupied. The sound set is configured so that an occupied bath produces louder sounds for small amplitude values compared to an unoccupied bath. Entering or exiting the bathtub changes the value of a two-state variable. Whenever the state changes, a sound like the crunching of seashells plays. This crunching seashell sound is the same for entering and exiting the bathtub; however, the sound plays longer when the bathtub is being exited. In this way, it is possible to distinguish between entering and exiting of the bathtub by the length of the crunching seashell sound. We also added sound components that only play while a person is bathing. They include a piano sound and a sound synthesized based on an image of the moon. The synthesized sound repeats an underlying bass sequence phrase, to which various alto phrases are randomly selected and added. The tempo and expressive probability of an alto phrase can change based on an amplitude trigger. Like the synthesized sound, various piano phrases are available. Piano phrase selection and occurrence timing are controlled by an amplitude trigger. However, if the amplitude trigger detects a new state while one phrase is playing, a new phrase is not played immediately. This control prevents the occurrence of a cacophony.

6.2.4.2 Sound Set 2

Sound Set 2 is a background music component that expresses the bright and relaxed ambiance of a tropical seashore at noon. With an underlying sound of guitar strings, various synthesized sounds and effects come into play when the pressure changes as the bathwater is stirred. The tempo of the guitar emulates the heartbeat of the bather. Thus, it is possible to be aware of one's own beating heart. The heartbeat emulator harmonizes completely with the instantaneous heartbeat, so it is possible for the music tempo to change sharply. To control sharp changes, the heartbeat is averaged over five values. During a quiet bathing state, a clear, refreshing synthesized sound plays in harmony with the amplitude of the breathing curve. One objective of this design is to evoke a feeling of relaxation as the sound harmonizes with the deep breathing of the bather.

6.2.5 Bath Remote Control

Figure 6.6a shows an image of a bath remote control operated from a computer that has a touch panel display. Figure 6.6b shows the remote control's display window. In addition to conventional displays for hot water supply and bath temperature settings, this remote control has various other settings in the display window, such as sound set selection, display of the water level with surface wave information including breathing information, display of ECG data and heartbeat information, and sound volume control for each sound set.

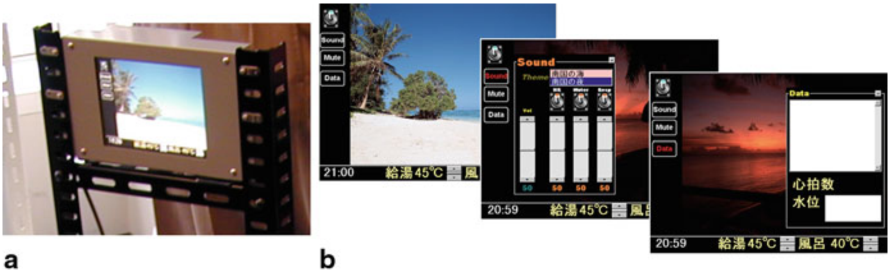


Fig. 6.6 Bathonify remote control **a** Touch panel display, **b** Examples of display window examples

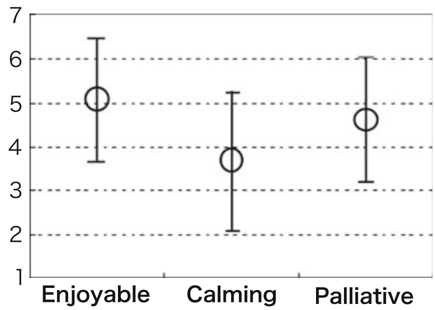


Fig. 6.7 Result of subjects' answers

6.2.6 Evaluation of Bathonify

In order to verify that the Bathonify system provides an amenity space that bathers enjoy, we conducted a simple evaluation. Thirteen male subjects ranging from 20 to 35 years old were asked to evaluate the bath system one at a time and experience the interactive sound, after which each subject completed a questionnaire. The questionnaire asked the subjects to give their impressions about various aspects of the system on a scale from one to seven: Enjoyable (1-Not enjoyable to 7-Enjoyable), calming (1-Not calming to 7-Calming), and palliative (1-Not palliative to 7-Palliative). Space was also made available for them to freely write comments. We set the room temperature at 28 Â°C and the hot water temperature at 40 Â°C (the actual temperature of the water in the bathtub was 38 Â°C), which are normal bathing conditions. We used Sound Set 1 and left the bathing time up to each subject's discretion. Figure 6.7 gives the average and standard deviation of the evaluation results.

Figure 6.7 shows that the subjects felt the experience was enjoyable and palliative. These positive results suggest that the system is efficacious for bathers. Nine out of the 13 subjects wrote favorable comments about the interactive environment under the enjoyable aspect. Their comments suggest that the system fulfills its objectives. Eight subjects who evaluated the calming aspect at three or below felt a sense of discomfort from the novelty of the experience or that the wave volume was a bit too loud. Other comments related to sound and sound requests can be handled by the system through remote control operations or by creating new sound sets.

During verification of Sound Set 2, one bather observed that the music tempo increased the more deeply he became engaged in the sound interaction. Prior to this, the subjects had only been aware of the music tempo, not their rising heartbeats. The experience of this subject, though, suggests that it is possible for a bather to notice his physiological state through interactive sound information.

The Bathonify system was demonstrated at the IPSJ Interaction 2002 conference in Tokyo, and also exhibited in a home equipment showroom in Osaka for two weeks in February of 2006. It has also won several awards and earned praises as an enjoyable system.

6.2.7 Bathonify Concluding Remarks

This section described the Bathonify system, for which the focus is the provision of a ubiquitous computing, healthcare, and entertainment bath system environment with interactive sonification tuned to bathing motions and vital signs. The system measures the bathing state using sensors inside a hot water heater and an electrode attached to a conventional Japanese bath system. Bathers can take baths in their customary fashion because the sensors are embedded and hidden, and they can select from various sound designs and adjust the sound volume as they like. This system can also be used to express life log data, especially for bathing activities in everyday life.

6.3 TubTouch

6.3.1 System Overview and Design

TubTouch (Sakakibara et al. 2013; Hirai et al. 2013) provides an integrated user interface and several interaction features in the bathtub for the control of various equipment and applications. As illustrated in Fig. 6.8 capacitive touch sensors are attached to the inside edge of the bathtub to enable bathers to interact by simply touching the bathtub. A video projector installed above the bathtub projects virtual buttons and/or a screen for applications over the touch sensors, shown in the picture on the right side of Fig. 6.8. In Japan, standardized bathroom systems are widespread in homes, including houses, condominiums, and apartments. The bathrooms are constructed from unit elements, such as wall, floor, ceiling, bathtub, and are relatively easy to assemble and remove. The space inside the side of the bathtub can be accessed by removing a side panel; resulting in easy installation of capacitive touch sensors, shown in the picture on the left side of Fig. 6.8. The space in the side of the bathtub was designed specifically for additional equipment such as a Jacuzzi. The picture on the left side of Fig. 6.8 also shows several electrodes on the upper inside edge of the bathtub, and a sensor box containing a touch sensor controller board. This arrangement means that TubTouch can be installed as an additional system in any

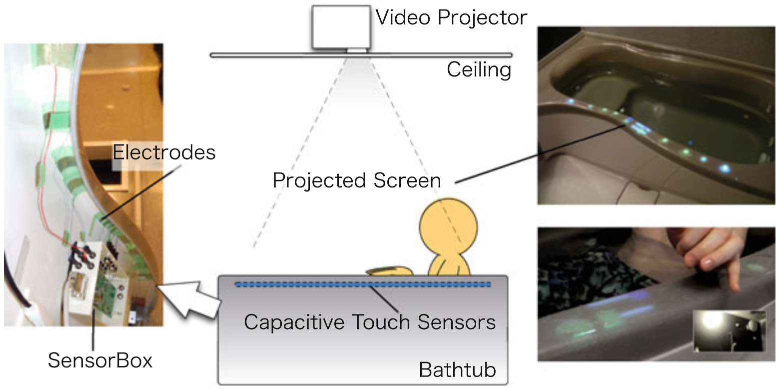


Fig. 6.8 Tubtouch system overview

such existing bathroom. In addition, electrodes can be freely installed on the rear side of surfaces, including curved surfaces. Another advantage is the flexibility of the interactive display and its compatibility with conventional household environments.

Capacitive sensors usually respond to contact with water and are therefore used to measure water levels in tanks. Recent multi-touch input devices tend to be incompatible with wet environments. However, the basic function of a capacitive sensor is to react to the presence of dielectric objects. Since water and the human body have different relative permittivity, TubTouch can indeed be used to detect human touch, even when wet, in response to each sensor signal.

Japanese bathroom systems also have space in the ceiling to install equipment such as ventilators, dryers, mist generators, loudspeakers, and audio units. An access hatch is provided in the bathroom ceiling for easy access to this space; thus, a projector can very easily be installed there.

There are three ways to interact with TubTouch: touching, sliding, and proximity to the edge of the bathtub[1, 2]. As mentioned above, the proximity value is measured by reaction to the presence of dielectric objects, such as fingers and hands in this case. Touch detection is a proximity state that can be determined quite simply using a threshold. Sliding motions can be detected by transitions of proximity values from multiple electrodes.

6.3.2 *TubTouch Entertainment Applications*

TubTouch has several entertainment applications, including control of some bath equipment such as lighting, audio, and TV. In this section, we introduce three entertainment applications that, in particular, provide new experiences during baths.

[1] TubTouch Example 1: http://www.youtube.com/watch?v=lDKR6rTwobM.
[2] TubTouch Example 2: http://www.youtube.com/watch?v=oiKocZ1IORw.

Fig. 6.9 Appearance of bathtuboom

6.3.2.1 Bathtuboom

Bathtuboom, shown in Fig. 6.9, is a kind of interactive art system. Each colored ball projected onto the edge of the bathtub is a button that is able to activate sound phrases and move light shapes on the top of the bathtub. When a bather touches these buttons simultaneously, the overlapped sound phrases generate music that can be listened to. Bathers, especially children who dislike bathing, can experience some amount of pleasure by touching these balls and listening to the resulting music.

6.3.2.2 Batheremin

Batheremin, shown in Fig. 6.10, is a theremin application. The theremin is a very famous electronic musical instrument that is controlled by the proximity of the two hands via capacitive sensors. We designed a bathtub embedded touch sensor system as a theremin that can be played using two hands.

6.3.2.3 BathCount

When taking a bath, many Japanese children play a game, while in the tub of water, in which they count from one to a few tens until the end of the bath. Children learn numbers and counting through these experiences with their parent(s) in the bathroom. BathCount, shown in Fig. 6.11, is a kind of support system for this counting experience. When a button is touched, BathCount displays a corresponding number on the bathtub, and speaks the number or plays some sounds. Children using this system can count numbers with or without a parent, resulting in more fun at bath time.

Fig. 6.10 Appearance of batheremin

Fig. 6.11 Appearance of bathcount

6.3.3 TubTouch Concluding Remarks

In this section, the TubTouch bathroom system was described. This system enables a bathtub to become an interactive controller using embedded capacitive touch sensors, and a number of new entertainment applications associated with it. The TubTouch system and these applications have been exhibited and demonstrated at several exhibitions and conferences, for instance, at Makers Faire Tokyo 2012 and IPSJ Interaction 2012. The general feedback from people who experimented with the applications has been very positive; they usually state a desire to have the TubTouch system and its applications in their own homes.

We plan to develop middleware for TubTouch, using the TUIO protocol (Kaltenbrunner 2009) to divide it into hardware and software platforms, in order to make applications easier to develop.

Fig. 6.12 Appearance of Bathcratch

6.4 Bathcratch

The sounds that a bathtub makes when rubbed, brushed, or struck are familiar to virtually everyone. We propose using the bathtub as an interface for creating music. To explore this concept, we developed Bathcatch (Hirai et al. 2012), a system that detects the squeaks made when rubbing a bathtub, as well as the sounds made by other such actions, and converts them into musical sounds (see Fig. 6.12)[3]. By embedding sensors that can detect touch and sounds, the bathtub is virtually converted into a user interface (UI) for a DJ controller. We intend for this to be a new way to make everyday activities more fun.

In this section, we present a system overview and describe the method by which scratching sounds are processed to associate interaction with rhythm tracks. In addition, we describe the feedback received from the public at an exhibition where the Bathcratch system was installed.

6.4.1 System Overview

As shown in the overview in Fig. 6.13, a contact microphone (a piezo sensor) is attached on the inside edge of the bathtub at the point where the right hand of the user would normally be placed. The microphone senses squeaks made when the bathtub is rubbed as solid vibrations in the body of the tub. The sounds are processed by a software called the Squeaking Sound Detector, which handles the rubbing input. For the left hand, capacitive touch sensors are provided, which allow various other inputs to be given to Bathcratch. These embedded sensors represent one novel feature of the system: they are invisible and do not impede everyday cleaning of the bathtub. A video projector installed above the tub projects virtual buttons over the touch sensors on the left side and marks the input area on the right for the contact microphone. Another novelty is the flexibility of the interactive display

[3] Bathcratch movie 1: http://www.youtube.com/watch?v=kp_0rPx-RSY.

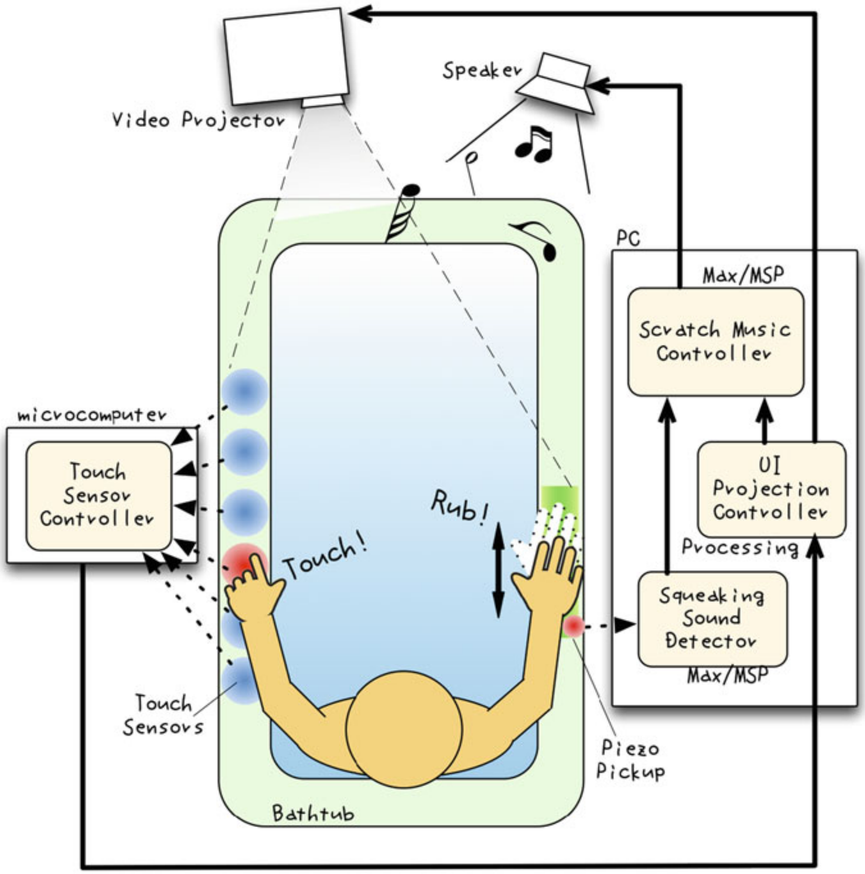


Fig. 6.13 Bathcratch system overview

and its compatibility with the ordinary household environment. The Scratch Music Controller generates scratching phrases according to the squeaks detected and also changes the scratching effects and rhythm tracks in accordance with the touch inputs, as illustrated in Fig. 6.14.

