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Supporting Early Literacy with Augmented Books – Experiences with an Exploratory Study

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Abstract: We here report on a study exploring the use of augmented books for early literacy education. Children aged 6-7 interacted alone and in pairs with an AR-book. The study was iterated with two groups with different reading skills and socio-economic backgrounds.

Educators and researchers put hope in new technologies to enhance and support children's learning. One such technology may be Augmented Reality, which allows the user to view and manipulate virtual 3D objects in a real-world environment. An area of high educational relevance is literacy as a basic cultural technique enabling participation in society. With interest in books declining educators need to explore means to boost children's motivation to read and to support the development of reading skills.

Augmented Reality (AR) provides an opportunity to integrate interactive sequences into books and to make them 'come to life'. The notion of an 'augmented book' was proposed with the MagicBook [BK01] and inspires researchers and educators alike as a means to enhance books with interactive visualizations, animations, 3D graphics, and simulations [Sh02]. Educators expect augmented books to provide a better understanding of complex content that can be actively manipulated and explored, and to enhance engagement, supporting immersive learning [MD04]. Users can navigate through the book by turning physical pages. Other tangible interaction tools may allow them to further interact with story elements and to influence story events. A range of studies indicates that tangibility can provide innovative ways for children to learn, bringing playfulness back into learning and supporting collaborative learning [OF05, Pr03, Ta05]. Despite much research, most of this has to date focused on technological development. Today we still know little about the "how, what, and why" [Sh02] of augmented books, their effectiveness as instructional tools, or the instructional support needed.

We here report on a study exploring the use of augmented books for early literacy education. Children aged 6-7 interacted alone and in pairs with the AR-Jam storybooks (developed by the BBC). Two groups of children with different reading skills and socio-economic backgrounds participated in the study. The first trial involved children from a

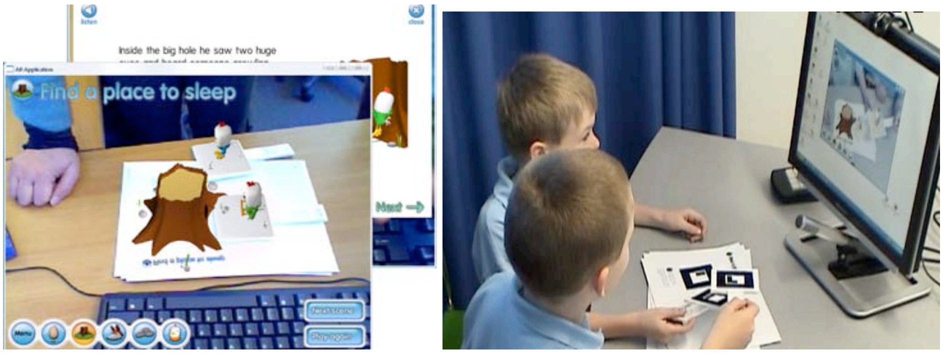

Figure 1 (left) Example of interactive screen with virtual objects and navigation elements overlaid (front) and text page (back), (right) children using paddles during an interactive sequence

middle-class neighbourhood that had been identified by teachers as „eager readers“ (reported on in [DH107, DH207]). As a contrast in our second trial we involved children of the same age with reading skills below their chronological age. We here integrate data from a preliminary analysis of the second trial with findings from the first trial.

1 Our Study – the AR-Books Utilized and the Study Design

The BBC provided the HitLab NZ research team with two augmented story books created for the AR-Jam project. These employ a combination of physical story pages and desktop interaction (screen, mouse), and alternate traditional narrated text pages with interactive sequences. On each text page (on-screen) the children can either read by themselves or listen to a recording. By clicking on buttons on the screen they can navigate between consecutive text pages. After each text section they need to close the text page, starting an interactive sequence where they interact with physical pages and paddles (see figure 1) and see an augmented view on the monitor. The paddles represent and control the main characters of the story and the paper pages constitute the setting (and other characters) for interactive sequences, organized as a series of physical pages.

The augmentation is based on AR Toolkit markers on the pages and paddles that are detected by a web-cam [BK01] and are replaced in the video image with computer-generated, animated 3D images. The image also is overlaid with navigation elements. The augmented book thus becomes visible *on the screen* when pages and paddles are in camera view. The pages usually have ‘hot spots’ next to markers, indicated by a grey outline. Placing paddles on a hot spot triggers story events – in figure 1 the chick will inspect a hole in the tree-trunk. A web-cam connected to the computer and positioned on top of the screen allows the technology to be used in most classrooms, being a low/no cost setup. However this does not provide a fully integrated view of real and virtual objects, unlike other AR-setups using head-mounted or hand-held see-through displays.

We used two storybooks for our trials. “Big Feet and Little Feet” tells of two little chickens, left outside the hen house in their eggs, who have to overcome several obstacles to escape a fox and find home. ”Looking for the sun” has four insects (thus four paddles) that try to get to the sun. The chick story had been specifically written for the AR-Jam while the other was adapted from an existing book by Rob Lewis.

Children from two local primary schools, ages 6 ½ to 7 (year 2), participated in the study at the Christchurch South Learning Centre (New Zealand). This corresponds to key stage 1 (age 5-7) in the UK system where schooling starts at 5.[1] For the first trial, avid and good readers were solicited from a nearby school in a middle-class neighbourhood. Six pairs and six individual children 'read' and interacted with one of the two stories. Then, each child was interviewed individually. As only the interview questions changed, we include the video from a pilot study (two pairs) in our analysis. The children were videotaped with the written consent of their caregivers and the school. Video analysis encompassed children's actions, nonverbal behaviours, and talk. Analysis was open-ended, iteratively evolving and collecting categories and issues for further analysis. From the pair condition we expected closer insight into the children's thoughts and opinions, constructive interaction creating a naturally communicative situation [AJ01]. We employed both stories for wider insight into relevant design issues.

