The Display Cube as Playful TUI To Support Learning

Matthias Kranz Paul Holleis Corinna Grueber
Mark Bilandzic Johannes Vetter Albrecht Schmidt
{matthias, paul, corinna, mark, johannes, albrecht}@hcilab.org

Research Group Embedded Interaction
University of Munich
Amalienstrasse 17, 80333 Munich, Germany

Abstract. In this paper we present new results of our ongoing research project on the Display Cube. The Display Cube is a playful tangible user interface for fostering learning for young children aged between 6 and 12. We designed the Display Cube as a generic platform for learning applications, supporting all kinds of quiz-based and multiple choice tests. Questions and answers can be images or text. Exploiting the physical affordances of physical cubes and augmenting them with embedded sensors and displays on each face, we present different learning applications. This paper and accompanying video present findings from first real-world tests of the Display Cube with the envisioned users in their original environments, a Kindergarten and a primary school as well as the usage of the Display Cube at home.

1 Introduction

Tangible user interfaces have shown their potentials in many recent publications in pervasive computing and human-computer interaction. Alas, many applications and scenarios in ubiquitous computing are constrained to a fixed laboratory scenario and are in parts questionable or unfeasible when deployed outside the laboratory.

We present an interesting, real-world appliance for fostering learning for young children using unobtrusive and invisible technology. The Display Cube is a small cuboid equipped with acceleration sensors and one display at each of its six faces. Text and small images can be shown on the displays while the sensors can be used to determinate orientation and detect a set of simple gestures. This project also remembers to have the social responsibility of computer science of developing technology only as a vehicle for human well being. The underlying technology is kept simple, incorporated components are wide-spread and the focus is placed on user experience.

2 Related Work

The affordances of the cube as a 3D object have been studied by Sheridan [1], suggesting a description of possible manipulations of the cube, based on action, description and events, that potentially provides a framework for the design of gesture based interaction techniques.

Tom Pfeifer et al. (Eds.): Advances in Pervasive Computing 2006
Adjunct Proceedings of Pervasive 2006, Dublin, 7-10 May
books@OCG.at Vol. 207, ISBN 3-85403-207-2

The engagement and playfulness afforded by the cube has already been exploited in several occasions: besides the popular Rubik's Cube, or the simple dices, HCI research has looked at the cube as user interface. Zhou et al. [2] explore the application of a foldable 3D Cube interface, complemented with augmented reality technology, to the field of interactive storytelling. Camarata et al. [3] use cubes as physical blocks to navigate a data space in a virtual museum, thus exploiting the everyday understanding of three-dimensional spatial relationship.

A discussion of related work focusing more on cultural and social aspects of cubes has been discussed in our prior work in [4]. The initial idea has been presented in [5].

3 System Implementation

The Display Cube is a synthetic hollow cuboid that has a display at each of its faces. The Barton BT96040 displays controlled via I2C bus are used to display text and images like questions and answers. The intelligence is implemented on the micro controller from the Particle Computer platform, discussed in [6][7][8]. Besides controlling the six displays, it uses two two-axes Analog Devices ADXL311JE analog acceleration sensors for orientation and shake detection.

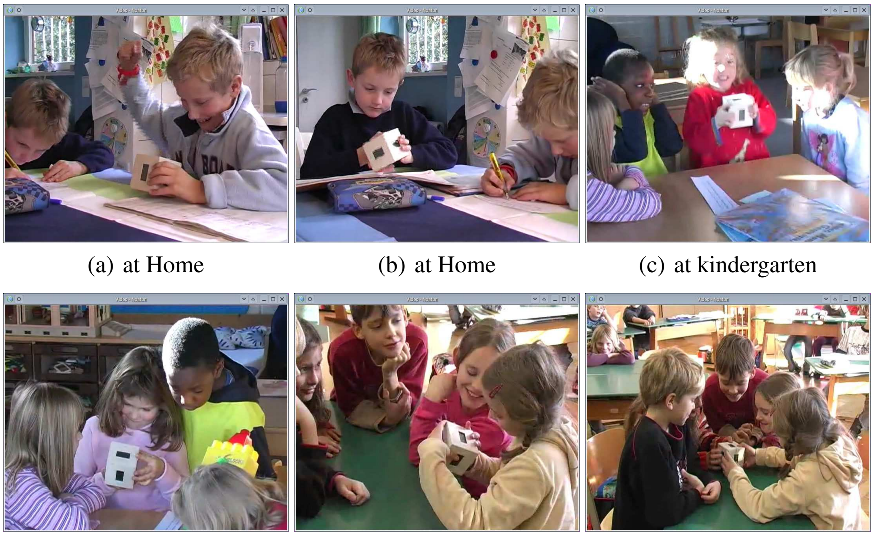
The cube can communicate and be accessed via radio frequency. This enables users to add new data to the system during runtime as well as remote monitoring.

4 User Experience

In conjunction with the video that comes with this paper, we conducted two short user studies, one at a local Kindergarten and one at a primary school. We programmed the Display Cube with multiple choice tests suitable for each age class: The younger children had to match capital letters to their small counterparts while we presented the primary school children with simple mathematical tasks. The displays always showed one question, its correct answer and four false answers.

