Designing for Children
- With focus on 'Play + Learn'

A Case for Reading and Writing on a Classmate PC

Mayank Sharma, Intel Corporation, Oregon, USA, mayank.sharma@intel.com
Tabita Abraham, HumanFactors International, Bangalore,India,tabita.k@humanfactors.com
Russell Beauregard, Intel Corporation, Oregon, USA, russell.beauregard@intel.com

Abstract: Computing technology is adding new facets to the way children learn. There is a fear that children might loose touch with traditional methods of reading and writing with PCs becoming prevalent in schools as personal learning devices. In this study, we explore a new purpose built hardware and software technology design and qualitatively assess the value of this as compared to traditional reading of printed text and writing on paper. Reading printed books was compared with reading on a small form factor convertible tablet PC. The study evaluated the advantages and challenges specifically focusing if the form and features helped motivate children, teachers, and parents to adopt reading and writing on computers. We present the methodology and results of a task based comparative study of use between computers and paper conducted with children (aged 5-11), parents and teachers to delineate the motivations and barriers in adopting reading and writing on tablet PCs.

Key words: technology enhanced learning (TEL), user centered design, classmate PC, reading, writing, convertible tablet, educational tablet PC, eBooks, e-learning

1. Introduction

Children, "digital natives", are increasingly exposed at early ages to computing technology, which has become a common tool to facilitate education, communication, access to knowledge, and flow of information. Technological advances in hardware and software can help reshape learning styles of students adding value to learning [1] [2]. Research has shown use of ordinary software applications like word processors have helped improve achievements in many areas e.g. writing, language, reasoning /comprehension skills, verbal/nonverbal creativity, meta-cognition and independent thinking [3]. However, there remains a well-known gap between the analog world of reading and handwriting and the digital world of computers. Some teachers and parents fear losing traditional methods of learning and computing is perceived as a threat to established pedagogies. Mainstream computers historically have not been designed to support these fundamental activities of reading, handwriting, and drawing. Studies have shown there is a perceptible reduction in

time children spent in reading printed text in favor of computer usage [4]. Anderson et al have shown that the amount of time devoted to reading in the period from grade 2 to 5 is the best predictor of the child's development as a reader [5]. Observations in classrooms have shown children prefer typing on a keyboard after they pick up the skill as opposed to writing, thus losing out on developing the art of writing. This is worrisome especially for younger children because handwriting helps develop particular muscular dexterity and hand eye coordination. Studies have shown that children who are poor writers upon entering primary school are likely to stay this way throughout elementary school [6].

Our thesis attempts to mitigate these concerns through appropriate design of technology and unique opportunities offered through interactive technology when it is purposefully designed to fit the use context - the classroom teaching and learning experience.

Intel Corporation in collaboration with network local computer manufacturers and software partners are exploring design and development of low cost and purpose built PCs bundled with software to improve learning experiences in the classrooms/home that has traditionally been analog. Key characteristics include touch screen, writing on screen, rotational camera, accelerometer (senses physical motion of the tablet PC), small size, handle and design affordances for many flexible-holds. Based on observational design research in 1:1 eLearning settings, these features are designed to enhance learning experiences of children above general purpose built PCs [7]. These address key gaps observed in student computer use and migrate these activities from paper to digital media. The form factor and technology components are optimized for seamless reading/ interaction with e-books, writing/drawing (Fig 1). This study highlights a single example of observational research and design effort leading (in this case in collaboration with Human Factors International) to continuous optimization of classmate PC for educational activities.

Figure.1 Classmate PC, Intel Learning Series convertible tablet reference design with touch screen

2. Methodology

This was designed to understand the design challenges/opportunities for reading /writing on a classmate PC. Previous studies have shown that children can play an important role in designing appropriate new technologies for themselves [8] [9]. The research study used a multi-session task based qualitative approach with 10 children (both genders) aged five to eleven, their parents (n=2) and teachers (n=4). All participants used computers on a regular basis. The study was executed in 2 phases with tasks and 1:1 interviews at participant's homes. The sessions were audio recorded and photographed for later analysis.

For this study the research props were categorized into 3 buckets – classmate PC, software applications for reading/writing activities and e-books.

