Popular eReaders

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***Abstract*—**The evaluation of electronic consumer goods are most often done from the perspective of analysing the latest models, comparing their advantages and disadvantages with respect to price. This style of evaluation is often performed by one or a few product experts on a wide range of features that may not be applicable to each user.

We instead used a scenario-based approach to evaluate a number of e-readers. The setting is similar to a user who is interested in a new product or technology and has allocated a limited budget. We evaluate the quality and usability of e-readers available within that budget range. This is based on the assumption of a rational market which prices older second hand devices the same as functionally equivalent new devices.

We describe our evaluation and comparison of four branded eReaders, as the initial stage of a larger project. The scenario has a range of tasks approximating a busy person who does not bother to read the manual.

We found that navigation within books to be the most significant differentiator between the eReaders in our scenario based evaluation process.

***Keywords*—**eReader, scenario based, price comparison, Kindle, Kobo, Nook, Sony, technology adoption.

I. Introduction

In 2007, Amazon launched the Kindle in the United States and it sold out in under 6 hours [1].

Prior to the Kindle launch there was not a huge demand for e-readers as earlier releases were the Rocket eBook in 1998, the Sony Libriè in 2004 and Sony Reader in 2006. These earlier devices were unsuccessful because they were very expensive, had too many technological limitations and lacked available content. The Kindle was different because it was more affordable, consumers could purchase a wide variety of e-books via the wireless data connection and it was comparatively easy to use.

E-readers with e-ink screens simulate the experience of reading a paper book and are not multifunctional devices. The advantage of an e-reader is that it is easier to read even in direct sunlight, does not consume a lot of battery, is lighter in weight, permits undisturbed reading of an e-book and the eyes do not fatigue compared to devices with backlit LCD displays.

In the United States, the cost of e-readers has continued to fall, making them more accessible to purchase. Data from Pew Research Centre over a three-year period from May 2010 to January 2014 indicate e-reader ownership has grown over 20%, see Figure 1 on ownership growth of e-readers and tablets in the United States. Overall, 50% of Americans now have a dedicated handheld device – either a tablet computer like an iPad, or an e-reader such as a Kindle or Nook for reading e-content, and $^1/_3$ of US adults now own an eReader (Zickuhr and Rainie, 2014).

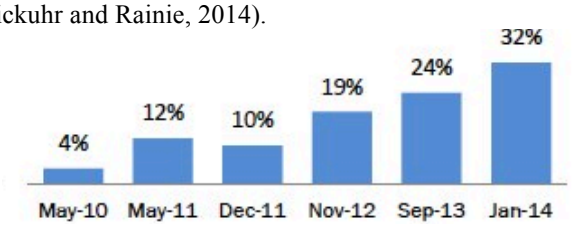

Fig. 1 eReader ownership in the US

II. Background

To establish design guidelines for e-readers, a study [3] was conducted to determine the usability concerns with user interface of the e-readers using human computer interaction (HCI) principles. The experiment was carried out using the Kindle 2, Sony PRS 600 and Sony PRS 300. These three e-readers had similar screen type (e-Ink technology), screen size (six inches) and resolution (600 x 800). The Sony PRS 600 has a combination of touch and button device whereas the Kindle 2 and Sony PRS 300 were button devices.

Based on the guidelines and principles for ergonomics, consistency, completeness, page numbering, book marks, annotation and magnification, the Kindle was found to be better than Sony PRS-300 and PRS-600. The positioning of the buttons in the Kindle made it easier to turn pages for both left and right-handed users. The Kindle had a full QWERTY keyboard which supported web browsing and location identifiers in relation to the file instead of page numbers. The availability of full annotation and zooming was only available on the Sony PRS-600. User feedback on the three e-readers was leveraged from Amazon's online customer review and weighted on a Likert scale rating. This could have attributed for the higher ratings for the Kindle, as it is produced by Amazon.

Based on reported sales and market share in the United States, [4] studied five leading e-readers namely Kindle 3G; iPad 1G; Nook; Kobo N647; and Sony PRS950. Their objective was to identify the advantages and disadvantages of e-readers and "to compare and contrast the most popular (i.e. bestselling) devices against a comprehensive, if not exhaustive, set of technical specifications as well as qualitative judgment of users".