6.4.2 The Bathtub as an Interaction Medium

6.4.2.1 Detecting Squeaks

This system must detect and differentiate between various squeaks and play associated scratch sounds. These squeaks have subtle differences depending on the material of the bathtub and the way it is rubbed, for instance, with different finger angles,

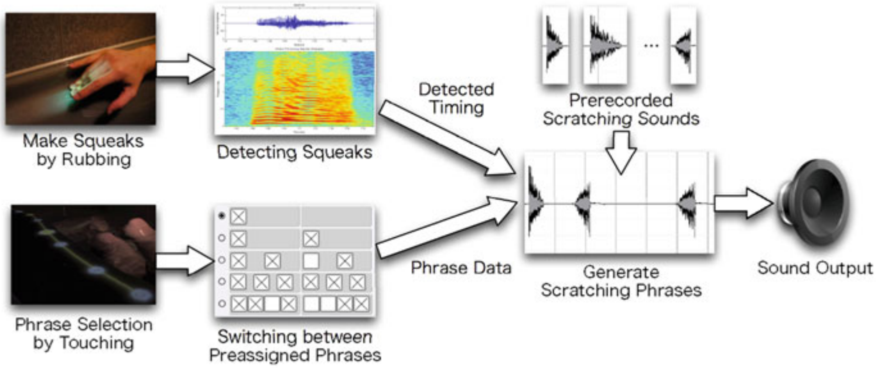


Fig. 6.14 Internal process of the Bathcratch system

rubbing directions, and pressure values. However, these sounds have a fundamental frequency (F0) and specific harmonic structures, as shown in Fig. 6.15. This spectrogram shows the harmonic structure and its continuous characteristic. We confirmed that the same characteristic exist for various bathtub squeaking sounds. The range of F0 is 100-600 Hz.

In addition to squeaks, taps and knocks on a bathtub also produce solid vibrations, although they do not have the same characteristics as squeaks; they have short durations and do not have a distinct harmonic component, as shown in Fig. 6.16. The other sounds with harmonic components in a bathroom are human voices. However, we confirmed that a contact microphone attached to a bathtub filled with water will not detect a human voice. Thus, in order to isolate squeaks, the system must identify signals with a certain continuous harmonic structure and amplitude. However, the current system does not detect a continuous harmonic structure accurately. Therefore, the external object sigmund in the Max/MSP software environment is used to estimate F0 instead.

6.4.2.2 Using TubTouch and Projection Display on Bathtub

Bathcratch partially utilizes the TubTouch system, which enables switching of rhythm tracks, scratching phrases, and sounds while playing. The embedded contact microphone and capacitive touch sensors are invisible and no changes are made to the surface of the bathtub, as mentioned above. Instead, a video projector installed above the tub projects virtual interactive objects over the touch sensors and indicates a designated rubbing area near the microphone (see Fig. 6.12). Note that the contact microphone (piezo sensor) can be installed anywhere on the edge of the bathtub as the solid vibrations are conducted quite well through the bathtub. The designated rubbing area is only intended as a visual aid to prompt the user to rub the bathtub.

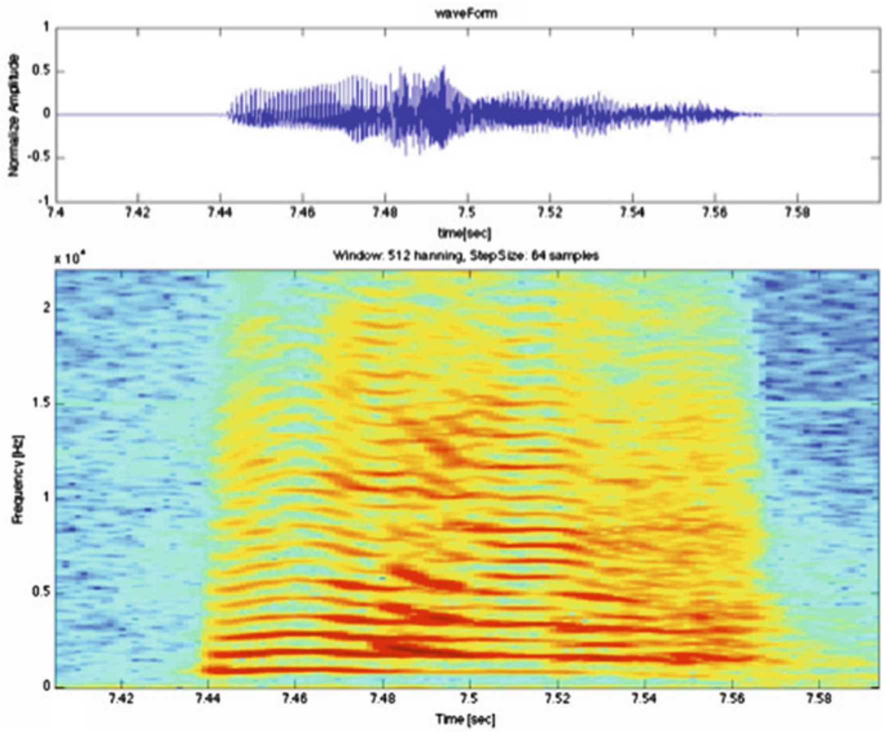


Fig. 6.15 Spectrogram of a bathtub squeak

6.4.3 Scratching Music Controller

6.4.3.1 Overview of Scratching Phrase Generation

We implemented the Squeaking Sound Detector and Scratching Music Controller were implemented as a Max/MSP patch, as shown in Fig. 6.17. The checkboxes at the top are toggle switches to control the entire Bathcratch system in order to play specific rhythm tracks and to change the pitch of the scratching sounds. The faders control the volume of each scratching phrase and the master output. The checkboxes in the middle can be used to make scratching phrases, as described in the next section. To the right of these checkboxes is an option to set the tempo for the rhythm tracks and scratching phrases. The current Bathcratch system does not generate scratching sounds synchronized with the actual rubbing motion, but generates phrases synchronized with the tempo of the selected rhythm track. This is because of the latency in detecting squeaking sounds and the difficulty users encounter trying to rub and make squeaking sounds coordinated with the rhythm track. Therefore, we designed the interaction with Bathcratch such that rubbing actions (making squeaking sounds) are first used to prearrange a set of scratching

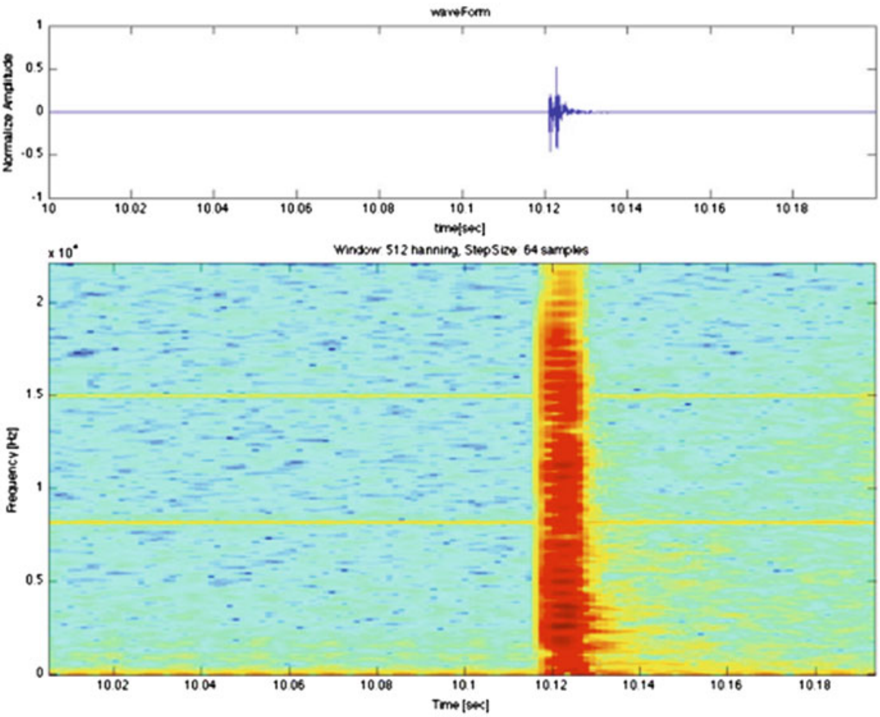


Fig. 6.16 Spectrogram of a bathtub knock

phrases, which can be switched by using the touch controls. Thus, any user can intuitively create DJ scratching sounds with relative ease. We plan to implement synchronized, real-time scratching for experts in the next version of Bathcratch.

6.4.3.2 Switching Between Scratching Phrases

Five scratching phrases can be arranged freely based on the basis of half notes, quarter notes, eighth notes, sixteenth notes, and triplet notes. These phrases are prearranged with checkbox groups in the middle area of the patch shown in Fig. 6.17, and icons representing each phrase are projected on the top of the touch sensors. Users can switch between the five scratching phrases by touching the projected objects. The five phrases are always played in the tempo of the current rhythm track, and Bathcratch outputs only the phrase selected by controlling the faders for each phrase.

Consequently, even if a user rubs vigorously and quickly, the output phrase is not changed. Furthermore, when a user selects another phrase before the current phrase has completed, a smooth transition is made using crossfading effects.

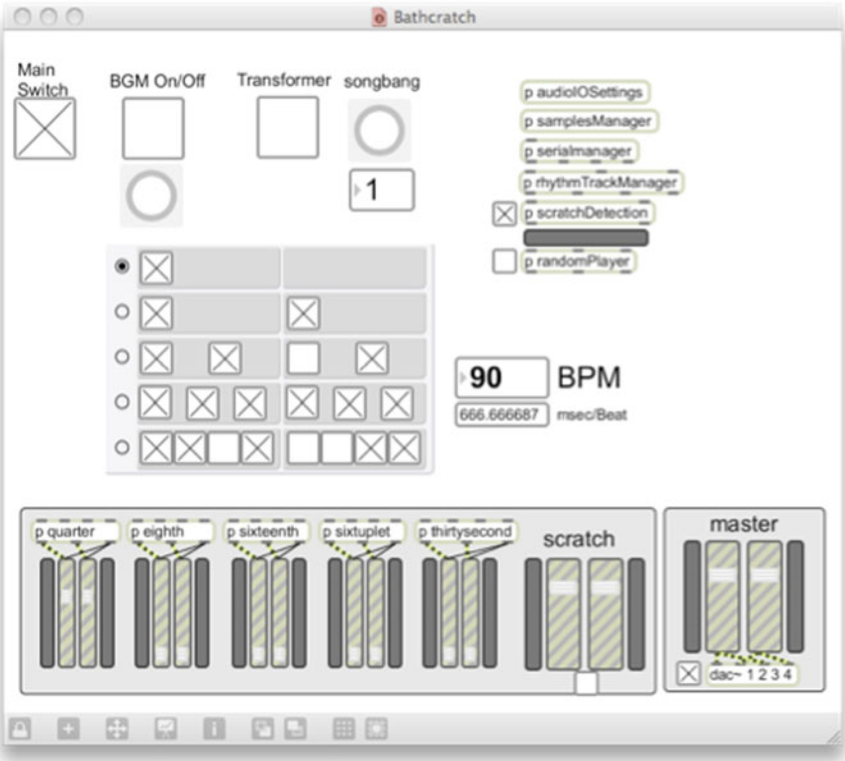


Fig. 6.17 Max/MSP patch for Bathcratch

6.4.3.3 Sound Sources and Effects for Scratching

Currently, this system plays prerecorded scratching sounds for each note in the scratching phrases. It is possible to assign a single sound source and slightly change each note in the phrase and to change the playback speed of the assigned source to create individual effects. By using these functions, the same sound source can be used in a phrase, although each note played is not the same. This reduces the number of sound files and materials necessary and makes it easy to create a phrase with a few sound sources. Even if only one sound file is assigned to all the notes of all phrases, a wide repertoire of phrases can be realized by randomly changing playback speeds. Although individual assignments are performed before playing with this system, the randomizing mode can be controlled in real time using the touch inputs. This method of sound assignment and generating effects makes the phrases seem more natural and nonmechanical. In addition, actual DJs employ a variety of techniques on real turntables and faders, for instance, chirp scratch, forward/backward scratch, and transformer scratch. These functions of Bathcratch can be considered as simplified and modified functions that are carried out using actual turntables and faders.

Fig. 6.18 Bathcratch installation

6.4.3.4 Rhythm Tracks

We prepared a range of background rhythm tracks, such as, OldSchool, Dubstep, JazzyHipHop, and Electronica, for the scratching performances. Users can select a rhythm track by sliding the track selection area over the touch sensors. However, the rhythm track manager always plays all tracks in parallel and only turns up the volume of the selected rhythm track while muting the others.

6.4.4 Demonstrations and Exhibitions

The initial version of Bathcratch with a simple UI can be seen on YouTube (Fig. 6.12). The installation version of Bathcratch (Fig. 6.18) with an improved UI (Fig. 6.19) was exhibited at the 2010 Asia Digital Art Awards at the Fukuoka Asian Art Museum in Fukuoka, Japan, from March 17 to 29, 2011. It was also been exhibited at the National Museum of Emerging Science and Innovation (Miraikan) in Tokyo on October 10, 2011. The UI was changed for this version because it was operated on the sides of the bathtub (see Figs. 6.20 and 6.21)[4].

The UI of the installed version presents a movable gradation square for rubbing on the right edge, as seen when standing to the side of the bathtub. The buttons used to select scratching phrases are along the left side of the square rubbing area. Each button represents a musical note, for instance, a quarter note, an eighth note, a sixteenth note, etc., which represents a fundamental note of a scratching phrase. Users can select and change phrases by touching these buttons. In addition, on the left

[4] Bathcratch movie 2: http://www.youtube.com/watch?v=g-Z0visXQwo.

Fig. 6.19 User-interface of the Bathcratch installation

Fig. 6.20 Exhibition at the Fukuoka Asian art museum in Fukuoka, Japan

side, there are effect buttons to change the pitch of phrase notes as well as a sliding selector and a mute button for the rhythm tracks. Each icon of the sliding selector represents the characteristics of the associated rhythm tracks in terms of color and icon design. We provided a wet sponge along with the setup to allow users to wet their fingertips in order to create squeaks when rubbing the bathtub. It was placed near the square area designated for rubbing. A few drawbacks were noticed during this exhibition. One involved the setting of the input gain for the piezo sensor when there is no water in the bathtub. Turning a rhythm track up at high input gain caused misdetection of F0 because of interference with the notes from the rhythm track. This phenomenon does not occur when there is water in the bathtub. Therefore, we think that water acts as an attenuator that blocks surrounding sounds. Another problem was that some users could not understand the difference between the rubbing UI and

Fig. 6.21 Demonstration at the national museum of emerging science and innovation (Miraikan) in Tokyo, Japan

the touch UI. Most of them did not rub but slid their fingertips lightly on the rubbing area despite the fact that they needed to make squeaks. Fortunately, the exhibition staff explained the operation of Bathcratch and showed users how to use it.

This indicates that we need to improve the UI to more clearly indicate that a rubbing motion that produces squeaks is necessary.

6.4.5 Bathcratch Concluding Remarks

This section described the Bathcratch system, which allows anyone to create DJ scratching sounds by rubbing a bathtub. The system utilizes the squeaks produced by rubbing smooth surfaces, of a bathtub, in this case. This section also described the UIs used for rubbing and touch inputs, which were implemented with a projector, along with the systems for detecting squeaks and controlling the scratching music. Bathcratch has been presented at several exhibitions, where it has been awarded several prizes. Squeaks produced by rubbing smooth surfaces are quite common in everyday life; for instance, when polishing mirrors, windows, bathtubs, and dishes. Therefore, this system can utilize a casual action that occurs in daily life as a means of entertainment. People can control various devices via rubbing motions and squeaks. Moreover, the input functionalities of this system can be increased by including rubbing length and timing as additional parameters. As future work, we plan to simplify the system and analyze the squeaking sounds accurately in terms of the timing. We also plan to analyze the feasibility of including various other aspects of rubbing motion as additional input parameters for a general UI; for example, the number of rubbing fingers, rubbing direction, and the intensity. Finally, we plan to improve Bathcratch's entertainment functionality, including the music controller, and further explore the concept of entertainment with common objects found in a typical home.

6.5 Related Work

6.5.1 *Bathonify*

In building Bathonify, reference was drawn from the concept of ambient media (e.g., light, sound, water) as defined by the Tangible Media Group at MIT (Ishii and Ulmer 1997). Ambient media research related to water as a form of visual expression has been used by Dahley et al. in the Water Lamp (Dahley et al. 1998), and by Sugihara et al. in the Dome (Sugihara and Tachi 2000) and in the Water Display (Sugihara and Tachi 2001). Works of art using sound to express water movement include Tangible Sound by Yonezawa (Yonezawa and Mase 2000) and Sound Flakes by Moroi (Moroi 2004). AquaTop display (Koike et al. 2012) uses the surface of the in a bathtub as an interactive visual display.