As a contrast, we focused the second trial on children with reading abilities below their age that are hesitant about books. The trial was organised as part of one of the Learning Centre's "book wizards" workshops (one day program aimed at this group of learners). Participants attended another school and predominantly lived in a very different socio-economic neighbourhood with lower income levels. For this trial we used only the story about the two chicks, as we had identified a range of interaction problems with "Looking for the Sun" that the good readers had already struggled with. We further limited the trial to the pair condition (with six pairs) as this had been more revealing for analysis. Again, we videotaped the interactions and interviewed children individually, using the same set of questions as in the first trial. Supervised by two experimenters, one pair at a time read and interacted with the storybook. During that time the rest of the group continued with the "book wizard" activities under supervision by a teacher in another room.

2. Findings

We here restrict the summary of findings from the first trial to interaction issues. These arose mainly from the existence of two navigation methods, from the 'mirror-effect' of the augmented view, and from the expectation that AR objects on paddles would exhibit 3D physical behaviours. The different navigation methods for screen-based and interactive sequences often led to problems when switching from one to the other. Due to the webcam setup the augmented image on-screen was mirrored, resulting in repeated 'spatial confusion' about whether the paddle should move back or forth. Children often had to interrupt and correct paddle trajectories or to re-establish orientation. We further found that the physical affordances of tangible input elements made children expect 3D

[1] At age 7 pupils should have at least Level 1 attainment (of 8 levels in total), being able to recognise familiar words in simple texts, using knowledge of letters and sound-symbol relationship and to establish meaning when reading aloud (at Level 1 they can sometimes require support). The majority of pupils is expected to be at level 2. (See [NC07] for details on the UK system)

physical behaviour. They tried to let their chick jump over a fence by moving the paddle in an arch over it, or to let objects slide down from the paddle by tilting it. Nevertheless, it was encouraging that most children picked up quickly how to interact and navigate, and, after some initial scaffolding got along on their own. The interviews indicated that children liked the problem solving activities and remembered the story very well, in particular referring to funny or dramatic incidents during interactive sequences.

Video analysis of the second trial confirmed the interaction issues reported in [DH107]. Children expected the AR-objects on paddles to exhibit physical 3-D behaviour, were confused by the mirrored image on the screen, and required assistance to learn how to switch between text sequences on-screen and interactive sequences on paper. Most had experience with using computers from school and partly from home where they predominantly would play games or do 'internet' (the first trial group also often mentioned learning software). Their reading abilities were very low, and a few could hardly read on their own. Some were struggling from word to word, without understanding what they read (questioned, they did not remember a word of an instruction that they had just read out aloud). Text understanding and the recall of text sections were lower than with the first group. Some children did not know the aim of an interactive sequence even though the narration had just told them that the chicks needed to e.g. "look for a place to sleep". Overall most had not reached the minimal attainment level of literacy for their age, the end of key stage 1 (see footnote 1). We also found that some children showed little reaction to our verbal instructions. They furthermore seemed to be acting more impulsively, to have difficulties focussing on a task (short attention span), and coordinated their interactions less with each other than the group from the first trial (getting in each others way, occluding each other's paddles, or not waiting when something needed to be done in sequence). Some continued to bang their paddle onto or into any other 3D-object, regardless of whether this made sense for the story or tended to click repeatedly on the Next button, accidentally jumping pages.

We were rather surprised that the children had little problems with on-screen navigation - they seemed to recognize standard 'close' and 'next' buttons and quickly picked up how to interact with the digital system (evident e.g. when they pointed out hotspots to each other that paddles needed to be put on) even if they could not read. What provided more difficulties for this group was the distribution of navigation, creating confusion about what constituted 'a page'. In particular one pair reacted to instructions to 'flip the page' by clicking on-screen. Another pair flipped the sheets when they wanted to read the previous text page (which is on-screen). Yet overall, this group learned just as well as the first group of eager readers how to interact with the system and navigate through the story, albeit with more intensive initial scaffolding. For a second or third story, the children would likely need less and less assistance.

In the interviews the children from the second trial were somewhat less positive about the augmented books than the first group. About half were not interested in other books done in the same way (AR), and some hesitated when asked how they liked it (this can indicate that positive responses were rather trying to please the interviewer), gave very short answers and/or could not say what exactly they liked. Most memorable and liked were the interactive sequences, but children had difficulties retelling the story line.

3. Conclusion

In our exemplary study we have uncovered a range of issues that can severely hamper the user experience in interacting with an augmented book. Some issues (such as the mirror view) may appear rather trivial. Yet their occurrence despite the relative maturity of the technology shows that awareness of these subtle design issues is still missing. While 3D augmentations and physical interaction tools are motivating for children and encourage playful interaction, these can at the same time create new difficulties, for example raising too high expectations about which physical actions have meaningful effects.

Even though it was encouraging that both groups learned with some scaffolding how to interact with the book and many children quickly understood how the system worked, the AR-book seemed not to increase hesitant readers' *general* interest in books (or AR-books) much. These children, that do not like reading and have limited literacy skills, were clearly intrigued by the augmentation and animation provided by the system, but unable to deal with the rather lengthy text sections. Different design strategies are needed that take account of the kinds of activities and stories these children might find engaging, their attention span (shorter text elements), the kinds of media they are used to and enjoy, the kinds of animals, characters or topics that they are interested in, and their limited reading skills. Overall the given books tended to separate interactive sequences from prose. The incentive to read (and the fun) might be raised by integrating very short text elements into interactive sequences, making these part of the interactive challenge.

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