E-books

Two types of e-books for different age groups based on their reading/comprehension levels were provided:

1. Interactive e-books with animation and audio (Fig.2)
2. Non-interactive e-book with plain text or text and images.

Figure.2Interactive e-book with audio and animation

Software

These included commercially available applications for reading (FB Reader and Adobe PDF reader), writing (Evernote) and drawing (Art Rage). (Fig.3)

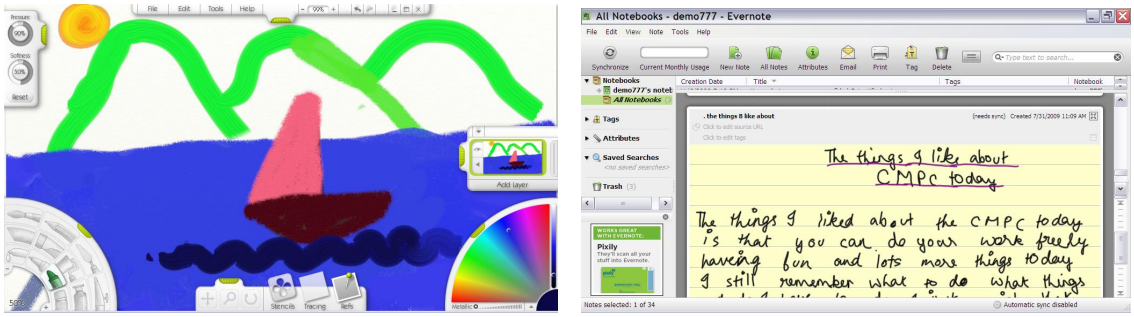

Figure.3 Software applications used on the CMPC (Art Rage and Evernote)

Phase 1 semi structured interviews focused on understanding the current reading/writing practices including participants' preferences regarding books and selection criteria of a book. Participants shared favorite books to demonstrate reasons and physical interactions with the printed books. The curricular and non-curricular textbooks and notebooks were documented along with their arrangement of books (Fig.4). Similarly the writing activities on school notebooks were documented.

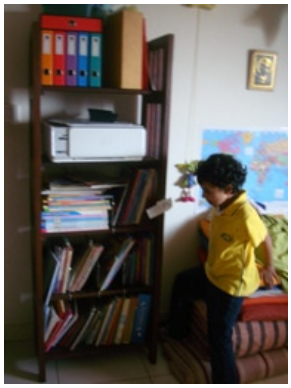

Figure.4 Bookshelf storage unit for textbooks, non-curricular books and notebooks

Participants were then introduced to Intel learning series classmate PC and given time to freely explore to familiarize with unique reading, drawing and touch screen features. Subsequently, they were asked to complete a few reading and handwriting activities which were customized according to age and comprehension level related to school activities.
e.g. Reading stories from the e-Books provided on the classmate PC
Drawing of their choice on the preloaded software
Writing in English and local language
Solving mathematics problems

The classmate PC was to be used for at least an hour a day and the reflections had while using the device recorded. In phase 1, parents were asked to interact and guide their children as they completed their tasks such that parents would gain familiarity with the classmate PC and its features. Interviews with the teachers focused on understanding the

techniques for teaching reading, developing writing skills and assessing if current quality of writing and reading on classmate PC is acceptable in the classroom.

Phase 2 sessions were conducted following a week of use by students and focused on perceived differences between reading, handwriting, and drawing on paper and on classmate PC. This was couched in terms of their personal experience with classmate PC over the past week accomplishing these tasks. Their experiences were validated on the spot by asking participants to show examples and complete minor reading /writing activities. Toward the end, children were asked about what ways they would like the device/applications to change for the better.

3. Findings

3.1 Current State of Reading

Libraries are primary sources of books, from where only 2/3 books are borrowed a week. Many books are handed down from generations and shared among siblings. Books are treated with sacred trust (in an Indian context) and not placed on the ground or pages torn from it as a mark of respect. Book selection was by their cover, which is consistent with previous studies where younger children chose books based on the cover appearances and illustrations, while older children focused on information on book jackets [10]. Children typically flipped through the books to make a judgment on readability of the content, how well images were integrated with text and number of pages. Some even looked at the back cover to review if it was worth reading. Children liked completing a book series. Five of the ten children were voracious readers for whom the quality and engagement with content were very important. They took precedence over the physical condition of the books. Books playing dual role as a writing notebook was fairly common. E.g. language books played a dual role as note taker, with meanings of words written over it to aid in recollection. While children wrote on school textbooks, which have exercises or workbooks while most of them did not write on their storybooks, as they liked keeping it neat. Some children competed to complete a book, after which they shared their understanding and opinions. They also recommend books they liked to friends. Children were drawn towards colored pictures and interactive artifacts within books since this kept their attention on the task. Typographic layout was very important for children as it allowed them to parse information adequately. All the children preferred medium size fonts with good line spacing. Research shows that children preferred text in narrower columns, although wider columns did not slow down reading speed [11]. Costs of certain storybook series were perceived as barriers to purchase for many parents. Children were

reluctant to lend for fear of loss or damage and commonly left some of their books in school so as to not carry it every day.