Sonification research for everyday life activities or life log has also been done. Mynatt et al. attempted to sonify activities at home in the Aware Home project (Mynatt et al. 1998; Tran et al. 2000). Oki et al. attempted something similar using an orgel (Oki et al. 2008) in the OchaHouse project. These sonification research activities tend to not be in the bathroom, but in the living room, bedroom, and kitchen.

6.5.2 *TubTouch*

Smartskin (Rekimoto 2002; Fukuchi and Rekimoto 2002) is one of the important UI researches that uses capacitive touch sensors into a table and a pad. These are surface computing researches that provide a multi-touch, gesture, proximity and shape input. The TubTouch system references them but is applied to the narrow edges of the bathtub while coping with water.

DiamondTouch (Dietz and Leigh 2001) can identify users. The possibility exists that TubTouch will be used by multiple persons, such as children and a parent, at the same time. This matter can be dealt with by referencing DiamondTouch. Westerman's system (Westerman 1999) can identify fingers by proximity images from touch sensor arrays. At present, TubTouch is applied to the bathtub's narrow edges, which restrict arrangements of touch sensor electrodes. Therefore, TubTouch is limited in its ability to recognize finger gestures that are usually used in surface computing.

TubTouch can be applied to not only flat surfaces, but also curved surfaces. There are several research efforts related to curved surfaces computing, for instance, Sphere (Benko et al. 2008) and a dome display by Benko and Wilson (2010). These systems also use video projectors to display on curved surfaces. However, they use infrared (IR) to detect touches.

Touché (Sato et al. 2012) can not only detect a touch, but also recognize how the touch was done. This system uses the capacitive sensing technique with swept frequency and support vector machine to classify the touch context. In comparison with normal capacitive touch sensing techniques including TubTouch, this recognition process needs some latency and a high performance CPU. TubTouch will reference Touché in the future for various interaction designs.

The AquaTop display (Koike et al. 2012), previously mentioned in work related to Bathonify, is also a surface computing system that does not use the capacitive touch sensing technique. This system uses a depth camera to detect some finger and hand gestures at the surface of the water in a bathtub. In order to display on the water surface, a video projector is used, same as with TubTouch.

6.5.3 Bathcratch

Considerable research has been conducted on music systems and UIs for DJ controllers, including inputs for scratching. For example there are experimental turntables and wearable UIs such as the DJammer (Slayden et al. 2005), Music-Glove (Hayafuchi and Suzuki 2008) and Wearable DJ System (Tomibayashi et al. 2009) that allow users to Air-DJ and scratch. Mixxx (Andersen 2003) uses AR-ToolKit to implement an augmented reality turntable that can play various sounds. D'Groove (Beamish et al. 2003) has a turntable with force feedback as well as a DJ mixer that allows users to practice the fundamental techniques of DJing. Hansen uses the Reactable as an UI for DJ scratching (Hansen et al. 2007; Hansen and Alonso 2008). Fukuchi's system uses a capacitive multi-touch surface and allows multi-track scratching (Fukuchi 2007). Another turntable controller that includes commercial products for scratching is described in detail in Hansen's doctoral thesis Hansen (2010).

In addition, some research has been conducted on utilizing acoustic sensing in a UI. Scratch Input (Harrison and Hudson 2008) to detects scratching sounds and the associated finger motions using a piezo microphone attached to a wall, table, etc. Stane (Murray-Smith et al. 2008) attempted to the detection of vibrations when the surface of a small device with built-in piezo sensors is scratched. The device also used various input patterns that depended on the vibration length. Skinput (Harrison et al. 2010) uses sounds and machine learning to implement a UI. The system uses the human body itself as the UI by recognizing finger taps through vibrations transmitted along the skin surface using a piezo film rolled around the upper arm. Lopes's system (Lopes et al. 2011) uses the sounds of finger, knuckle, fingernail and punch touches, in order to expand the input language of surface interaction.

6.6 Discussion

Japan has a unique bathing culture. A lot of people feel that bathrooms are amenity spaces for refreshing the mind and relaxing. Half-body bathing is typical of this. Hence, general bath modules in Japan have a feature to expand various functionalities with optional equipment; for instance, ceiling speakers for listening to music, ceiling illuminations with spotlights for room effects, and mist generators for beauty and fine skin. People read books and listen to music while in half-body bathing or bathing with mist generators, which can also make sauna baths. In spite of these advanced bathroom situations and environments in Japan, it is important to note that the systems introduced in this chapter can make bathing a more entertaining experience. The common grounds of these systems are the embedded sensors and the provision of interactivity with entertainment while in the bathroom. The embedded sensors have two benefits. The first is that sensors do not hinder the normal cleaning of the bathroom and/or bathtub. The second is that it is a smart environment with many kinds of software applications, including entertainment for various persons, from children to elderly people. This embedded and smart environment realizes one of the concepts of the Ubiquitous Computing Environment (Weiser 1991). Bathonify uses the built-in water pressure sensor of the external water heater, and an ECG sensor. Fully-automatic water heaters are already widespread in Japan and all have a water pressure sensor. The ECG sensor unit also exists as an extension unit for some external water heaters. Thus, the practicability of this system does not depend on hardware, but rather on the software and the network to carry out signal processing, play sounds, and download additional sound sets. TubTouch and Bathcratch need to embed touch sensors and a piezo sensor as a contact microphone into the inside edge of the bathtub. As stated above, most bathtubs in Japan have a removable side panel. Optional equipment, such as a whirlpool and an ECG sensor unit, can be installed inside the bathtub at the side. The picture on the left side of Fig. 6.8 shows a bathtub with its side panel removed, installed capacitive touch sensor unit, and red lines as sensor electrodes. Piezo sensors can also be easily installed in this space. Thus, it is already possible to install these sensors in existing bathtubs. The most difficult part of the system may be installation of the video projector in the ceiling. However, pico-projectors are presently undergoing remarkable development and a waterproof version that can easily be installed in the ceiling will be released soon. Consequently, these systems may soon be released as practical entertainment systems.

The systems described in this chapter will bring interactivity while bathing and utilize a bather's actions and/or vital signs. Bathers need active interaction to use TubTouch and its applications and Bathcratch. These applications facilitate extraordinary bathing activities and entertainment, so it is envisioned that they will be used by bathers who would like to have fun. Bathonify, on the other hand, can be used with both active interaction and passive interaction. Some bathers may have fun with the interactive sonification of some sound sets using active motions, whereas others may not pay extra attention to the interactive sounds but hear the sounds produced by their vital signs passively. Bathers who dislike sounds while bathing can have the sounds conveyed to another place, such as the kitchen in the home or a remote location where a relative is, while experiencing silence from the system in the actual bathroom. Hence, Bathonify is useful both explicitly and implicitly.

These novel interaction and entertainment systems, which can be used actively or passively, explicitly or implicitly, improve QoL with bathers' selections.

6.7 Conclusion

This chapter described three interactive and smart bathroom systems that comprise aspects of ubiquitous computing and entertainment systems.

The first system, Bathonify, reflects the sounds made by a bather's movements and vital signs, such as ECG and breathing. This system can be seen as a kind of interactive sonification system to reflect a bathing life log. Bathers can take their baths as usual because the sensors are embedded in the system. Further, they can monitor their own vital signs and transmit bathing state and other information to another place.

The second system, TubTouch, is a controller platform that transforms a conventional bathtub into an interactive controller using embedded capacitive touch sensors and a video projector. This system provides a surface computing platform for the bathtub that can be used as an integrated controller for various conventional bath equipment, such as water heaters, TVs, audio equipment, Jacuzzis, dryers, and mist generators. In addition, this system can be used to provide novel applications in the bathroom, such as Bathtuboom, Batheremin, and BathCount, as discussed above.

The third system, Bathcratch, is a DJ scratching application that uses the squeaks produced by rubbing the bathtub to provide entertainment. This system uses an embedded piezo sensor inside the bathtub to detect squeaks, and partially utilizes the TubTouch system.

We also introduced works related to the above systems and discussed them from the point of view of practicability, common grounds, and interactivity.

These smart, interactive entertainment systems and technologies for bathrooms will change and improve QoL in the future.

Acknowledgement These research were partially supported by Osaka Gas Co.,Ltd and a grant from the Hayao Nakayama Foundation.

References

Andersen, T. H. (2003). *Mixxx: Towards novel DJ interfaces*. Proceedings NIME03, pp. 30–35.

Beamish, T., Maclean, K., & Fels, S. (2003). *Manipulating Music: Multimodal interaction for DJs*. Proceedings CHI, 327–334.

Benko, H., & Wilson, A. D.. (2010). *Multi-point interactions with immersive omnidirectional visualizations in a dome*. Proceedings of ACM international conference on interactive tabletops and surfaces, pp. 19–28.

Benko, H., Wilson, A. D., & Balakrishnan, R. (2008). *Sphere: Multi-touch interactions on a spherical display*. Proceedings of UIST2008, pp. 77–86.

Dahley, A., Wisneski, C., & Ishii, H. (1998). *Water lamp and pinwheels: Ambient projection of digital information into architectural space*. Proceedings of CHI '98, pp. 269–270.

Dietz, P., & Leigh, D. (2001). *DiamondTouch : A multiuser touch technology*. Proceedings of the 14th annual ACM symposium on user interface software and technology, pp. 219–226.

Fukuchi, K. (2007). *Multi-track scratch player on a multi-touch sensing device*. Proceedings ICEC (LNCS 4740), pp.211–218.

Fukuchi, K., & Rekimoto, J. (2002). *Interaction techniques for smartSkin*. Proceedings of UIST2002.

Hansen, K. F.. (2010). *The acoustics and performance of DJ scratching, Analysis and modeling*. Doctral Thesis, KTH, Stockholm, Sweden.

Hansen, K. F., & Alonso, M. (2008). *More DJ techniques on the reactable*. Proceedings of 8th international conference on new interfaces for musical expression, pp. 207–210.

Harrison, C., & Hudson, S. E. (2008). *Scratch input: Creating large, inexpensive, unpowered and mobile finger input surfaces*. Proceedings UIST'08, pp. 205–208.

Hansen, K. F., Alonso, M., & Dimitrov, S. (2007). *Combining DJ scratching, tangible interfaces and a physics-based model of friction sounds*. Proceedings of the international computer music conference, pp. 45–48.

Harrison, C., Tan, D., & Morris, D. (2010). *Skinput: Appropriating the body as an input surface*. Proceedings CHI, pp. 453–462.

Hayafuchi, K., & Suzuki, K. (2008). *MusicGlove: A wearable musical controller for massive media library*. Proceedings of 8th International conference on new interfaces for musical expression.

Hirai, S., & Ueda, H. (2011). *Towards a user-experience research in a living laboratory*? Home (KSU-iHome). Proceedings of SI2011. (In Japanese).

Hirai, S., Fujii, G., Sakonda, N., & Inokuchi, S. (2004). Bathroom toward a new amenity space: Bath system representing bathing states by sounds. *Journal of Human Interface Society, 6*(3), 287–294. (In Japanese).

Hirai, S., Sakakibara, Y., & Hayakawa, S.. (2012). *Bathcratch: Touch and sound-based DJ controller implemented on a bathtub*. Proceedings of ACE 2012, pp. 44–56.

Hirai, S., Sakakibara, Y., & Hayahshi, H.. (2013). *Enabling interactive bathroom entertainment using embedded touch sensors in the bathtub*. Proceedings of ACE 2013, pp. 544–547.

Intille, S. S., Larson, K., Beaudin, J., Munguia, T. E., Kaushik, P., Nawyn, J., McLeish, T. J. (2005). *The placelab: A live-in laboratory for pervasive computing research* (Video). Proceedings of Pervasive 2005 Video Program.

Ishii, H., & Ulmer, B. (1997). *Tangible bits: Towards seamless interfaces between people, bits and atoms*. Proceedings of CHI '97, pp. 234–241.

Kaltenbrunner, M. (2009). *reacTIVision and TUIO: A tangible tabletop toolkit*. Proceedings of ITS2009, pp. 9–16.

Kidd, C. D., Orr, R. J., Abowd, G. D., Atkeson, C. G., Essa, I. A., MacIntyre, B., Mynatt, E., Starner T. E., & Newstetter, W. (1999). *Proceedings of the second international workshop on cooperative buildings-cobuild'99*.

Koike, H., Matoba, Y., & Takahashi, Y. (2012). *AquaTop display: Interactive water surface for viewing and manipulating information in a bathroom*. Proceedings of ITS 2012, pp. 155–164.

Lopes, P., Jota, R., & Jorge, J. A. (2011). *Augmenting touch interaction through acoustic sensing*. Proceedings ITS'11, pp. 53–56.

Mason, R., Jennings, L., & Evans, R. (1983). *XANADU: The computerized home of tomorrow and how it can be yours today*! Washington, D.C.: Acropolis Books.

Moroi, S. (2004). *Sound flakes*. Proceedings of SIGGRAPH 2004 Emerging Technologies, pp. 25.

Murray-Smith, R., Williamson, J., Hughes, S., & Quaade, T. (2008). *Stane: Synthesized surfaces for tactile input*. Proceedings CHI, 1299–1302.

Mynatt, E. D., Back, M., Want, R., Baer, M., & Ellis, J. B. (1998). *Designing audio aura*. Proceedings of the SIGCHI conference on human factors in computing systems, pp. 566–573.

Oki, M., Tsukada, K., & Kurihara, K. & Siio, I. (2008). *HomeOrgel: Interactive music box for aural representation*. Adjunct Proceedings of Ubicomp2008, pp. 45–46.

Rekimoto, J. (2002). *SmartSkin: An infrastructure for freehand manipulation on interactive surfaces*. Proceedings of the SIGCHI conference on human factors in computing systems, pp. 113–120.

Ruyter, B. de, Aarts, E., Markopoulos, P., & Ijsselsteijn, W. (2005). *Ambient intelligence research in homelab: Engineering the user experience*, Ambient Intelligence (pp. 49–61). Berlin: Springer.

Sakakibara, Y., Hayashi, H., & Hirai, S. (2013). Tubtouch: Bathtub touch user-interface toward curved surfaces and unaffected by water. *Journal of Information Processing Society of Japan, 54*(4), 1538–1550. (In Japanese).

Sato, M., Poupyrev, I., & Harrison, C. (2012). *Touché: Enhancing touch interaction on humans, screens, liquids, and everyday objects*. Proceedings of CHI2012, pp. 483–492.

Schafer, R. M. (1993). *The soundscape: Our sonic environment and the tuning of the world*. Vermont: Destiny Books.

Siio, I., Motooka, N., Tsukada, K., & Kanbara, K., Ohta. Y. (2010). Ocha house and ubiquitous computing. *Journal of Human Interface, 12*(1), 7–12. (In Japanese).

Slayden, A., Spasojevic, M., Hans, M., & Smith, M. (2005). *The DJammer: "Air-Scratching" and freeing the DJ to join the party*. CHI 2005 Extended Abstracts, pp.1789–1792.

Sugihara, Y., & Tachi, S. (2000). *Water dome-an augmented environment*. Proceedings of international conference on computer visualisation, pp. 548–553.

Sugihara, S., & Tachi, S. (2001). Development of head-mounted water display. *Journal of The Virtual Reality Society of Japan, 6*(2), 145–152. (In Japanese).

Tomibayashi, Y., Takegawa, Y., Terada, T., & Tsukamoto, M. (2006). *Wearable DJ system: A new motion-controlled DJ system*. Proceedings of ACE '09, pp. 132–139.

Tran, Q. T., & Mynatt, E. D.. (2000) *Music monitor: Ambient musical data for the home*. Proceedings of the IFIP WG 9.3 international conference on home oriented informatics and telematics.

Ueda, H., & Yamazaki, T. (2007). Ubiquitous home: A study of an intelligent living environment for the daily life support. *The Jorunal of Robotics Society of Japan, 25,* 10–16. (In Japanese).

Weiser, M. (1991). *The computer for the 21st century*. Scientific American special issue on communications, computers, and networks. http://nano.xerox.com/hypertext/weiser/SciAmDraft3.html.

Westerman, W. (1999). *Hand tracking, finger identification and chordic manipulation on a multiTouch surface*. PhD Thesis, University of Delaware.

Yonezawa, T., & Mase, K. (2000). Interaction of musical instrument using fluid media. *Journal of The Virtual Reality Society of Japan, 5*(1), 755–762.

