Designing for Diversity: developing Complex Adaptive Tangible Products

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ABSTRACT
Interactive products can help very young multi-handicapped children (1-4 years) develop their language and communication skills, under the condition that they are optimally tuned to the individual child. This has great consequences for design, since this kind of interactive products need to be adaptive to the child’s development, possibilities, interests and needs. There are currently hardly any guidelines for designing adaptive interactive tangible products for such a heterogeneous user group. Through LinguaBytes, a three-year research project aimed at the development of an adaptive interactive toy for stimulating language and communication skills of multi-handicapped toddlers, we want to establish a theoretical framework, including guidelines and tools, for designing complex interactive products.

Author Keywords
Interactive toys, adaptability, tangible interaction, multi-handicapped children, complex products, edutainment.

ACM Classification Keywords
H.5.2 User Interfaces; D.2.2 Design Tools and Techniques

INTRODUCTION
Very young children, as of 1 year old, learn by exploring their surroundings, mostly by playing. During play, which in this age group is mainly physical and social, toddlers construct mental representations of the world around them. Senses and skills (perceptual-motor, cognitive and emotional) are trained. Through the contact with more capable peers or adults, the toddler is stimulated to try out things they are incapable of on their own; a process Vygotsky calls scaffolding [9]. One example of this process is early language development. According to Heim [3], the foundations of language acquisition are laid by early parent-child interaction. When early language development is distorted, as is generally the case with multiple handicapped children, parent-child interaction does not start or progress normally. This causes extra stagnation of the communicative and linguistic development. Moreover, since the developments of all of the child’s skills are interdependent, problems in the development of language and communication will cause the development of other skills to impede. Therefore, it is of great importance to enhance and optimize the interaction between parents and non-speaking children and stimulate communication and linguistic usage.

Product design can play an important role here, since products can offer possibilities for augmentative or alternative communication (AAC). AAC aims at enhancing the communicative skills of handicapped people, or offering alternatives for communication. In earlier studies [4, 8] we have investigated AAC systems for multiple handicapped toddlers and established that designing for this specific user group has great implications for product design. The main reason for this is that, due to the immense diversity of multiple handicapped toddlers (or even toddlers in general), such products should be extremely well tuned to the individual child. Moreover, these products should be adaptable to the skills and needs of the child, and ideally even grow along with him as his skills and needs change over time. In the case of multiple handicapped toddlers acquiring language, this implicates that a product should not only be adaptive to the child’s linguistic development, but also to its motor skills, its perception of the world, its interests, needs, attention span, cognitive development, ergonomic preferences, optimal learning environment, social skills,
et cetera. Moreover, it should monitor developments in any of these aspects and react to that.

Now, what would such a product look like? How would it behave? What would the interaction be? Currently, there are no guidelines for designing adaptive and complex products for such a diverse user group. In this paper we describe our approach to this design problem within LinguaBytes, a three-year research program which aims at developing an interactive and adaptive educational toy that stimulates the language and communicative skills of multiple-handicapped children between 1 – 4 years old. Based on the LinguaBytes project, we wish to establish guidelines for designing complex adaptive products in general, so for any heterogeneous groups of users.

CURRENT SITUATION IN AAC
Several products and programs are available today that support and/or train linguistic and communicative skills. Many of them make use of multimedia techniques, e.g. Classroom Suite & IntelliKeys (IntelliTools), Sound Beginnings (SEMERC) or ChatBox (Prentke Romich Company). However, despite their success, these and other AAC systems are not tailored to very young non- or hardly speaking children with severely impaired motor and cognitive skills [1]. Most AAC devices aren’t appealing to young children with respect to their design [6]. Additionally, most AAC devices resemble PCs with respect to navigation (menus and decision trees), input and output. Since PCs were originally designed for office use (see Figure 1), they don’t reflect the way very young children think and interact. The resulting cognitive load for these children to learn and use these devices is too high. Additionally, many early intervention programs are PC-based, making it mainly suitable for individual use and more difficult for social interaction. Finally, current AAC systems do not capitalize on novel technology and multimedia possibilities [8], which are aspects that can enhance adaptation to an individual child and offer the possibility to use a variety of strategies to improve language and communicative skills. Some attempts to move away from the traditional PC interfaces gradually appear on the market, e.g. TOM by Platus Learning Systems (see Figure 2). Finally, all these interactive systems are rarely being used within language education programs for multi-handicapped toddlers under 4 years old. We feel that, in order for these systems to be used effectively by toddlers between 1-4, the interaction should correspond much better to the natural interaction style of these toddlers.

OUR METHOD
In order to achieve this, we use a design approach called research-through-design, i.e. through the act of designing resulting in experiential prototypes, and subsequently testing these prototypes in real life settings, we generate scientific knowledge [7]. When we design interactive products, the process typically moves through several cycles of designing- building- testing, in which each iteration refines the product and increases our knowledge. The overall process of LinguaBytes consists mainly of two phases: conceptualization and specification. During the conceptualization phase, we explore the scope of the new tangible tool by building and testing a comprehensive set of concepts / prototypes. The most appropriate concept is then to be further developed, completed, built and extensively tested during the specification phase. Within both phases, specialists from both the technology / design field and from education / therapy (a.o. speech therapists, occupational therapists, child physiotherapists) are involved in the prototype ideation and selection processes.
DESIGN GUIDELINES

We are currently in the final stage of the conceptualization phase. In previous stages we have built and tested one extended concept and four simple concepts based on interactive books, prints, and tangible objects, after having conducted an extensive literature research. More about this can be read in [4]. As a result of these findings we have formulated a large body of design guidelines, of which we will outline the most important aspects:

- **Playing** – Young children learn mostly through play. Play permits making mistakes and trying again. Therefore, interaction should be playful.