3.2 Current state of writing

Written word is fairly important in early education and our participants reinforced this point. In the Indian education system writing is preferred to typing, with neatness and calligraphy skills allocated additional points in tests. In schools, notes are written on the blackboard till grade 5 after which notes were dictated. Research has shown that development of writing in early schooling is very important for developing comprehension and motor skills. Students are proud to show off their notebooks and sections with complements (Fig 5). Children are initially taught to write with thick pencils/crayon before writing with pencils and finally graduating to ink pens in grade 5. They are taught to write on 4 lined books, to encourage practice of well formed letters while writing (Fig 5). Previous research has shown that children faced issues related to writing viz., handwriting/typing, spelling, capitalization, punctuation and formatting [12].

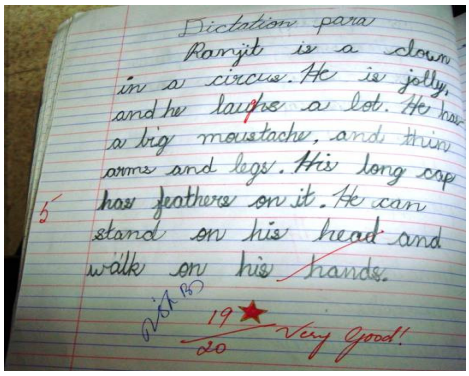

Figure.5 Student showing their school note book where the teacher has given a star

4.1 Motivations for reading on CMPC

Reading on classmate PC ranged from e-books, documents prepared by children and teachers and web content. Children loved that one device was enabled to do all these reading tasks, could store multiple e-books which saved physical space and considered this environmentally friendly. Further, students had access to the same e-book unlike in libraries where the copies are circulated or stocks limited.

All the students enjoyed using the touch screen and tablet form factor. They could sit on their bed/chair and comfortably read the e-book. Most students used the tablet form factor to read and were excited about the accelerometer which assisted in landscape/ portrait orientation. Tablet form factor reduced the overall device visual foot print

considerably making it very competitive with traditional books. Touch was a benefit as students weren't relying on keyboard or mouse. This brings into play the idea of kinetic learning which hypothesize that students learned better when allowed to manipulate and interact with their world using their extremities. Using touch functionality the book could be accessed quickly without a mouse or keyboard. Some students preferred the stylus while others used their fingers to navigate through the book. Children preferred flipping the page using finger touch to scrolling using a mouse.

All the children were drawn to the e-books with multimedia which enhanced the experience especially the audio feature which read out. The teachers and parents felt this audio feature could help in teaching pronunciation and appreciated that the word being read was highlighted. Shilling believes that speech-synthesized feedback is most effective when children already have some reading ability [13] and that makes classmate PC suitable for elementary school.

Overall, students were motivated to use classmate PC for reading tasks primarily because the change of paradigm from purely reading as in a physical book to freely interacting with the content.

4.2 Opportunities and future work for reading on classmate PC

There are significant findings from this research based on student's positive attitude toward reading on computers. However, there remain numerous challenges for the educators; technology enhanced learning communities and businesses. The interaction design with software for reading and interacting with digital content is critical. This must be child friendly and follow some of the same paradigms from physical world. e.g. children have little knowledge about e-book contents without opening the application, which is time consuming. Additionally, an e-book must be designed with care, e.g. students found the text size small to read and zooming made it difficult to get the whole picture (Fig 6). The very nature of a book makes text and image of equal value in the experience and if they were separated a crucial element of the reading/learning experience would be lost [14]. Similarly, students had to remember the page they stopped because of a lack of bookmarking feature on the software .Children were unable to annotate and also found scrolling difficult because it did not take full advantage of the touch capability. User interface design must take into account the limited screen real estate provided by educational net books and icons size and resolution were not optimized for screen so children touched two icons simultaneously.