Chapter 7
Social Presence and Artificial Opponents

André Pereira, Rui Prada and Ana Paiva

You can discover more about a person in an hour of play than in a year of conversation.

Plato

Abstract In this paper, we argue that playing board games is a form of entertainment that provides participant's with rich social interactions. However, when we try to replace one of the players with an artificial opponent, the social interaction between players is negatively affected by the social inability of nowadays artificial opponents. Currently, the social presence that human players attribute to artificial opponents is quite low. In order to tackle this problem, we investigate the topic of social presence, its definitions and which are its contributing factors. Also, we looked at nowadays social interactions with artificial agents and how these kind of agents deal with long term interactions. This related work along with some previous studies contributed to the development of a set of five guidelines intended for improving social presence in board game artificial opponents. Finally, in order to illustrate how one can implement such guidelines, we give an example of how we implemented them in a scenario where a digital table is used as an interface for a board game and a social robot plays Risk against three human opponents.

Keywords Social presence · Board games · Artificial opponents

7.1 Introduction

Evidence of the existence of board games date back to at least 3100 BC where a variation of the game Senet, probably the oldest game in the world, was found (see Fig. 7.1). This type of game has always been associated with rich social environments. Playing board games is generally a social event where family and friends get together

A. Pereira (✉) R. Prada · A. Paiva
INESC-ID and Instituto Superior Técnico, University of Lisbon, Lisbon, Portugal
e-mail: andre.a.pereira@tecnico.ulisboa.pt

R. Prada
e-mail: rui.prada@tecnico.ulisboa.pt

A. Paiva
e-mail: ana.paiva@inesc-id.pt

A. D. Cheok et al. (eds.), *Entertaining the Whole World*,
Human–Computer Interaction Series, DOI 10.1007/978-1-4471-6446-3_7,

Fig. 7.1 Nefertari playing Senet. Painting in tomb of Egyptian Queen Nefertari

around a table and engage in face-to-face interactions, reading each other's gestures and facial expressions. Examples of such rich social interactions can be identified when we look at more recent examples of board games. Players laugh with each other when someone makes an ugly drawing playing Pictionary, yell at each other when someone makes a bad deal at Monopoly, use their facial expressions to bluff while playing Poker, or can even mock somebody who does not know the answer to a simple Trivial Pursuit question.

However, the static nature of tabletop games can limit the scope of realisable games (Magerkurth et al. 2004) when compared to console or PC games. An area named computer augmented tabletop games (Magerkurth et al. 2005), tries to maintain the social aspects of these traditional board games and augment them with computerized benefits. Computer augmented tabletop games gives us the best of two worlds: the interaction and communication between the players, who sit around the same table, facing each other at an intimate distance, and the computing support that can enhance games with visual and audio effects or relieve players from tasks such as score keeping. One of the benefits from this hybrid form of interaction is the possibility of creating artificial opponents. However, opponents in such novel environments are still scarce and generally don't have any kind of embodiment or believable social behaviour. The social inability of current artificial opponents results in humans perceiving them as not socially present.

This paper addresses the possibility of using today's technology to maintain user's perceived social presence towards an artificial opponent steadier over longer periods of time. In order to do so, we start by reviewing some literature on social presence and performing some initial studies. Afterwards we establish guidelines for creating socially present board game opponents and following these guidelines, we have developed a scenario where an artificial opponent plays Risk against three human players. These guidelines and the reported scenario presented in this paper provide useful information on how to develop the next generation of board game opponents that aim to be socially present.

7.2 Related Work

Humans consider many media devices as social beings (Reeves 1996). Social agents or artificial opponents can be examined as one instance of this effect. In this section, we start by analysing the concept that measures the extent in which such effect occurs, the concept of Social Presence. Following, as research in artificial opponents is still very scarce in terms of social behaviour, in order to tackle the social deficits of existing artificial opponents, we will look at research in socially intelligent and embodied agents.

7.2.1 Social Presence

Techniques for representing others in order to evoke social presence have an ancient history that dates back to the first stone sculptures (Biocca et al. 2003). More recently, many science-fiction movies or books include characters such as intelligent computers, robots, and androids that also provoke the same kind of social responses from the audience or the reader (Lombard and Ditton 1997). With the evolution of technology, new interactive media have been progressively designed to evoke the same social responses from its users. With this new type of media, an increasing number of quasi-social relationships are being established with computers, robots and intelligent virtual agents. These kinds of relationships are still quite unexplored in traditional sciences, but some researchers already assessed how individuals interact and relate to these entities.

In 1950, the "Turing Test" (Turing 1950) launched the debate on the potential that modern computers have to mimic humans. Later in 1996, Reeves and Nass (Reeves 1996) demonstrated that computer interfaces can generate strong and automatic social responses from minimal social cues, and that most of the times these responses occur with the user being quite aware that he is facing a machine and not a social being. This phenomenon seems to exist even with today's less sophisticated computers, but it appears stronger when computers use natural language, interact in real time, have an embodiment, or exhibit a believable social behaviour.

People treat media entities in social manners, while knowing that these entities do not have real emotions, ideas or bodies. They could ignore these entities as they are not real, but they do not because they attribute social presence to them. Studying social presence can contribute to the understanding of human social behaviour while using these types of technologies and achieving a sense of social presence is the design goal of many types of hardware and software engineering. Social presence theory can allow researchers and designers to guide their design and to anticipate and measure differences on new types of social technology. Instead of using trial and error exploration, a better understanding of what social presence is and how we can improve it can save valuable time and money and improve the end-product in the design of new media technologies (Lombard and Ditton 1997).

Many studies regarding social presence are found in new forms of human-human communication such as computer conferencing (Rourke et al. 1999). But social presence is also used to measure individual's perception of a particular interactive media, be it a virtual reality environment (Heeter 1992; Slater 2009) or the interaction with a social robot (Schermerhorn et al. 2008).

In the rest of this subsection we will look at definitions of social presence and what are its contributing factors.

Definitions The term "presence"originally refers to two different phenomena (Witmer and Singer 1998; Biocca et al. 2001b; Heerink et al. 2008), telepresence and social presence.

Telepresence can be defined "as the sense of being there", and social presence, "the sense of being together with another". Telepresence is a reoccurring concept in the area of teleoperator systems and was introduced by Minsky in 1980 (Minsky 1980). Initially, Minsky described it as the sense of being at the location of a remote robot that the user is operating. This concept is also often used for the feeling of "being there" in virtual environments (Witmer and Singer 1998; Biocca et al. 2003).

The other phenomenon, social presence, was initially proposed by Short Williams and Christie (Short et al. 1976) as "the degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationships". More recently, Biocca argued that since we are social beings the most common purpose of physical presence is to increase the sense of social presence (Biocca et al. 2001a). Biocca (1997) proposes a definition of social presence that is more oriented to human-computer interaction: "the amount of social presence is the degree to which a user feels access to the intelligence, intentions, and sensory impressions of another".

A distinct definition by Lombard and Ditton (1997) defines presence as the perceptual illusion of non-mediation. The term perceptual is used to indicate that the feeling of presence towards an object or an entity, involves continuous real time responses from the humans sensory, cognitive and affective processing systems. Non-mediation is mentioned to indicate when the user fails to perceive the existence of a medium, or when the user reacts as if the medium is not in their environment.

Recently, in the field of virtual environments, more specifically cave like environments (Cruz-Neira et al. 1992), Slater defined two distinct concepts (Slater 2009) that are analogous to the concept of social presence: Place illusion and Plausability illusion. The first is about how the world is perceived and the latter about what is perceived.

Place illusion relates to the concept of Telepresence. It is defined as the feeling of being in the place depicted by the virtual environment, even though the user knows he is not there. Slater argues that place illusion cannot occur in computer games when they are played using desktop systems. However, he argues that in principle it is possible to simulate place illusion by playing a computer game inside an immersive or pervasive system.

Plausibility illusion relates to the illusion that what is happening is really happening, even though the user knows it is not. It is also described as the extent in which the system can produce events that relate to the participant, and to the credibility of the scenario being depicted in comparison with user's expectations. In order to achieve Plausibility illusion, credible scenarios with very little room for error and with plausible interactions between participants and entities in the environment are required. In our case, the focus is in modelling socially believable artificial opponents for board games, where the virtual environment is mainly comprised by a virtual opponent. Here, plausibility illusion directly relates to definitions of social presence whereas seen above, can be shortly described as "the sense of being together with another". Slater also argues (Slater 2009), that plausibility illusion (social presence, in our case) is a more fruitful and challenging research area than place illusion or telepresence.

Contributing Factors to Social Presence Social presence can be used to measure the individual's perception of a particular interactive media, be it a virtual reality environment (Heeter 1992; Slater 2009) or the interaction with a social robot (Schermerhorn et al. 2008). Properties of the medium, context of interaction and individual differences will change the way we experience social presence, this presence can be superficial or strong enough to elicit powerful emotional reactions, such as crying at a movie screening or smiling at a computer character. Several authors have discussed which factors influence social presence, but none of them has focused in artificial opponents before. In the remaining of this subsection we gather the factors that we conceptualise to be the most important for creating a board game artificial opponent.

Interactivity Interactivity is referred by most authors as the primary cause of presence. If users cannot interact with an artificial agent, they usually do not consider it as a social entity. There are different modes of interacting with a virtual agent, but in terms of social presence, face-to-face interaction is still considered the gold standard in communication, against which all platforms are compared (Adalgeirsson and Breazeal 2010). Social presence is assumed to be highest when two people are within reach of each other interacting on a task (Biocca et al. 2001b). As such, virtual agents that do not use the rich set of social behaviours and cues involved in face-to-face interaction are assumed to support less social presence. One reason why face-to-face interaction is preferred is that a lot of familiar information is encoded in the non-verbal cues that are being exchanged.

Face-to-face interaction is generally accompanied with verbal communication. Machines are still quite limited in understanding the human counterpart in this respect, both in terms of speech recognition and dialogue systems. However, there are already some successful cases of virtual agents that are able to verbally interact with humans in very contextualized scenarios (Anderson 2008). The output of such systems is generally implemented by using pre-recorded utterances or by text-to-speech systems. Voices with higher audio realism and fidelity increase the illusion of interaction with a social entity (Lombard and Ditton 1997). High quality text to speech

Table 7.1 Factors relevant for achieving social presence in terms of interactivity

Interactivity
Face-to-face interaction
Verbal communication
Quick feedback

systems are widely available nowadays but using them with emotional capabilities has not evolved greatly since 2005 (Turk et al. 2005). Voice is a potent social cue, it can even evoke perceptions that a machine has multiple distinct entities (Nass and Steuer 1993) or even personalities (de Ruyter et al. 2005) so it is an highly important factor for the perception of social presence.

Interactions should also feel natural and quick. Systems should have quick feedback, for the user to feel immediacy of control, as delays between actions and reactions can diminish the sense of presence (Lombard and Ditton 1997). In robots or on-screen characters, having a responsive real time gaze system can alone produce a high sense of agency and increase the agent's perceived social presence (Yoshikawa et al. 2006).

In Table 7.1, a summary of the interactivity factors that we consider most relevant for improving social presence in board game artificial opponents, is presented.

Individual Differences Different age groups can sometimes experience social presence with different intensities. Children may more easily perceive a machine as alive, as they have less difficulty in attributing human characteristics to virtual agents or robots (Beran and Ramirez-Serrano 2010). Older people may be influenced by other factors, such as the need to overcome loneliness. Heerink et al. (2008) assessed that loneliness directly influences social presence and the acceptance of a companion robot by older people.

The observer's ability to focus on the virtual environment and ignore distractions (selective attention) also increases presence (Witmer and Singer 1998). When users focus more attention on a stimuli, they become more involved in their experience, which leads to an increased sense of presence. Conversely, personal problems or outside tasks can hinder the users' potential to feel presence. Users that are worried with personal problems or focused on outside activities will most probably attribute less attention to the task in hand.

When we are interacting with media applications we often feel emotionally connected to an event or a character. When the connection is strong enough the character can trigger emotional expressions from the human side. The intensity and valence of experienced emotions such as fear or strong empathy seem likely to affect presence (Lombard and Ditton 1997). Moods are also reported to change how we percept digital entities, if we are feeling sad or disturbed we may give less attention to digital media compared to when we are in a more relaxed state.

User's personality type is also an important factor for experiencing social presence. One experiment by Lee and and Nass (2003) shows that when users' personality matches a synthesized computer voice personality it positively affects user's feelings of social presence.

Table 7.2 Factors relevant for achieving social presence in terms of individual differences

Individual differences
Age and gender
Selective attention
Emotional state
Personality
Knowledge and prior experience

Knowledge and prior experience with the medium likewise influence the sense of social presence. Social presence varies across individuals and across time for the same individual. When we have been exposed for a long time to media artifacts we have a higher knowledge of interacting with it, and it is possible to have an increased feeling of social presence. However, most times continued experiences causes the well-known habituation or novelty effect (Karapanos et al. 2009), this effect causes an initially higher sense of presence that fades away as users become more experienced with novel technology. This novelty effect is present in almost all types of media, including artificial agents or robots (Gockley et al. 2005).

In Table 7.2 we list the factors that influence social presence in terms of individual differences.

Realism When we are watching a dramatic film, playing a video game or interacting with a virtual character, if the story or persona being presented to us makes sense and is consistent with the experience the story, or character is more likely to ring true for its users. Below, some factors that influence the realism of artificial opponents are described (also summarised in Table 7.3).

The ability to attribute mental states to oneself and to others is fundamental to human cognition and social behaviour (Sodian and Kristen 2010). Biocca et al. (2001b), quoted the importance that theoryof mind has in social presence. He defines social presence as the sense of "being together with another" and attributes this sense to the ability to relate to, or to construct mental models of another's intelligence. If we can interact with an agent and create a mental model of its behaviour it will helps us to anticipate the agent's behaviour and to judge its consistency.

The number and quality of the sensory channels are important for generating a sense of presence, but the consistency between all of the different modalities is one of the most important keys for achieving social presence: "the information received through all channels should describe the same objective world" (Lombard and Ditton 1997). If we do not meet this criterion, we emphasize the artificial and lessen the feeling of social presence. Correlations between actions and reactions should be credible when compared to events that would be expected in reality in similar circumstances.

Slater (2009), refers that another important factor for presence is the existence of some events not directly related to the users' actions, showing some autonomy in the environment or character. In a cave like environment (Garau et al. 2004) participants spent approximately five minutes in a virtual bar interacting with five virtual characters. Participants reported to automatically respond to the virtual characters present in the bar in social ways. They attempted to engage virtual characters by

Table 7.3 Factors relevant for achieving social presence in terms of realism

Realism
Theory of mind
Consistency
Autonomy
Embodiment
Social and emotional behavior

saying "hello", and by waving at them. These virtual characters had limited social behaviour. However, mutual gaze combined with lucky randomness was perceived by participant's as the characters were watching and imitating them.

Embodiment is also important for designing a computer that aims at achieving a higher sense of social presence. In Jung and Lee (2004), participants felt a significantly stronger sense of social presence when they were interacting with a physically embodied Aibo robot than with a physically disembodied Aibo displayed on an LCD screen.

Research indicates that humans and computers can work together more effectively (Schermerhorn et al. 2008) if human-like cues extracted from usual social behaviour are employed. We use our emotions in our social world almost constantly. We use them for communication, signalling and for social co-ordination. This kind of natural social primitives can be interpreted by humans without the need to learn something new. As so, a human-like computer can cause social facilitation in users and endowing agents with emotional behaviour can contribute to the realism of a character and thus to the perceived social presence.

7.2.2 Social Relationships with Intelligent Agents

Humans can build social relationships with a large variety of entities. In some cases, interaction with pets complements or even substitutes interpersonal relationships (Veevers 1985). The same phenomenon is beginning to happen with digital entities. Social relationships can now be established with new forms of artificially intelligent beings, such as a simple desktop or laptop (Reeves 1996), virtual agents (Cassell 2000) and robots (Brooks et al. 2004; Breazeal 2002; Jung and Lee 2004). In this subsection we will look at some research examples where embodied agents, being it screen characters or social robots, are designed with some kind of social behaviour.

The term "socially interactive robots" has been used by Fong et al. (2003) to describe robots for which social interaction plays a key role. These robots are important in application domains where social skills are required. These domains include those where the ability to cooperate with humans by helping them to fulfil a task (Cao et al. 1997) is important, or domains where the primary function of the robot is to socially interact with people such as companion robots (Dautenhahn et al. 2005) or robots for learning or education (Argall et al. 2009).