We gathered small groups of three to five people, briefly demonstrated the way to use the cube and left the children playing. Screen shots of the video depicting the children solving tasks with the Display Cube are depicted in Fig. 1. We were eager to see the children's reactions and experience in the environment and with people they were used to. Therefore, we gave the teachers a quick overview over the system and let them answer the questions of the children.

After a short while, at least one of the children in each group was able to grasp the way the cube worked and started using it as we anticipated. In all of these events, the child was then able and willing to help the others understand and use the cube themselves. In addition, we were positively surprised to see that the cube was not only used by one child after the other. We quickly discovered that our playful application initiated collaborative processes. Children not only helped others to understand the task, but also helped in reading the questions, looking for answers and finally even gave explanations to others who found that the cube did not act as expected or answered a question incorrectly. Although there was of course a certain amount of competitiveness



(a) at Home (b) at Home (c) at kindergarten

(d) at kindergarten (e) at primary school (f) at primary school

Fig. 1. Screen shots from the video submission showing the joint playful usage of the Display Cube by the children

between pupils to get hold of the cube, we saw our assumption that the mobile and autonomous nature of the device invoked action and collaboration was correct.

Although we have not (yet) tested if the time the children spent with the device actually helped in learning the facts we displayed, we got tremendously positive feedback on the user experience from both children and instructors.

5 Current and Future Work

We are currently improving the cube for a deployment in later this year. We incorporate the feedback we got from the user study done in the Kindergarten and the primary school.

We will allow for different textures and colors on the faces of the new hardware version of the Display Cube. We will also change the displays to quadratic, full-graphical color displays of 128x128 pixels. These displays will also be more readable as they also have a back light. The color will allow more types of image recognition tasks, especially for the younger children using the cube. Colored faces will also allow for easier finding and remembering of specific faces for e.g. questionnaires.

Currently, we are building a simple and easy to use editor allowing teachers to define questions for pupils. Each pupil will have his own personal cube. In class, the teacher can assign new questions to a pupil's cube and download them.

We plan to do long-time user studies under real-world conditions in primary schools with a larger number of participants. The idea is to leave one or several of the cubes in the class room for half a year to see if teachers are able and willing to use it in their lessons and what their primary intentions are when handing them out. This will also show if the Display Cube is a short term attraction only or if there is a continuing demand from the pupils. In cooperation with the teachers we also hope to be able to see if there is an intensified learning experience.

6 Conclusion

We presented the Display Cube, a tangible user interface to playfully support learning for children aged 6 to 12. We evaluated the concept with a prototype and an initial user study and are currently going on to iterate on the design. The requirements for the hard- and software are stable and known by now. We demonstrated the feasibility of the idea in the laboratory and the real world by letting children use and comment on our initial prototypes. A real-world deployment of the device over a several months in schools will provide further details. The video presentation accompanied by this paper vividly demonstrates that our idea of playful interaction works.

7 Acknowledgments

The work has been conducted in the context of the research project Embedded Interaction ('Eingebettete Interaktion') and was funded by the DFG ('Deutsche Forschungsgemeinschaft').

References

1. Sheridan, J., Short, B., Laerhoven, K.V., Villar, N., Kortuem, G.: Exploring cube affordance: Towards a classification of non-verbal dynamics of physical interfaces for wearable computing. In: In Proceedings of the IEE Eurowearable 2003, IEE Press (2003) pp 113–118
2. Zhou, Z., Cheok, A.D., Pan, J.: 3d story cube: an interactive tangible user interface for storytelling with 3d graphics and audio. Personal Ubiquitous Computing **8** (2004) 374–376
3. Camarata, K., Do, E.Y.L., Johnson, B.R., Gross, M.D.: Navigational blocks: navigating information space with tangible media. In: IUI '02: Proceedings of the 7th international conference on Intelligent user interfaces, New York, NY, USA, ACM Press (2002) 31–38
4. Terrenghi, L., Kranz, M., Holleis, P., Schmidt, A.: A cube to learn: a tangible user interface for the design of a learning appliance. In: 3AD: Third International Conference on Appliance Design. (2005) pp. 82–86
5. Kranz, M., Schmidt, D., Holleis, P., Schmidt, A.: A display cube as tangible user interface. In: In Adjunct Proceedings of the Seventh Internation Conference on Ubiquitous Computing (Demo 22). (2005)
6. Decker, C., Krohn, A., Beigl, M., Zimmer, T.: The particle computer system. In: IPSN Track on Sensor Platform, Tools and Design Methods for Networked Embedded Systems (SPOTS), Proceedings of the ACM/IEEE Fourth International Conference on Information Processing in Sensor Networks. (2005)
7. Gellersen, H.W., Kortuem, G., Beigl, M., Schmidt, A.: Physical Prototyping with Smart-Its. IEEE Pervasive Computing Magazine **3** (2004) 74–82
8. Beigl, M., Krohn, A., Zimmer, T., Decker, C., Robinson, P.: AwareCon: Situation Aware Context Communication. In: Proceedings of Ubicomp 2003, Seattle, USA (2003)