A major hurdle in adoption of reading on computers is the availability of relevant content. Currently the state of digital education content that is school accepted is still in infancy and the industry must grow such that availability of content is widespread and low cost. More importantly, the industry must take full advantage of digital media and not stop short of just replicating or digitizing printed text book. We hypothesize the return on such an investment is limited and can hurt adoption of digital media in education. e.g. e-books with text only were not liked by children with expectation being that content must be interactive with rich media.

On the hardware side, there are a few important elements, which need to be continuously improved as technology matures and costs drop. These include touch capability which must be excellent quality and allow for light finger touch to permit gestures like sweeping pages for page turn, hitting hyper linking with a simple touch on the screen. Kinetic interaction with digital content is the key for adoption and ability of the digital content to create an emotional connection with the learner. Further, providing reading specific features and affordance such as a scroll buttons or home buttons will enhance the reading experience.

.

Figure.6 Reading applications where the image gets cropped while zooming into text.

4.3 Motivations for writing on CMPC

Parents and teachers appreciated the stylus writing on the screen, as newer technologies weren't overpowering basic skills like writing. However, it was clear even during the design phase the need to deliver better writing value proposition. Our intent here was to evaluate how far we are with respect to expectations from users and key stakeholders.

Touch screen for tasks like drawing were accepted very well with children preferring it to track-pad usage. A dramatic difference was seen in the quality and complexity of drawings created during tasks on touch screen when compared to the mouse/track pad.

The research also evaluated handwriting notes by directly writing on screen. An additional feature to create free form handwritten text into digital alpha numeric text was evaluated. Children were excited about their handwriting being converted to text and the undo button, which is not prevalent in the physical media allowing them to quickly undo mistakes. The digital data can be saved, copied, edited and shared. Children could jot down hand written notes just like on paper and the art of writing which is unique to each child would be maintained. Children could write in different local languages, unlike using the keyboard (Fig7). Time could be spent efficiently to understand concepts rather than copying notes.

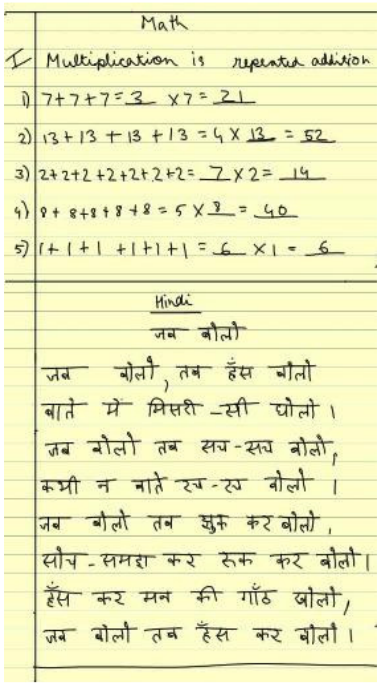

Figure.7 A 7-year-old child doing tasks on CMPC using ever note

Classmate PC was designed in solution to address the problem of vectoring. Students can effectively rest their palms on the screens while taking notes, which is analogous to the way notes are written on paper notebooks. This capability was positively received by the participants. However, there were instances where the palm cancellation did not work appropriately. For e.g. it was observed that the stylus was not being held as a normal pencil and “floating hands” came into play to avoid vectoring as needed. (Fig 8)

Figure.8 Participant (9 years) trying to draw without his palm touching the screen

Pen input resolution on the touch panels are a key determinant if the touch screen is going to be used for extensive writing exercises. This is an inherent feature of the technology of touch being used (resistive, capacitive or electromagnetic). As expected with a resistive touch panel on classmate PC, participants had troubles taking detailed notes and general feedback on the quality points in direction of continuous improvement required to improve handwriting resolution. One child said, 'my handwriting is not that bad.' Some children were concerned about the inability to hang their paintings.

Differentiating certain characters were difficult e.g., "r" and "n". Children had to write bigger as the applications were unable to recognize detailed strokes. (Fig 9) Many features and icons present were found to be complicated. The double scroll on the right was confusing. Majority of the children did not use a logical method of saving file names, which caused problem during retrieval (Fig 10).