Breazeal argued (Breazeal 2002) that it is still very difficult to develop a robot that behaves in a naturalistic manner similar to an adult. As such, and to take advantage of human social expectations, she created Kismet, a robot that behaves and is successfully perceived as an infant even by adults.

Leonardo (Brooks et al. 2004) is another robot specifically designed for social interaction by means of facial expressions and life-like body poses. A social game that uses this robot along with speech and gesture recognition, was created. The objectives of the game were to teach the robot names and locations of different buttons placed in front of it, and then check to see if it knew the names by asking him to push the buttons again. Leonardo is constantly shifting its gaze between the object and the human to direct the human's attention to what it needs help with. The authors claim that these kinds of behaviour ensure that Leonardo acts as expected by a socially-aware play partner.

A social robot developed by Phillips Research, the iCat robot (van Breemen 2004), can communicate information through multicolour LEDs in its feet and ears, can use natural language synthesis through its speakers, and is also capable of mechanically rendering facial expressions and give emotional feedback to the user. The iCat can be considered a social robot since it has many of the characteristics needed to simulate human-to-human interaction. This robot has been used to study the influence of many social aspects such as personality (van Breemen et al. 2005), emotional exchange (Leite et al. 2008) and social acceptance by older people (Heerink et al. 2008).

Within 3D and virtual reality communities a large number of works also studies the incorporation of socially intelligent virtual characters into virtual and augmented reality environments (Holz et al. 2009). However, like most studies conducted on social robots, they are mainly focused on interactions of a single user with a single character. Autonomous characters or robots generally lack the necessary social skills to interact in a group. One example that tackles this challenge is a multi-agent collaborative game called Perfect Circle (Prada and Paiva 2009) where the user controls a character that can interact with four other autonomous agents. The group formed by the player and the autonomous agents must search a virtual world for a magical item that enables them to complete the game. The autonomous agents are endowed with social skills that allow them to interact in groups with human members. In this game, the autonomous characters exhibit behaviours that depended and are in agreement with the group's composition, context and structure. To win in this simulation, players have to be aware of the social relations with the autonomous characters. Results in this study showed that the model had positive effects on users' social engagement, namely, on their trust and identification with the group.

These examples are somewhat successful in socially engaging users in short term interactions. Socially engaging users in long term interactions is a much more challenging task that is beginning to be researched in human-agent interaction.

Long Term Interactions One of the first long-term experiments with social robots was performed using a service robot named CERO (Huttenrauch and Eklundh 2002). This robot assisted motion impaired people in an office environment. After participants fully integrated the robot into their work routine, researchers concluded that when robots interact with real people, they need to be aware of the shared social environment and be capable of social interaction.

Another long-term experiment was performed by Kanda et al. (2004). The study describes a field trial evaluation for two weeks with elementary school Japanese students and two English-speaking interactive humanoid robots behaving as peer English tutors for children. The study revealed that the robot failed to keep most of the children's interest after the first week, mostly because the first impact created unreasonably high expectations in the children.

A longer study was carried out at Carnegie Mellon University using Valerie, a "roboceptionist" (Gockley et al. 2005). Students and university visitors interacted with the robot over a nine month period. The results indicated that many visitors continued to interact daily with the robot, but over a certain period of time only few of them interacted for more than 30 s.

Some of the studies on long-term human-computer relationships are grounded on human social psychology theories, such as the work of Bickmore and Picard (2005). They developed a social agent and evaluated it in a controlled experiment with approximately 100 users who were asked to interact daily with an exercise system. After four weeks of interaction, the social behaviours increased the participant's perceptions of the quality of the working alliance (on measures such as liking, trust and respect), when comparing the results with an agent without social behaviours. Besides, participants interacting with the social agent expressed significantly higher desire to continue interacting with the system.

So how do we design for long-term interaction? To develop artificial agents that are capable of building long-term social relationships with users, we need to model the complex social dynamics present in human behaviour (Leite et al. 2010). For users to remain engaged for months, or years, social agents need to be capable of long-term adaptiveness, associations, and memory (Fong et al. 2003). Also, if the interaction with a social agent is enjoyable throughout long periods of time, users may eventually spend more time interacting with them. This is an important step for designing artificial companions or, in our case, opponents that are capable of engaging users in the long term.

7.3 Towards Socially Present Board Game Opponents

Current artificial opponents lack social presence and when human players perceive artificial opponents as not socially present, their enjoyment while interacting with them decreases. Johansson (2006) stated that "bots are blind and objective, while humans may decide to eliminate the bots first, just because they are bots". This sentence shows that, over repeated interactions, humans attribute very low sense of social presence to artificial opponents. To struggle this kind of degradation in interaction, in this section, we present five guidelines for designing more socially present board game opponents.

In this section, we will argue that to improve social presence an artificial board game opponent should:

1. *Be physically embodied and be able to engage users in face-to-face interactions*
2. *Exhibit believable verbal and non-verbal behaviours*
3. *Have an emotion system*
4. *Be able to recognise, greet and remember users*
5. *Simulate social roles common in board games*

7.3.1 Physical Embodiment and Face-to-Face Interaction

When playing board games against digital opponents the social possibilities are restricted. When someone plays against a human opponent, he/she can try to look for a hesitation or an expressed emotion that could indicate a bad move. In contrast when playing against a computer, in most cases, we can only see pieces moving on a graphical interface. Nevertheless, as we have seen in our related work we can already encounter some embodied artificial opponents. Artificial opponents are in most part represented by simple avatars (static pictures) or by two or three dimensional animated virtual agents. It has been reported in virtual poker environments that the simple addition of a picture to personify players can be considered as more likeable, engaging and comfortable (Koda and Maes 1996). We can also find examples where physically embodied agents (or robots) are used to simulate opponents. In our previous work, we have showed that by using a robotic embodiment, artificial opponents are reported to have an improved feedback, immersion and social interaction (Pereira et al. 2008).

Facial features might be the most important factor to embody in most tabletop game opponents. Users are not distracted by the presence of a face or facial expressions. Instead, they are more engaged in the task because they can try to interpret faces and facial expressions. The embodied use of facial features, believable movement and the ability to express or recognize emotional content are also important factors for artificial opponents and for achieving a higher sense of social presence, as argued in subsection 7.2.1.

As such, a board game artificial opponent should have a physical embodiment and be able to engage in face-to-face interaction with one or multiple participants. Placing more than one person in media interactions can be an easy way to induce a sense of presence regardless of the other perceptual features of the world (Heeter 1992). The number of entities (being them virtual or human), influence positively the perception of social presence in an interactive system.

7.3.2 Believable Verbal and Non-Verbal Behaviour

When we interact with virtual characters or robots, verbal communication offers the most attractive input and output alternative. We are familiarized with it, requires minimal physical effort from the user, and leaves users' hands and eyes free (Yankelovich et al. 1995). In Andre Pereira and Paiva (2011), we analysed the verbal communication in a board game and identified the most relevant categories to simulate dialogue in an artificial opponent.

Non-verbal behaviour is used for communication, signalling and for social coordination. This kind of natural social behaviour can be interpreted by humans without the need to learn something new. As such, a human-like computer that can express patterned non-verbal behaviours can cause social facilitation in users. Believable non-verbal behaviours can show autonomy and contribute to the feeling of social presence towards an agent. In robots or screen characters, having a responsive real time gaze system can alone produce a high sense of agency and increase the agent's perceived social presence (Yoshikawa et al. 2006).

Besides choosing the best move to play, artificial opponents should grab players' attention by using both verbal and non-verbal behaviours. An opponent can for example show a sad expression attached with a sad speech when losing and a pride expression associated with an excited speech when winning. Showing these kind of behaviours should increase interactivity and realism (see Sect. 7.2.1) and users should be able to attribute mental states towards the artificial opponent and perceive it as a social entity.

7.3.3 Emotion or Appraisal System

Emotion is a relevant topic in multiple disciplines such as philosophy, psychology, neuroscience, machine learning and, most recently, in affective computing (Picard 2000). It is universally recognized that emotions have a powerful influence in our decision-making (Damasio 1994). The same holds true when players make decisions while playing board games, they let their emotions take part in their decision process. Appraisal theories seem like the best alternative for influencing the decision process with emotions and for generating emotional behaviour in an artificial opponent. Appraisal is an evaluation of the personal significance of events as central antecedents of emotional experience. Appraisal theories specify a set of criteria or dimensions that are presumed to underlie the emotion constituent appraisal process. These theories (Lazarus and Folkman 1984; Sander et al. 2005; Scherer 2001) are built upon studying our brain processes and the difficulty of simulating appraisal models in computers is related to the complexity of the mental structures that need to be simulated. However, some projects (Aylett et al. 2005; Bartneck 2002; Paiva et al. 2004) already successfully used an appraisal model, the OCC model (Ortony et al. 1990), to simulate human cognitive processes in their applications.

In our previous work, a social robot provided feedback on the users's moves by employing facial expressions determined by the robot's appraisal system. This appraisal system was composed by an anticipatory mechanism that created expectations on children's upcoming moves, and then based on the evaluation of the actual move played by children, an affective state was elicited, resulting in different facial expressions for the robot. It was shown that the emotional behaviour expressed by this social robot increased the user's understanding of the game (Leite et al. 2008).

The importance of emotions for simulating social behaviour in an artificial entity was already mentioned in our related work where we identified emotional behaviour as one of the contributing factors for the perception of social presence (see Sect. 7.2.1) and in subsection 7.2.2 we discussed the importance that emotions have in socially intelligent agents. Summarizing, an artificial opponent should have an emotion or appraisal system in order to make better judgements and to simulate human emotions.

7.3.4 Recognise, Greet and Remember Users

In order to greet, recognise, gather a history or mention past events with users, an artificial opponent has to be able to recognize the user, or each user individually if playing against multiple opponents. In computer games, generally, players create a profile and when they login by using it, the system recognizes the user. The same concept can be used by an artificial opponent but more natural interactions are preferable. By using video sensors, artificial opponents can already deal with face detection and recognition. However, vision algorithms that deal with such problems are still quite unreliable.

At the beginning of almost every social interaction, an initial introduction or a greeting behaviour is appropriate and essential to take off most social interactions. We can obviously see this behaviour as constant in board game players. And if we want to create socially present artificial opponent's we should not skip this important phase. Once that initial greeting behaviour has occurred, remembering, deciding upon or mentioning our past history with others is one of our most important social features and maybe the most essential way of establishing and maintaining relationships. Sharing personal interests or preferences, as well as showing some understanding of others' interests or preferences is also a fundamental point in most relationships.

Complex models of the human memory can already be seen in human robot interaction research. The importance of such mechanisms for fighting the habituation/novelty effect and for achieving longer term interactions, have also been reported (Bickmore and Picard 2005; Leite et al. 2009). In board games, we can assess the importance of these mechanisms by some common game situations. Such situations include when players' speech and in-game actions are influenced by previous negative or positive relations established with others or by events that took place earlier in the game, or in previous games.

In order to create believable agents that play more than one game with the same participants, they have to recognize each user, remember them individually and its past interactions with them.

7.3.5 Simulate Social Roles

Our final guideline is inspired by a rule of thumb described by Eriksson et al. (2005), that games should allow different modes of play based on social roles. Risk and most board games already support multiple social roles in their game-play. The challenge in this case is not to build games that can support various social roles. Instead, the challenge consists of endowing artificial opponents with the capability of simulating such roles.

Examples of social roles in board games are: *Helper*—actively helping another player perform actions in the game; *Dominator*—trying to influence other players to perform specific actions for the player's own in-game benefits; *Negotiator*—negotiating between two other players; and *Exhibitionist*—performing actions in the game to gain the other players' attention.

During the length of a single board game, players constantly change between social roles. A player that is displaying the social role of helper towards one player can later on adopt the social behaviour of dominator towards that same person. Concurrent social roles can also happen while playing board games. Players can, for example, exhibit both the social role of negotiator and dominator to try to influence players using external negotiation. Such social roles should be taken into consideration when developing artificial opponents for board games.

7.4 Scenario

We developed a scenario where an artificial opponent plays the Risk board game against three human players. The goal of this artificial opponent is to be able to socially interact with multiple humans and still be socially perceived for extended periods of time. The human players use a digital table as the game's interface and Risk was chosen because it is a game where face-to-face interactions, social actions and strategic social reasoning are important components of the interaction.

In this section, we go through the guidelines presented on the previous section and explain how we chose to implement them.

7.4.1 Physical Embodiment and Face-to-Face Interaction

In our scenario, over one side of the table stays the social robot that interacts with three other players on the three other sides of the table (see Fig. 7.2). With the use of a digital table, human players are able to freely communicate between them and still be aware of the game state as it happens in Eriksson et al. (2005). By using a digital table as compared to a vertical display, multiple players can more easily be engaged with both the game and by each other (Rogers and Lindley 2004). This includes the robot that inhabits the same physical space.

We have built a custom digital table and we are using a robotic head to embody our artificial opponent. By using a social robotic head, our board game opponent is able to engage in face-to-face interaction with multiple participants. For embodying our social Risk opponent we are using a social robotic head, the EMYS (EMotive headY System) robotic head (Ribeiro et al. 2011). EMYS is a "turtle" type head

Fig. 7.2 Computer augmented risk game

that can perform facial expressions and gaze by using 11 degrees of freedom. Audio speakers are used because EMYS does not have integrated speakers. A kinect sensor is also used for speech direction detection.

One of the main limitation of our scenario is that our robot does not have any speech recognition capabilities. This was a design decision, since that with today's technology it would be almost impossible to recognize speech in a scenario where three different users may be talking concurrently. As such, for receiving user's input, our robot as in Castellano et al. (2009), only considers information provided by in-game actions. Users can only "communicate" with the agent by attacking it or by proposing an alliance using the interface on the digital table. The robot is able to perceive such events without using any kind of speech recognition. We believe that by making the proposal and acceptance of alliances occur in the virtual interface does not deteriorate the social experience and gives more contextual information about the task to the robot.

However, for achieving believable face-to-face interactions we have developed a gaze system that equips our robot with the capacity of interacting with multiple players simultaneously.

7.4.2 Believable Verbal and Non-Verbal Behaviour

The robot's non-verbal behaviour and gaze system is influenced not only by the agent's own appraisal system but also by the other players' voice and game actions.

The facial expressions and idle behaviours for our embodiment were developed by Ribeiro et al. (2011, 2012). These authors, took inspiration from principles and practices of animation from Disney and other animators, and applied them on the development of emotional expressions and idle behaviours for the EMYS robot. The idle behaviour was adapted to our scenario to work in conjunction with the gaze system. Facial expressions are used in our scenario for establishing turn-taking and for revealing internal states like confusion, engagement, liking, etc.

The robot's non verbal behaviour also has a mood variable that can be either positive or negative. Like in our previous scenario (Leite et al. 2008), this variable is mapped to a positive or negative posture.

Regarding the robot's verbal behaviour we defined a typology of speeches adapted to the Risk game by separating utterances that human players vocalize in different categories (Prada et al. 2011). This categorization helped us in pinpointing the most important behaviours in Risk but also a database of possible utterances. This database contributed for the creation of a believable vocalization system, as the utterances in this system were retrieved from real human social behaviour. In our scenario, a high quality text to speech is used to vocalize these utterances.

7.4.3 Emotion or Appraisal System

After performing studies on the original Risk game, we were able to extract the most relevant variables that influence human's appraisal. We achieved this by asking participants to think out loud while they were playing Risk. These appraisal variables evolve during the game and some of them are stored in the agent's memory for future interactions. The chosen variables and how these variables are computed is in our opinion quite scenario dependent. The ones we chose were based upon the results of our studies and how we compute them by a simplification of each of these processes. However, most of these variables might make sense in many other scenarios.

Our artificial opponent's emotion system is comprised by several appraisal variables. Variables such as *power, mood* and *concentration* influence the robot's gaze system and idle behaviour. *Relevance* of an event influences our robot's dialogue system. Also, when generating dialogue or choosing the next move to play, our artificial opponent takes into account relationship appraisal variables established towards particular users. These variables are *familiarity*, *like/dislike* and *luck perception*.

7.4.4 Recognise, Greet and Remember Users

In our application we simplified the recognition process by making each user login with their own private interface on the digital table. At that time the robot acknowledges the presence and position of a user, greets that particular user, and updates the history with him/her.