- **Social Interaction** – Toddlers play and work in groups and not so much on their own. Our approach is to stimulate interpersonal interaction.

- **Tangibility** – Especially for very young children that naturally explore the world through play, interaction should be tangible. Tangible interfaces offer a number of advantages over the standard PC-interface, e.g. stimulation of multiple senses and skills, affording both actions and play, offering more room for social interaction, a more personal interaction style, a slower pace, more involvement and a more active interaction.

- **Challenge** – In order for children to learn, they need to be motivated. Challenge is a key element of motivation. It engages the child by stimulating it to reach for the boundaries of its skills. We wish to challenge children by designing interactions that are appealing, rewarding, engaging and fun.

- **Adaptivity** – To support the diverse group and enable multi-handicapped toddlers to be independent on a hardware, software and interaction level we aim at a product that adapts to the individual child. This optimizes the learning setting and avoids frustration.

- **Technology** – Supporting such adaptability requires advanced technologies, which are not capitalized on today. Embedded intelligence, wireless networking and interactive, adaptive narratives offer possibilities for innovative designs

- **Design** – We wish to design products that are appealing to both challenged and able-bodied children by making products that resonate with young children. Designs should be non-stigmatizing and can benefit from success formulas from the toy industry.

Based on the abovementioned guidelines we have designed and evaluated product sketches and mock-ups that explored the design space within each guideline and the interplay between guidelines. These preliminary designs have resulted in three product concepts, which were evaluated by specialists from both the technology / design field and from education / therapy. One concept, KLEEd, was selected to be developed further. The main selection criteria were: the extent to which each concept met the design guidelines, the usability and the feasibility of each concept. We are currently building the first working prototype of KLEEd that will be tested with children in December 2006 and January 2007.

KLEED

**Design**

KLEEd (Kids Learn through Engaging Edutainment) is a modular system consisting of exercise mats that can be connected to a central console (see Figure 3), and upon these mats a standard set of tagged objects and additional tagged personal material can be used to hear, and respond to interactive stories and exercises. The modularity, tangibility and adaptability of the system all add to its playfulness, appeal and challenge, making it more motivating for the child to use and learn.

The central console contains a flatscreen monitor and electronics for connecting exercise modules to the system. The position of the monitor can be adjusted to the optimal learning settings of individual toddlers. This means that the screen can be placed in both a horizontal position, enabling the use of KLEEd on the floor or table, and a range of tilted positions. The central console is embedded in a sleeve of a soft and friendly material, that can be washed separately after screen and electronics are taken out.

Exercise modules can be easily attached to the console in different set-ups, enabling both individual and collaborative use, thus stimulating social interaction. Every exercise module has its own goal, e.g. exercising phonology (through rhymes or songs), semantics, syntax, or just free play. By giving every module its own goal, each can be designed optimally for the type of exercise, making the interaction more intuitive, engaging and suitable for toddlers. Materials, textures, colors, sounds et cetera will therefore vary between exercises, thus offering a variety of configurations for three exercises.

![Figure 3. Current prototype of KLEEd, which can be used in a variety of configurations for three exercises](image)
described here. In order to develop these complex products, like the multiple handicapped children we have

Many user groups would benefit from complex adaptive evaluation techniques [2].

In order to test KLEEd quickly at a low cost, some parts of KLEEd will be fully operational, while other parts will be tested using a Wizard of Oz technique, in which a hidden person takes over the role of the computer, i.e. initiates appropriate feedback. The prototype will be evaluated using formative evaluation techniques [2].

In the first prototype of KLEEd we will design three exercise modules (out of a future 20-25):

- a rhyming exercise to train phonologic awareness;
- a hide and seek exercise to train semantics;
- a word combining exercise to train syntaxes.

KLEEd will be tested in December 2006 and January 2007 in two schools in the Netherlands [5]. In order to test KLEEd quickly at a low cost, some parts of KLEEd will be fully operational, while other parts will be tested using a Wizard of Oz technique, in which a hidden person takes over the role of the computer, i.e. initiates appropriate feedback. The prototype will be evaluated using formative evaluation techniques [2].

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FUTURE PLAN

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CONCLUSION

Many user groups would benefit from complex adaptive products, like the multiple handicapped children we have described here. In order to develop these complex adaptive products successfully, we need to develop new theories, guidelines and tools to support developers to design, build and test these products. Through LinguaBytes we try to develop such a framework, by iteratively designing and testing an interactive toy that stimulates multi-handicapped children to develop language and communication skills. We have just started our search and hope that it will be an interesting and fruitful path to go.

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REFERENCES