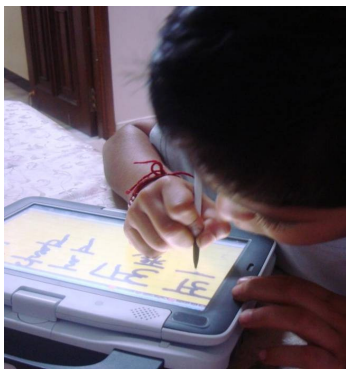

Figure.9 Participant (5 years) writing big alphabets, as the screen is unable to identify detailed pen strokes with varying stylus pressure

Figure.10 Participant (7 years) trying to find one of the drawings she made on the CMPC

4.4 Opportunities and future work for writing on CMPC

It is clear that more work needs to go into perfecting the touch, writing experience. These points towards keeping up with the latest in touch screen technologies and working with the industry to bring the cost lower for higher quality touch panels. For e.g. the touch experience was not entirely seamless especially while writing to text conversion and the children needed to write in a specific way for their hand writing to be recognized. Read et al have shown that even if the user of the digital pen writes the correct letters in a sensible way, the system may still produce an incorrect representation of their words [15] leading to user frustration and lost productivity . Previously published studies have also shown that the features of child writing that have been shown to be problematic for recognition were 'beautifying' and the 'obliteration' of text [16].

5. Conclusions and Further Research

Results from this study are encouraging and indicate progress in the right direction. The novel experience of writing on screen excited the children. Although the classmate PC are not yet directly competitive with paper so as to replace them, this study gives valuable data for the design team on steps to move forward towards that goal. Certain design decisions made following earlier studies have proved useful in actual usage by students. This initial study has uncovered several critical problems children were facing. In depth studies would need to be done to validate the finding among children with different age groups, gender, technological skills and cultures.

This paper is also a call for the industry to move the development of the right technologies (Hardware and Software) that will lead to right cost levels and at the same time deliver reading and writing experiences that are directly value against printed paper.

Acknowledgement

We would like to thank Dr. Girish Prabhu and Sarit Arora from HFI and Intel.

References

1. Bennett, S., Maton, K., & Kervin, L. (2008). The ‘digital natives’ debate: A critical review of the evidence. British Journal of Educational Technology. pp 39, 5, 775-786.
2. Dede, C. (2005). Planning for neo-millennial learning styles. EDUCAUSE Quarterly, 1, 7.12.
3. Roschelle, J.M., Pea, R.D., Hoadley, C.M., Gordin, D.N. (2000).Changing, How and What Children Learn in School with Computer-Based Technology. The Future of Children. 10(2) pp 76-100.
4. Prensky, M. (2001) Digital Natives, Digital Immigrants, On the Horizon MCB University Press, Vol. 9 No. 5
5. Anderson, R.C., Wilson, P.T. and Fielding, L.G. (1988), Growth in reading and how children spend their time outside of school. Reading Research Quarterly, 23, pp 285-303.
6. Juel, C. (December 1988) Learning to Read and Write: A Longitudinal Study of 54 Children from First through Fourth Grades. Journal of Educational Psychology 80, 4, pp 437-447.
7. Cramer, M., Beauregard, R., Sharma, M. (2009) An Investigation of Purpose Built Netbooks for Primary School Education.
8. Druin, A. (1999). Cooperative Inquiry: Developing New Technologies for Children with Children. In Proceedings of Human Factors in Computing Systems (CHI 99) ACM Press, pp 223-230.
9. Druin,A., Stewart, J., Proft, D., Bederson, B. B., & Hollan, J. D. (1997). KidPad: A Design Collaboration between Children, Technologists, and Educators. In Proceedings of Human Factors in Computing Systems (CHI 97) ACM Press, pp 463-470.
10. Kragler, S. and Nolley, C. (1996). Student Choices: Book Selection Strategies of Fourth Graders. Reading Horizons, 36 (4), pp 354-365.
11. Bernard, M., Fernandez, M., and Hull, S. (2002) The effects of line length on children and adults' online reading performance. Usability News. 4, 1.
12. MacArthur, C. A. Overcoming barriers to writing: Computer support for basic writing skills. Reading and Writing Quarterly 15, 2 (April-June 1999), pp 169-192.
13. Shilling, W.: Young Children Using Computers to Make Discoveries about Written Language. Early Childhood Education Journal. 24(4) (1997), pp 253-259.
14. Bederson, B., et al, (2009) Designing the Reading Experience for Scanned Multi-lingual Picture Books on Mobile Phones.
15. Read, J.C. and M. Horton. (2004) The Usability of Digital Tools in the Primary Classroom. in EdMedia2004. Lugano: AACE Tavel, P. 2007 Modeling and Simulation Design. AK Peters Ltd.
16. Dix, A., Finlay, J., Abowd, G., Beal, R. (2004): Human-Computer Interaction. Third edition ed. Pearson Education Ltd.