Some of the appraisal variables described in the subsection above evolve only during the game, but some are stored in the agent's memory for future interactions.

Familiarity is one variable that is stored in the agent's memory and will be remembered in future interactions. Luck perception is also stored in memory, so the agent can assess and comment if a player was lucky in previous games. Like/Dislike variables are also stored so the robot discloses, for instance, that it holds a "grudge" against a particular player, because of previous games. The last data that is stored in memory are the results and dates of previous matches. This type of data is often mentioned in the beginning of the interaction, where the robot says for example: "One week ago I lost against all of you, this time I am going to win!".

7.4.5 Simulate Social Roles

In our observations of users playing Risk, we have indeed noticed that users use social roles and change between them throughout the game. Examples included players that in one phase of a game were exhibiting a Helper social role (actively helping another player without seeking any in-game benefit) and in later parts of the game a violator role towards the same player (giving up in the game and trying to destroy another player just because of an argument).

Risk is a highly social game that supports various social roles in its gameplay. However, we did not designed our social opponent to play specific social roles. The roles appear naturally by using our appraisal variables to influence the robot's social behaviour. For example, when the agent "likes" other players it often demonstrates the social role of helper by saying encouraging comments such as "It went well this turn!". Also, when the agent has a great advantage (high power) over the other players it is also more likely to adopt the dominator role by for example threatening other players.

7.5 Conclusions

By taking considerations from our previous design experience with board game opponents, research on the contributing factors for social presence, state-of-the-art research in socially intelligent agents and long term interaction with social agents, we present a scenario where a social agent has the capacity of being perceived as more socially present by complying with a set of five guidelines.

These guidelines are presented in this paper, and by applying them to our particular scenario, we created a physically embodied artificial opponent that is able to engage users in face-to-face interactions, has an emotion system used for exhibiting believable verbal and non-verbal behaviours, is able to recognise, greet and remember users, and uses all of these capabilities to simulate common board game social roles.

We believe that the guidelines proposed in this article can contribute to the creation of the next generation of board game opponents.

Acknowledgements The research leading to these results has received funding from European Community's Seventh Framework Program (FP7/2007-2013) under grant agreement no 215554, supported by national funds through FCT—Fundação para a Ciência e a Tecnologia, under project PEst- OE/EEI/LA0021/2013, the PIDDAC Program funds, and a scholarship (SFRH/BD/41585/2007) granted by FCT.

References

Adalgeirsson, S. O., & Breazeal, C. (2010). *Mebot: A robotic platform for socially embodied presence*. Proceeding of the 5th ACM/IEEE international conference on human-robot interaction, pp. 15–22. ACM.

Anderson, J. N., Davidson, N., Morton, H., & Jack, M. A. (2008). Language learning with interactive virtual agent scenarios and speech recognition: Lessons learned. *Computer Animation and Virtual Worlds, 19*(5), 605–619. ISSN 1546-4261. doi:10.1002/cav.v19:5. http://dx.doi.org/10.1002/cav.v19:5.

Argall, B. D., Chernova, S., Veloso, M., & Browning, B. (2009). A survey of robot learning from demonstration. *Robotics and Autonomous Systems, 57*(5), 469–483.

Aylett, R. S., Louchart, S., Dias, J., Paiva, A., & Vala, M. (2005). FearNot!—An experiment in emergent narrative. In T. Panayiotopoulos, J. Gratch, R. Aylett, D. Ballin, P. Olivier, & T. Rist (Eds.), *Intelligent virtual agents* (Vol. 3661, Chap. 26, pp. 305–316). Berlin: Springer.

Bartneck, C. (2002). eMuu—An embodied emotional character for the ambient intelligent home. Unpublished Ph.D. thesis, Eindhoven University of Technology, Eindhoven.

Beran, T. N., & Ramirez-Serrano, A. (2010). *Do children perceive robots as alive?: Children's attributions of human characteristics*. Proceeding of the 5th ACM/IEEE international conference on human-robot interaction, pp. 137–138. ACM.

Bickmore, T. W., & Picard, R. W. (2005). Establishing and maintaining long-term human-computer relationships. *ACM Transactions on Computer-Human Interaction (TOCHI), 12*(2), 293–327.

Biocca, F. (1997). *The cyborg's dilemma: Embodiment in virtual environments*. In Cognitive Technology, 1997. Proceedings of second international conference on humanizing the information age, pp. 12–26. IEEE.

Biocca, F., Burgoon, J., Harms, C., & Stoner, M. (2001a). *Criteria and scope conditions for a theory and measure of social presence*. Presence: Teleoperators and virtual environments 2001 conference, Phildelphia.

Biocca, F., Harms, C., & Gregg, J. (2001b). *The networked minds measure of social presence: Pilot test of the factor structure and concurrent validity*. Fourth annual international workshop on presence, pp. 9–11.

Biocca, F., Harms, C., & Burgoon, J. K. (2003). Toward a more robust theory and measure of social presence: Review and suggested criteria. *Presence: Teleoperators and Virtual Environments, 12*(5), 456–480.

Breazeal, C. (2002). Designing sociable machines: Lessons learned. In K. Dautenhahn, A. H. Bond, L. Canamero, & B. Edmonds (Eds.) *Socially intelligent agents* (pp. 149–156). New York: Springer.

Brooks, A. G., Gray, J., Hoffman, G., Lockerd, A., Lee, H., & Breazeal., C. (2004). Robot's play: Interactive games with sociable machines. *Computers in Entertainment (CIE), 20*(3), 10–10.

Cao, Y. U., Fukunaga, A. S., & Kahng, A. (1997). Cooperative mobile robotics: Antecedents and directions. *Autonomous robots, 4*(1), 7–27.

Cassell, J. (2000). Embodied conversational interface agents. *Communications of the ACM, 43*(4), 70–78.

Castellano, G., Leite, I., Pereira, A., Martinho, C., Paiva, A., & McOwan, P. W. (2009). *It's all in the game: Towards an affect sensitive and context aware game companion*. Proceeding of

3rd international conference on affective computing and intelligent interaction and workshops, ACII 2009, pp. 1–8. IEEE.
Cruz-Neira, C., Sandin, D. J., DeFanti, T. A., Kenyon, R. V., & Hart, J. C. (1992). The cave: Audio visual experience automatic virtual environment. *Communications of the ACM, 35*(6), 64–72.
Damasio, A. R. (1994). *Descartes' error: Emotion, reason and the human brain*. New York: Grosset/Putnam.
Dautenhahn, K., Woods, S., Kaouri, C., Walters, M. L., Koay, K. L., & Werry, I. (2005). *What is a robot companion-friend, assistant or butler*? IEEE/RSJ international conference on Intelligent Robots and Systems (IROS 2005), pp. 1192–1197. IEEE.
de Ruyter, B., Saini, P., Markopoulos, P., & van Breemen, A. (2005). Assessing the effects of building social intelligence in a robotic interface for the home. *Interacting with computers, 17*(5), 522–541.
Eriksson, D., Peitz, J., & Bjőrk, S. (2005a). *Enhancing board games with electronics*. Proceedings of the 2nd international workshop on pervasive games-perGames. Citeseer.
Eriksson, D., Peitz, J., & Bjőrk., S. (2005b). *Socially adaptable games*. Proceedings of DiGRA 2005 conference: Changing Views–Worlds in play.
Fong, T., Nourbakhsh, I., & Dautenhahn, K. (2003). A survey of socially interactive robots. *Robotics and autonomous systems, 42*(3–4), 143–166.
Garau, M., Widenfeld, H. R., Antley, A., Friedman, D., Brogni, A., & Slater, M. (2004). *Temporal and spatial variations in presence: A qualitative analysis*. Proceedings of international workshop on presence, pp. 232–239. Citeseer.
Gockley, R., Bruce, A., Forlizzi, J., Michalowski, M., Mundell, A., Rosenthal, S., Sellner, B., Simmons, R., Snipes, K., Schultz, A. C., et al. (2005). *Designing robots for long-term social interaction*. IEEE/RSJ international conference on Intelligent Robots and Systems (IROS 2005), pp. 1338–1343. IEEE.
Heerink, M., Ben, K., Evers, V., & Wielinga, B. (2008). The influence of social presence on acceptance of a companion robot by older people. *Journal of Physical Agents, 2*(2), 33–40.
Heeter, C. (1992). Being there: The subjective experience of presence. *Presence: Teleoperators and virtual environments, 1*(2), 262–271.
Holz, T., Dragone, M., & O/'Hare, G. M. P. (2009). Where robots and virtual agents meet. *International Journal of Social Robotics, 1*(1), 83–93.
Huttenrauch, H., & Eklundh, K. S. (2002). *Fetch-and-carry with cero: Observations from a long-term user study with a service robot*. Proceedings of 11th IEEE international workshop on robot and human interactive communication, pp. 158–163. IEEE.
Johansson, S. J. (2006). *On using multi-agent systems in playing board games*. Proceedings of the fifth international joint conference on autonomous agents and multiagent systems, pp. 569–576. ACM.
Jung, Y., & Lee, K. M. (2004). *Effects of physical embodiment on social presence of social robots*. Proceedings of presence, pp. 80–87.
Kanda, T., Hirano, T., Eaton, D., & Ishiguro, H. (2004). Interactive robots as social partners and peer tutors for children: A field trial. *Human-Computer Interaction, 19*(1), 61–84.
Karapanos, E., Zimmerman, J., Forlizzi, J., & Martens, J.-B. (2009). User experience over time: An initial framework, pp. 729–738. ACM. http://portal.acm.org/citation.cfm?id=1518701.1518814.
Koda, T., & Maes, P. (1996). Agents with faces: The effect of personification. Proceedings of 5th IEEE international workshop on robot and human communication, pp. 189–194. IEEE.
Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal, and coping*. New York: Springer.
Lee, K. M., & Nass, C. (2003). *Designing social presence of social actors in human computer interaction*. Proceedings of the SIGCHI conference on human factors in computing systems, pp. 289–296. ACM.
Leite, I., Martinho, C., Pereira, A., & Paiva., A. (2008). *icat: An affective game buddy based on anticipatory mechanisms*. Proceedings of the 7th international joint conference on autonomous agents and multiagent systems, Vol. 3, pp. 1229–1232. International foundation for autonomous agents and multiagent systems.

Leite, I., Martinho, C., Pereira, A., & Paiva, A. (2009). As time goes by: Long-term evaluation of social presence in robotic companions. The 18th IEEE international symposium on robot and human interactive communication (RO-MAN 2009), pp. 669–674. IEEE.

Leite, I., Mascarenhas, S., Pereira, A., Martinho, C., Prada, R., & Paiva, A. (2010). "why can't we be friends?" An empathic game companion for long-term interaction. In A. Safonova (Ed.) *Intelligent virtual agents* (pp. 315–321). Heidelberg: Springer.

Lombard, M., & Ditton, T. (1997). At the heart of it all: The concept of presence. *Journal of Computer-Mediated Communication, 3*(2), 0–0.

Magerkurth, C., Memisoglu, M., Engelke, T., & Streitz, N. (2004). *Towards the next generation of tabletop gaming experiences*. Proceedings of graphics interface, pp. 73–80. Canadian Human-Computer Communications Society.

Magerkurth, C., Cheok, A. D., Mandryk, R. L., & Nilsen, T. (2005). Pervasive games: Bringing computer entertainment back to the real world. *Computers in Entertainment (CIE), 30*(3), 4–4.

Minsky, M. (1980). Telepresence. *Omni, 20*(9), 45–52.

Nass, C., & Steuer, J. (1993). Voices, boxes, and sources of messages. *Human Communication Research, 19*(4), 504–527.

Ortony, A., Clore, G. L., & Collins, A. (1990). *The cognitive structure of emotions*. Cambridge: Cambridge University Press.

Paiva, A., Dias, J., Sobral, D., Aylett, R., Sobreperez, P., Woods, S., Zoll, C., & Hall, L. (2004). *Caring for agents and agents that care: Building empathic relations with synthetic agents*. Proceedings of the third international joint conference on autonomous agents and multiagent systems, Vol. 1, pp. 194–201. IEEE Computer Society.

Pereira, A., Martinho, C., Leite, I., & Paiva., A. (2008). *icat, the chess player: The influence of embodiment in the enjoyment of a game*. Proceedings of the 7th international joint conference on autonomous agents and multiagent systems, Vol. 3, pp. 1253–1256. International Foundation for Autonomous Agents and Multiagent Systems.

Picard, R. W. (2000). *Affective computing*. Cambridge: The MIT press.

Prada, R., & Paiva, A. (2009). Teaming up humans with autonomous synthetic characters. *Artificial Intelligence, 173*(1), 80–103.

Prada, R., Pereira, A., & Paiva, A. (June, 2011). *Towards the next generation of board game opponents*. FDG'11: Proceedings of the sixth international conference on foundations of digital games.

Reeves, B. (1996). *The media equation: How people treat computers, television, and new media like real people and places*. New York: Cambridge University Press. (Stanford, Calif.: Center for the Study of Language and Information).

Ribeiro, T., & Paiva, A. (2012). *The illusion of robotic life: Principles and practices of animation for robots*. HRI, proceedings of the seventh annual ACM/IEEE international conference on human-robot interaction, pp. 383–390.

Ribeiro, T., Leite, I., Kedziersski, J., Oleksy, A., & Paiva, A. (2011). *Expressing emotions on robotic companions with limited facial expression capabilities*. Proceedings of 11th international conference on intelligent virtual agents, pp. 466–467. Springer.

Rogers, Y., & Lindley, S. (2004). Collaborating around vertical and horizontal large interactive displays: Which way is best? *Interacting with Computers, 16*(6), 1133–1152.

Rourke, L., Anderson, T., Garrison, D. R., & Archer, W. (1999). Assessing social presence in asynchronous text-based computer conferencing. *Journal of Distance Education, 14*(2), 50–71.

Sander, D., Grandjean, D., & Scherer, K. R. (2005). A systems approach to appraisal mechanisms in emotion. *Neural networks, 18*(4), 317–352.

Scherer, K. R. (2001). Appraisal considered as a process of multilevel sequential checking. In K. R. Scherer, A. Schorr, & T. Johnstone (Eds.) *Appraisal processes in emotion: Theory, methods, research* (pp. 92–120). New York: Oxford University Press.

Schermerhorn, P., Scheutz, M., & Crowell, C. R. (2008). *Robot social presence and gender: Do females view robots differently than males*? Proceedings of the 3rd ACM/IEEE international conference on human robot interaction, pp. 263–270. ACM.

Short, J., Williams, E., & Christie, B. (1976). *The social psychology of telecommunications*. Hoboken: Wiley.

Slater, M. (2009). Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. *Philosophical transactions of the Royal Society B: Biological Sciences, 364*(1535), 3549–3557.

Sodian, B., & Kristen, S. (2010). Theory of mind. In B. Glatzeder, V. Goel, & A. Müller (Eds.) *Towards a theory of thinking* (pp. 189–201). Heidelberg: Springer.

Turing, A. M. (1950). Computing machinery and intelligence. *Mind, 59*(236), 433–460.

Turk, O., Schroder, M., Bozkurt, B., & Arslan, L. M. (2005). *Voice quality interpolation for emotional text-to-speech synthesis*. Proceedings of Interspeech, Vol. 5, pp. 797–800. Citeseer.

van Breemen, A. J. N. (2004). *Animation engine for believable interactive user-interface robots*. Proceedings of IEEE RSJ international conference on intelligent robots and systems (IROS 2004), Vol. 3, pp. 2873–2878. IEEE.

van Breemen, A., Yan, X., & Meerbeek., B. (2005). *icat: An animated user-interface robot with personality*. Proceedings of the fourth international joint conference on autonomous agents and multiagent systems, pp. 143–144. ACM.

Veevers, J. E. (1985). The social meaning of pets. *Marriage and Family Review, 8*(3), 11–30.

Witmer, B. G., & Singer, M. J. (1998). Measuring presence in virtual environments: A presence questionnaire. *Presence: Teleoperators and Virtual Environments, 70*(3), 225–240.

Yankelovich, N., Levow, G. A., & Marx., M. (1995). *Designing speechacts: Issues in speech user interfaces*. Proceedings of the SIGCHI conference on human factors in computing systems, pp. 369–376. ACM Press/Addison-Wesley Publishing Co.

Yoshikawa, Y., Shinozawa, K., Ishiguro, H., Hagita, N., & Miyamoto, T. (2006). *Responsive robot gaze to interaction partner*. Proceedings of robotics: Science and systems. Citeseer.

Chapter 8
Observations on Tinkering in Scientific Education

Maarten H. Lamers, Peter van der Putten and Fons J. Verbeek

Abstract In recent years in arts, technology and science there appears an increasing push to use technology and design in a more personal and autonomous context, integrated with the physical world. Creative platforms are developed that open up personal digital/physical technology to larger groups of novice tinkerers, allowing people to take control of technology and prototype solutions to personal problems and aims. Likewise, education benefits by providing students with tools and platforms to learn by doing and making. However, these advances lead to new challenges for scientific research and education. In this chapter, we explore some of the opportunities and challenges and summarize these into key observations. Particular attention is given to tinkering in research-based education, and the opportunities for digital tinkering in emerging worlds.

Keywords Tinkering · Education · Constructionism · Science practice · Creative research

8.1 A Return to Grass-roots Technology Development

Many of today's technology heroes and aficionados started their careers by what can be considered as tinkering. Bill Gates and Steve Jobs are well-known examples, illustrated by anecdotes of working in garages with small, enthusiastic teams, supposedly working under playful conditions. For many they exemplify what tinkering and grass-roots initiatives could lead to. But also the Wii Remote tinkering projects by Johnny Chung Lee (www.johnnylee.net), shown on Youtube.com, have captured and sparked the imagination of many.

M. H. Lamers (✉) · P. van der Putten · F. J. Verbeek
Media Technology Group, Leiden Institute of Advanced Computer Science,
Leiden University, Niels Bohrweg 1, 2333 CA Leiden, Netherlands
e-mail: m.h.lamers@liacs.leidenuniv.nl

P. van der Putten
e-mail: p.w.h.van.derputten@liacs.leidenuniv.nl

F. J. Verbeek
e-mail: f.j.verbeek@liacs.leidenuniv.nl

A. D. Cheok et al. (eds.), *Entertaining the Whole World*,
Human–Computer Interaction Series, DOI 10.1007/978-1-4471-6446-3_8,

At the level of today's technology consumer, there appears to be an increasing desire to interface our technological power-machines to the real physical world. And power-machines they are, our personal computers, tablets and smart phones—equipped with highly advanced man–machine interaction technologies, communication possibilities, location-determining hardware, acceleration sensors, and more. However, for all their strengths and possibilities, they do not offer the connectivity to the physical world around us that many dream of. No smart phone is currently on offer that drives itself around the house to play with the cat. No tablet is equipped with motors and sensors that make it suitable to steer a child's soap-box cart. No current iPhone models have a user-accessible digital thermometer to play with. And in a way, this is what we more-and-more expect our technology to do (well, perhaps not exactly this, but similar things)—to connect our computational devices to the physical world.

This desire to connect may have been always present, but there appears to be more of a push towards closing the gaps between human and technology, by leveraging technology in a more personal, private and autonomous manner, under control of the user.

As a result, tinkering with digital/physical computing systems has gained much attention over the last few years. For example, the Wiring (www.wiring.org.co) and Arduino (www.arduino.cc) projects offer immensely popular tools for lower- to intermediate-level software and hardware tinkerers (e.g. Thompson 2008; Banzi 2008), spawning thousands of interesting home-grown projects. Similar projects are Raspberry Pi (www.raspberrypi.org), MaKey MaKey (www.makeymakey.com) and, more in the creative coding domains, Processing (www.processing.org) and OpenFrameworks (www.openframeworks.cc).

These initiatives gave rise to low-cost rapid prototyping tools that offer rich, if not full functionality, while hiding complex underlying structures from the developer. The frequent open-source nature of the projects kindles what is, in essence, a community-like support structure, and the ongoing generation of example code and libraries. All this makes it possible for single medium-skilled developers to master complex (physical) digital prototyping tools.

Observation 1 In recent years, physical and digital prototyping was fitted to the scale of the individual. After years of increasing technological complexity in the systems around us, the right combination of technological abstraction and openness has re-empowered individuals to understand, own and prototype solutions to their own problems and aims. This re-enables grass-roots technological development at a greater scale.

We, the authors, are involved in a creative research-based academic program. In this context, we incorporate tinkering with (physical-) digital prototyping tools into our own education. From the above observation, our experiences, and from our interest in scientific education, we present further observations on tinkering in scientific education. Small parts of this chapter were published previously (Lamers et al. 2013).

First, however, the next section will briefly review the etymological, conceptual and theoretical roots of tinkering. Section 8.3 will touch on what can be learned from tinkering. Both sections focus on the *what*-question before we move on to the *where*-question in Sect. 8.4. There we discuss the different contexts within which tinkering can take place and focus on two contexts in particular, academic research education and emerging countries. We then argue *how* tinkering success can be optimized by taking psychological aspects into account, and end the chapter with a summary conclusion.

8.2 What is Tinkering, Really?

To understand the roots of tinkering, let's first review the word etymologically, beyond the context of this chapter. Merriam-Webster's online dictionary describes a tinkerer as 'a person who in the past traveled to different places and made money by selling or repairing small items'. It becomes more interesting when we get into the additional descriptions and synonyms, which describe a tinkerer as an 'unskillful mender', and tinkering as 'to repair, adjust, or work with something in an unskilled or experimental manner' with synonyms as 'to fiddle, fool, or mess', to 'play, monkey or toy' and finally as 'to handle thoughtlessly, ignorantly, or mischievously'.

In the context of education, these roots contain interesting connotations that relate to several key aspects of tinkering. Firstly, it emphasizes the tension between someone who repairs but is to some extent unskillful. In fact, this aspect aligns with applying tinkering as a tool to learn what you do not yet understand, either in an educational context ("I don't yet have the knowledge") or research context (the knowledge does not exist yet). Secondly, it expresses a notion of experimentation, exploration and playfulness. As such, it occurs in a safe environment where it is not a problem if something fails, as we will have nonetheless learned something. Finally, it mentions the notion of fooling, fiddling and messing around—this aligns with the tinkering notion of re-appropriation, using tools or technologies in unintended ways or fashions to induce different views or create tensions

From a learning theory point of view, a key related school of thought is constructionism, as introduced by MIT Media Laboratory researcher Seymour Papert, which in turn is linked to constructivism (Papert and Harel 1991). According to this, learning should not be seen as the transmission of knowledge from instructor to student, but as students learning by doing. It proposes an experiential learning approach in real world settings and contexts, balanced by reflection on this experience to reconstruct and update the conceptual understanding of the world. In constructionism specifically this is achieved by literally constructing prototypes and products.

In a creative science context, the concepts of producer, teacher and student may be somewhat blurred. Imagine an interactive art installation that poses research questions or suggests certain theoretical extensions or conjectures. The creator of the installation can be seen as the student and may have certainly learned something by

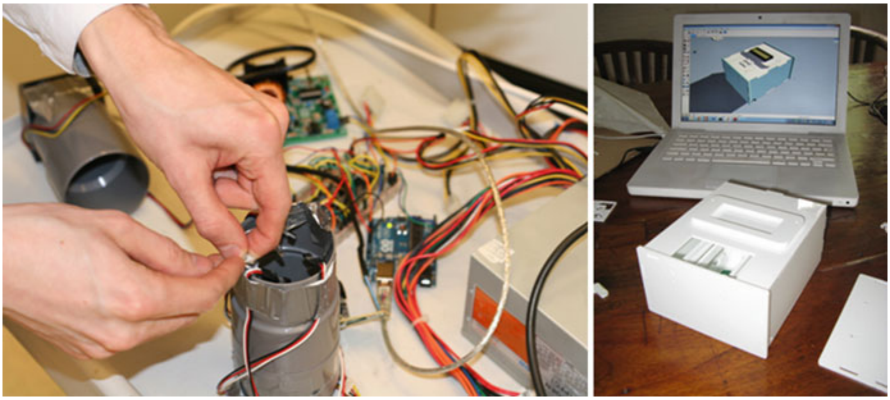


Fig. 8.1 Amplino prototype being tested (*left*) and mock-up of the imagined final Amplino malaria diagnostic tool (*right*). Photographs courtesy of Pieter van Boheemen, www.amplino.org

creating the piece. However, if the installation depends heavily on audience participation and interaction, they are in fact producers or co-creators to some extent, and as such will learn from actively engaging with the work.

8.3 What Tinkering can Teach You in Science Education?

The adoption of digital/physical tinkering by individuals, as formulated in Observation 1, has had its effect on science and education. Scientists increasingly use publicly available low-cost digital prototyping systems to create measurement tools and other experimental devices (e.g. D'Ausilio 2012). To witness, a Google Scholar query for articles containing the word "Arduino" in their title yielded a result of 490 scholarly articles.[1]

Naturally, developments in science and technology resonate in science education (e.g. Dougherty 2012; Gerstein 2012) and scientific education (e.g. Brock et al. 2009; Jamieson 2010), although not all experiences are always positive. Tinkering is found in curricula worldwide, and students realized a plethora of projects that are disseminated via the web.

An example of successful tinkering by academic students that stands out in our opinion is the Amplino project (www.amplino.org), in which students developed a low-cost Arduino-based polymerase chain reaction (PCR) diagnostic tool for malaria (Fig. 8.1). It exemplifies how a current scientific problem (i.e. offering affordable DNA-based malaria diagnosis) can be aided in unexpected ways by student tinkering. Although more examples exists (Reardon 2013), naturally, not all student

[1] Query result September 2, 2013 from www.scholar.google.com, excluding legal documentation, patents and citations.

projects are as successful as the Amplino project. However, they nonetheless have educational value.

Given the technical nature of such projects it is tempting to see this as teaching students certain technical abilities, while allowing them to 'geek out'. However, students also learn about the underlying scientific concepts (education), and occasionally even push the boundaries of scientific knowledge (research). Furthermore, students are trained on a constructionist tinkering approach to problem solving, which is a skill valuable for lifelong learning, also outside educational institutions.

Observation 2 Tinkering projects in education typically strive to teach various technical objectives such as programming skills, understanding of digital hardware, and rapid prototyping skills. However, in addition scientific education may also benefit from the tinkering approach by inducing playful interaction with scientific knowledge, exploration of a problem domain, and solution ownership by students.

8.4 Tinkering Across Various Learning Environments

It is important to realize that tinkering can take place in a variety of learning environments. As an experiential learning approach it is grounded in making learning in educational institutions resemble more the learning that occurs in the real world during one's lifetime. In other words, tinkering can be used as a learning tool all the way from nursery to PhD research. It also applies to environments outside schools and universities. Science museums have adopted tinkering as a means of knowledge creation and transfer. The San Francisco-based Exploratorium museum for science, art and human perception extended its vision of playful science education (Oppenheimer 1972) with an in-house Tinkering Studio (www.tinkering.exploratorium.edu). Multinationals are throwing hackathons to encourage corporate tinkering and problem solving, and to improve recruitment (Overfelt 2012). Grass-roots communities form on Meetup.com and other networks around typical tinkering subjects such as creative coding, interactive physical systems and DIY biotechnology.

Observation 3 Tinkering as an educational approach applies across the entire lifecycle of learning, both within and outside traditional learning institutions.

In our case, we are particularly interested in the role of educational tinkering within an academic research-oriented environment. Scientific research is a knowledge-driven activity, geared towards answering questions and generating new knowledge. Although exploration is an important force in science (Doherty 2008), typically scientific research is brought about through rigorous and methodical work, in which the exploratory and playful nature of tinkering has only limited place. The emphasis in science is typically on testing the validity of theories, hypotheses, methods, tools and other scientific end products, as opposed to providing the creative process and tools to discover and generate these. Furthermore, research agenda's may be based on timed delivery of knowledge products, something that does not evidently match the open-ended nature of tinkering. Finally, in research-based education, one may be uncertain how to evaluate the end results of tinkering—should evaluation be based on knowledge discovery, on work methodology, or on aspects of exploration? When to stop tinkering—what is the definition of 'done'?

Unfortunately, we cannot offer the reader solutions to these important questions and issues. It is our understanding that these issues must be raised as part of a larger discussion, involving researchers and lecturers from varying disciplines and learning environments. At this moment, we cannot extend our contribution to the discussion beyond observing the need for a discussion.

Observation 4 Aspects of tinkering in research-oriented education require special attention, such as how to combine the open-endedness of tinkering with more fixed research agenda, and how to evaluate tinkering results. Existing insights must be collected and further insight may be developed.

At this point and in resonance with the focus of this book, we would like to address the emerging world as a particular learning environment. Naturally, contrasting emerging countries from their further developed counterparts requires consideration of learning environments along a different dimension than used above—a dimension not spanned by varying types of educational institutions, but by international or interregional differences in economic status and development.

Grass-roots technology development and associated frugal science (Reardon 2013) are relatively independent from economic backing. Although stronger economic embedding makes *any* endeavor easier, if only as an effect of lesser external concerns or more available time, the cost factor of tinkering-based work is less discriminating than that of high-end technological work.

Given this relative independence of funding and the increasing availability of (physical-) digital prototyping tools expressed in Observation 1, grass-roots digital technology development and education are areas in which emerging countries have little disadvantage in comparison to their further developed counterparts, and in comparison to industry and education driven by high-end technology. In particular, youth in emerging markets have growing opportunities to become users and creators of low-cost technology, and to understand, own and prototype solutions to their own problems and dreams.

Observation 5 Low-cost and readily available digital prototyping tools lessen the gap between economically differing nations or regions, with respect to technology development in education and industry. This offers valuable opportunities for the emerging world to strengthen their technological industry, mainly through education.

8.5 Psychological Factors of Tinkering Success

We have argued in a previous section that tinkering aims to teach students more than technical skills. This implies that, to get the most out of tinkering as a learning tool, non-technical aspects need to be taken into account. Examples of such aspects are the psychological concepts of persuasion, motivation and ability (Petty and Cacioppo

1986). Essentially, education can be seen as a persuasion problem. To persuade people to actively learn we must ensure that the audience is motivated as well as able to learn. Interestingly, this can be seen both as a precondition for educational tinkering, as well as aspects that tinkering can help realize.

An example of how tinkering could help to overcome lack of motivation for learning would be a science museum targeting children or teenagers. A museum is a less structured learning environment than a school, depending more on the internal motivations of visitors than a traditional school environment does. To this effect, an in house tinkering studio or tinkering installations can increase the motivation as well as focus of visitors, in contrast to more passive, 'instructionist' setups.

To make the point about the importance of ability, let's contrast the above with an academic research context. Apart from differing technical abilities, graduate and doctoral students may have different personality and psychological profiles, which can affect tinkering success in opposing ways.

Take imaginary student A, with a more sensing personality. The student thinks very much in terms of concrete products or pieces, whether more technical or more artistic, and has a clear idea early in the process what needs to be made. A pitfall for this student however, is that tinkering implies one to be able to change direction, when at a conceptual or practical dead end—moreover, sometimes one needs to 'kill their darling' for such change in direction to take effect. A strong practical and perceptual attitude can in fact limit the reflective abilities. Understanding what one aims to achieve conceptually or how what was just discovered impacts one's abstract idea or understanding, is key in a constructionist tinkering approach. Mentoring such a student would be much more focused on stimulating reflection through questioning by instructors or peers and outsiders.

However, the opposite could occur also. Student B can be strong in terms of abstract and theoretical thinking, thereby limiting the ability to become concrete and start creating or changing a product. This could be related to a fear of 'making the wrong choice', either in terms of failing to implement the project aims correctly, or more commonly, the fear of not having chosen the optimal concept to do so. For student B, mentoring strategies could address this by clarifying that it is fine to fail quickly and readjust, as opposed to not trying at all.

Observation 6 For tinkering to be successful as a learning strategy, non-technical psychological factors such as personality, motivation and ability must be taken into account. Different motivational and ability profiles could warrant opposing mentoring strategies.

8.6 The Future of Tinkering in Scientific Education

In this chapter, we explored tinkering as a mode of education from different perspectives. Departing from an etymological view, we moved on to *what* can be learned from tinkering. Focusing next on contexts *where* tinkering can be a valid approach, we mentioned in particular academic research education and emerging worlds. Lastly, we argued *how* tinkering success can be optimized by taking psychological aspects into account. From this informal exploration, we formulated several observations regarding the topic at hand.

To draw extensive conclusions from our exploration would do injustice to its informal nature. Moreover, summarizing the observations appears fruitless, as we trust them to concisely speak for themselves. However, our explorations do lead us to some general comments regarding the future of tinkering in scientific education.

Firstly, it is our position that the value of tinkering has proven itself in scientific education, although this value remains to be quantified. Moreover, there is no reason to assume that this addition of value will diminish over time. Tinkering will remain a productive learning tool for new generations, even though we must not shy away from evolving its scientific results into more rigorous and methodical scientific studies.

Secondly, the observed need for further insight into aspects of tinkering in research-oriented education will not magically disappear. To this end, efforts must be made and extended over the different knowledge domains involved.

Finally, we acknowledged the benefit of digital tinkering for the emerging world. To maximally exploit this potential benefit, we must not accept it for *status quo*, but more actively involve emerging regions in our tinkering developments. In particular, we must recognize when groups and individuals from emerging regions have reached beyond tinkering and jointly take up the challenges that they encounter.

May the forces of tinkering be with you.

References

Banzi, M. (2008). *Getting started with Arduino*. Sebastopol: Make:Books & O'Reilly Media.

Brock, J. D., Bruce, R. F., & Reiser, S. L. (2009). Using Arduino for introductory programming courses. *Journal of Computing Sciences in Colleges, 25*(2), 129–130.

D'Ausilio, A. (2012). Arduino: A low-cost multipurpose lab equipment. *Behavior Research Methods, 44*(2), 305–313.

Doherty, P. C. (2008). The beginner's guide to winning the Nobel Prize: Advice for young scientists. New York: Columbia University Press.

Dougherty, D. (2012). Learning by making: American kids should be building rockets and robots, not taking standardized tests. Slate/Future Tense Article. http://www.slate.com/articles/technology/future_tense/2012/06/maker_faire_and_science_education_american_kids_should_be_building_rockets_and_robots_not_taking_standardized_tests_.html. Accessed 4 June 2012.

Gerstein, J. (2012). The flipped classroom: The full picture for tinkering and maker education. Post on User Generated Education Blog. http://usergeneratededucation.wordpress.com/2012/06/16/the-flipped-classroom-the-full-picture-for-tinkering-and-maker-education/. Accessed 16 June 2012.

Jamieson, P. (2010). *Arduino for teaching embedded systems. Are computer scientists and engineering educators missing the boat?* Proceedings FECS, Miami University, Oxford, 289–294.

Lamers, M.H., Verbeek, F.J., & van der Putten, P. (2013). Tinkering in scientific education. In D. Reidsma, H. Katayose, & A. Nijholt (Eds.), *Advances in computer entertainment* (pp. 568–571). LNCS 8253. Kathmandu: Springer.

Oppenheimer, F. (1972). The exploratorium: A playful museum combines perception and art in science education. *American Journal of Physics, 40*(7), 978–983.

Overfelt, M. (2012). Corporations adopt the Hackathon. Workforce Article. http://www.workforce.com/articles/corporations-adopt-the-hackathon. Accessed 12 September 2012.

Papert, S., & Harel, I. (Eds.). (1991). Situated constructionism. In Constructionism. Ablex Publishing Corporation.

Petty, R. E., & Cacioppo, J. T. (1986). The elaboration likelihood model of persuasion. *Advances in Experimental Social Psychology, 19,* 124–206.

Reardon, S. (2013, September 7). Frugal science gets DIY diagnostics to world's poorest. *New Scientist, 219*(2933), 20–21.

Thompson, C. (16 Nov 2008). Build it. Share it. Profit. Can open source hardware work? Wired Magazine.

Appendix
Enhancing Learning Experience Through Robotics in Nepal

Abstract The education system in developing country like Nepal is totally based on theory. Even engineering graduates lack practical problem solving skills, which otherwise have made them employed or an entrepreneur. Robotics Association of Nepal was formed on 2010 with an idea to share the knowledge and skill in robotics. The idea then grew into changing the whole experience of learning through robotics.

Allowing students in a classroom to play with microcontroller, programmers, motors, wheels, chassis, power supply etc. enhanced their learning experience. Students were self motivated to find creative ways to make robots and solve challenges given to them. In doing so they used their theoretical knowledge into practice and found meaning of their study for themselves. Robotics has changed the whole experience of learning inside a classroom.

Keywords Education · Robotics · Hacker space · Engineering · Coding

Introduction

Robotics Association of Nepal (RAN) is the only national non-profit association, that provides a platform for students and enthusiasts to come together in an effort to promote, educate, explore, and compete in the field of robotics.

RAN integrate principles from all disciplines of engineering in the development of robotics and provide valuable hands-on design and building experience to our members, which cannot be learned in the classroom. It also provides a comfortable platform for enthusiasts to learn more about robotic technologies practically in order to enhance their engineering skills by engaging in annual competitions the association facilitates, working on group projects, organizing workshops, documentary, presentations and seminar.

The association involves itself in a continuous process of learning and exploring the possibilities in the robotics field, most of which comes from the hands-on knowledge and experience in building robots. The experience is then transformed into a series of planned workshops which is delivered by its fellow members. These

Sunoj Das Shrestha: Robotics Association of Nepal (RAN), Kathmandu, Nepal
e-mail: sunoj.shrestha@gmail.com

A. D. Cheok et al. (eds.), *Entertaining the Whole World*,
Human–Computer Interaction Series, DOI 10.1007/978-1-4471-6446-3,

workshops are targeted towards a national level robotics competition which challenges students as well as provides thrill of being in a robotic competition.

Background

Education system of Nepal is very good in terms of theory but with there is very little practical components. This has become a fact which is true even for engineering field, which is supposed to be practical. Teachers think their job is to pour the knowledge they have in the head of students and students are supposed to take it for granted. There is no opportunity for students to process the information and make sense of it.

Paper-based examination and scoring system creates pressure for students to remember words and theory rather understand them. Teachers on the other hand don't want to leave their comfort zone and challenge students with practical education. This has caused serious damage in the career development of students because they lack critical thinking, problem solving ability and skills in the related field. Students can't think out of the box and unaware of what's going on around the globe.

Most of the credit for this chaos in education goes to the government and its political influence in Universities and partly to University itself for granting affiliation to those colleges below the standards. There is nothing much that we can do to change the policy but we can definitely do something for the students. If robotics could be integrated with current education then it might be able to increase the quality of education.

History

Robotics Association of Nepal
[between human and machine]

Formation of Robotics Association of Nepal was an initiative taken by final year under graduate students. Students from Kathford International College of engineering and management, Kathmandu engineering college, Himalaya College of engineering, Advanced College of engineering, Himalayan Institute of Science and Technology, Kantipur City College along with other engineering colleges of various Universities felt necessity of a central hub for exploring, promoting, learning, sharing robotics knowledge and to represent Nepal in the field of technology globally, in 2009.

After 6 months of preparation, constitution was finalized and Robotics Association of Nepal [RAN] was registered as not for profit organization, in 2010. The constitution has to be edited more than ten times as the term “ROBOTICS” was totally new for the Chief District Officer’s (CDO) office of Kathmandu. Defining the term ROBOTICS so that everyone, including officers in Chief District Office could understand was challenging. Despite being in the capital city, Robotics Association of Nepal is working as NGO because robotics is the least concerned matter for Nepal Government and people in general but in fact it is very important aspect of technical education.

There were lots of challenges both internal and external faced to run the association. Internal challenges were dividing responsibility, renting office space, managing resources and time within the organization. External challenges were raising funds, getting support from colleges and universities. One of the major setback occured when juniors pursuing final years of engineering were handed the responsibility of leading the association in less than 6 months of formation.

The association was then reformed with a new executive committee of 11 members, Sunoj Das Shrestha was elected as the President, Suresh Ghimire as the Vice President, Pavitra Gautam as the General Secretary and Elisha Rajbhandari as Treasurer. The team was handed major responsibility for 2 years time.

Since its reformation in 2010, Robotics Association of Nepal has made a number of efforts for the development of robotics in Nepal. It has conducted numerous orientation programs, workshop and trainings related to robotics for students from school and college level to undergraduate level. Till date, the numbers of students participating in these workshops have exceeded 1000. These training programs vary from simple line following robot making to RC controlled airplanes.

Activities

The only advantage that we had was robots are fascinating to everyone, even for those who are not interested in science, engineering and technology. Science and engineering students are naturally interested in making robots because it is fun to watch robots in action and it’s more fun if you can make your own robot.

This is where we saw an opportunity to integrate robotics into science, technology, engineering, mathematics and design (STEMD) education. A national level robotics competition “Yantra 1.0” was planned as grand challenge for students from schools to engineering college. Based on the theme and rules of the robotics competition, the content of the robotics workshop was generated. Every engineering college and its Principals and Head of Department of respective college were convinced about the idea. In this way, a network was build and each college had two RAN representatives to bridge RAN with college administration and students.

As there were no expert on delivering workshop to engineering colleges, trainer from India was invited for the first three workshops. Later we started delivering workshop which was in fact more effective because students had problem understanding Indian trainer. After engineering colleges, we conducted basic robotics training in +2 colleges and schools. We were excited from the feedback that we got from school, college and students. As this was totally new experience of teaching and being taught, students loved it. A week before conducting any workshop, we give one and half hour orientation to the students in respective institution to communicate with students what they will learn in workshop as well as to talk to the administration for arrangements for the workshop. We did orientation in more than 200 institutions but conducted workshop in less than 20 of those.

Regarding the response from students, engineering students said "Now I feel like I am an engineer", while + 2 college students said "I finally understood how circuits work" and school students said "I wish every class was this fun". We saw the effect of robotic workshop in a class, students were being curious and were asking questions, they were discussing with their peers, they were processing the information provided to them, they were engaging in challenges and they were having fun while learning. The robotic workshops really changed the environment of a classroom and learning experience. For 6 months we conducted orientation programs and workshops targeted to National Robotic Competition "Yantra 1.0".

Photo: Orientation program on Robotics
Venue: Amrit Secodary Boarding School, Mhenpi
Date: 18th March 2011
No. of participants: 60

Photo: Yantra 1.1 school workshop
Venue: Shikharapur School, Pherping
Date: 11th April 2012
No. of participants: 24

Photo: Yantra 1.4 engineering workshop
Venue: Kathmandu University, Dhulikhel
Date: 23rd March 2012
No. of participants: 40

Photo: Made in Nepal Expo
Venue: Bhrikurit Madap, Kathmandu
Date: 9-13th July 2012
National Exhibition

Photo: Honorary program through Press meet for young Nepali innovators
Venue: Educational Journalist Group
Date: 18th March 2011

Photo: Game Arena of "Mission Nepal" under Yantra Engineering, "Yantra 1.0" on 20th and 21st July, 2012. Venue: Dasarath Stadium, Covered hall

"Yantra 1.0" National Robotics Competition

"Yantra 1.0", first National Robotics Competition was inaugurated by Mr. John Tucknott MBE, HM Ambassador (UK), as chief guest, Senior Vice President Mr. Bhaskar Raj Rajkarnikar from FNCCI as guest of honor and Mr. Sunoj Das Shrestha, President of Robotics Association of Nepal along with distinguished guests from LCCI and NADA on 20th July, 2012. The 2 days competition had 40 participating teams consisting of about 160 participants. This was a historic moment with huge number of participants and highest prize money for the winners. Four pre-events were organized to select 20 teams for two different categories. This competition allowed students to compete with other students from around the country and face the real world challenges.

RAN organized second national level robotics competition and its first international robotic competition titled "Yantra GRC Techkriti 2013" which is the Nepal selection of the international Autonomous Robotic Challenge (iARC) on 12th January 2013. The international segment of the competition was held in various universities of different countries like Japan, UAE, Singapore, Thailand, Pakistan, Nepal, Bangladesh, Sri Lanka and Pakistan. The winner and first runner up from Nepal secured second and third position in the final at Techkriti'13, IIT Kanpur on 14th–17th March 2013.

Yantra has become the platform that we wanted to create. Every year students wait for this competition to happen. They are eagerly waiting for the game theme, so that they can make robots to compete. The education that schools offer is just in case education but we want students to have just in time education that can be used in real life.

Technology

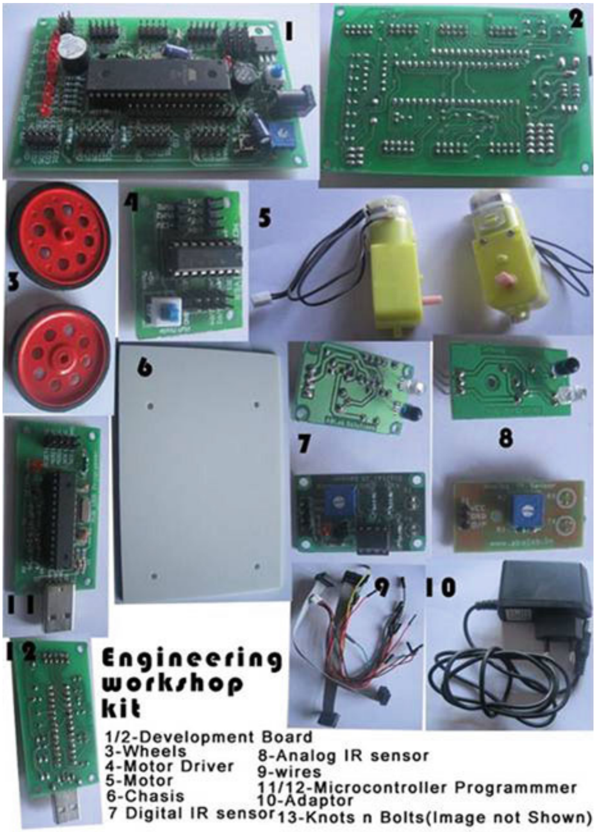
Robotics is a multidimensional field that requires skills from different engineering field. Integrating robotics in education was a challenge that we choose and to deliver workshop we used different hardware and software. Our team was not expert in teaching but we all had idea on how we would like to be taught if we were in a class. We all had some skills and strength that complimented each other to make a team.

Below is the list of hardware used in workshop to make a manual robot for school students and a white line tracking robot for + 2 students.

Below is the list of hardware used in workshop for engineering college that includes:

Introduction to Automation
Introduction to Robotics
Introduction to Microcontroller
Input/output Operations
Analog/Digital Converter in Microcontroller

Different Types of Motors
Different Types of Sensors
Line Follower
Wall Follower
Robo-sumo
Edge Detector
PID for Robotics



Besides these we use Arduino, sketch, processing, AVR microcontroller, Control AVR Programmer, AVT Studio 4 etc in our workshops. Even using these simple pieces of technologym the learning experience can be enhanced.

Building the Community

One of the purposes of formation of RAN was to build a community of people interested in science, technology and robotics. Nepal is lagging behind due to absence of strong tech community. It is obvious that our universities do not produce skilled manpower that a tech company can recruit and students graduating from university are unaware of the skills that they should have to get employed. This leads to unemployment even when there are job vacancies. The less skilled manpower ends up getting low paid jobs even with good grades.

To address this burning issue we are working to create an environment for student-industry tie up where both can interact to know each other's need. Hopefully some students will get internship in their future jobs. We have successfully created a strong network in all the engineering colleges and Universities of Nepal and its time to expand into industries and beyond boarders.

Conclusions

Education can and has changed the world. Development of a country can only be achieved if youths are well educated. Traditional teaching methods should be improved to educate today's youth. Current education system must give equal importance to practical as theory.

The teaching experience and learning experience can be made effective with hands on methods that allow students to make something and process given information. Modern teaching methods should be introduced in classes with trained teacher and tools to make learning more interactive.

The robotics workshop that RAN has started is just a beginning and there are lots of works to be done. This has created an impact in small magnitude but if replicated nationwide, it can make greater impact in education. We are seeking support from national and international organization to scale these workshops.

Acknowledgments I would like to thank ACE 2012 "Entertaining the whole world" organizing committee for providing Robotics Association of Nepal an opportunity to volunteer in the creative showcase of the projects and Professor Adrian David Cheok for inspiring me to write this chapter.

I would like to thank my executive member of RAN and specially Mr. Suresh Ghimire (Vice-president) and Mr. Pavitra Gautam (Secretary) for their support during hard times. I am very grateful to Late Ujwal Shrestha for his initiation to establish RAN, may his soul rest in peace.

I would like to thank all my family and friends who has inspired and supported me to come this far. I seek their support as there are greater things to achieve in future.

References

http://ran.org.np/ace-2012/.
http://ace2012.info/.