The results from that study showed that the Kindle was the most popular device, though some participants commented on

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poor navigation. Some 47% of the participants that undertook this study owned a Kindle, accounting for a probably biased popularity of the Kindle. There was no evidence for the technical comparison nor did they elaborate what it consisted of. The comparison between the iPad and the e-readers was not well justified as the tablet is a multi-function device, whereas e-readers are designed to read and purchase e-books. This means that the iPad on the one hand may be seen to be a more desirable device, yet have more features to distract the user when used as a reading device. So an ideal comparison would try to take into account these differences.

A usability study [5] of e-reading devices was based on a scenario, which involved the participants recording their experiences of opening and using a newly purchased e-reading device. A number of pages from a paper book was the benchmark for the evaluations. The same content being available on the e-reading devices. Over a week, seventeen participants recorded their reading times, places they had read and their experiences on using the e-readers. The time-based assessment tasks included opening the device; finding a book; finding a specific spot in the book and changing the font size.

The following e-readers in that study: Kindle (included both Kindle 2 and Kindle 3); Sony PRS600; iPad 1G; BeBook Neo; Booken Cybook Opus; Elonex eBook and Samsung galaxy.

The outcome of the usability study was the creation of a conceptual model of an e-reader labelled Acola. The Acola was a combination of touch sensitive and gesture savvy pad on an e-ink device. The pad would handle page turning and skimming. Swiping to the left would turn the page forward, swiping to the right would move one page backwards. Swiping fast two times successively, would turn two pages, three times: three pages etc. Swiping with two fingers simultaneously would move you between chapters. A menu and an OK button could be situated in the upper and lower border of the pad [5].

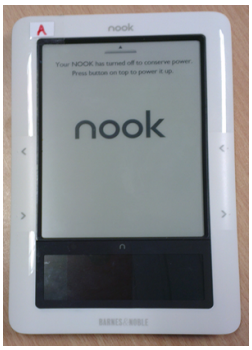
III. eReader Devices Evaluated

We set an approximate target price range of $50-$75, and sourced eReaders second hand via the well known eBay site. This has the implication that we will find that our devices are a mix of older high specification devices as well as new or near new lower lower specification devices (e.g. Kobo in this study). We decided not to include postage in this budget, so as to speed up acquisition of the devices, and open the much larger market of US sellers to us, though we note all devices were eventually available via ebay.com.au. The postage we paid ranged from $8 to $30.

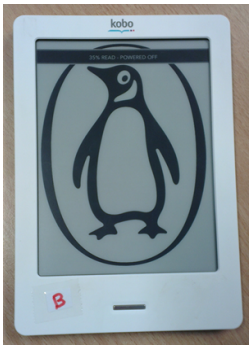
The significance of our budget approach is to compare devices at a snapshot of the industry, through a budget focused consumer lens. That is, the devices which are available at any point in time are the new or almost brand new items still in stores and the recent to older devices available via second hand such as via eBay. The second hand devices on eBay compete with current devices on a level customer playing field in that older but initially higher specification devices would sell for amounts equivalent to a functionally equivalent recent device, in a rational market.

TABLE I
EREADERS LABELLED A-D IN ORDER OF ARRIVAL

	e-Reader	Cost
A	Barnes & Noble Nook 1st Ed	69.90
B	Kobo Touch	60.00
C	Amazon Kindle 4G	57.85
D	Sony PRS-600	44.88



Properties:
Buttons: for page turning
Touch screen: no (main)
separate touch screen at bottom, colour (led)
Weight: 324g
Released: 06/2010
Display: eInk
Screen: 6 inch, 600x800
Separate: 3.5 inch 480x144



Properties:
Buttons: no
Touch screen: yes, IR based
Weight: 185g
Released: 05/2011
Display: eInk Pearl
Screen: 6 inch, 600x800

Properties:
Buttons: yes
Touch screen: no
Weight: 170g
Released: 09/2011
Display: eInk Pearl
Screen: 6 inch, 600x800

Properties:
Buttons: for navigation
Touch screen: yes
Weight: 284g
Released: 08/2009
Display: eInk
Screen: 6 inch, 600x800
Stylus: Integrated

Fig. 2 eReader properties

Each eReader was pre-loaded with over 70 books downloaded from the Gutenberg [6] website of books now in the public domain. The selection was eclectic, consisting of popular fiction [7], mythology [8], craft [9], history [10] and classical philosophy [11]. This was to emulate an eReader already loaded with content, which is the most plausible scenario for most real users of eReaders for most of the life-span of the device.

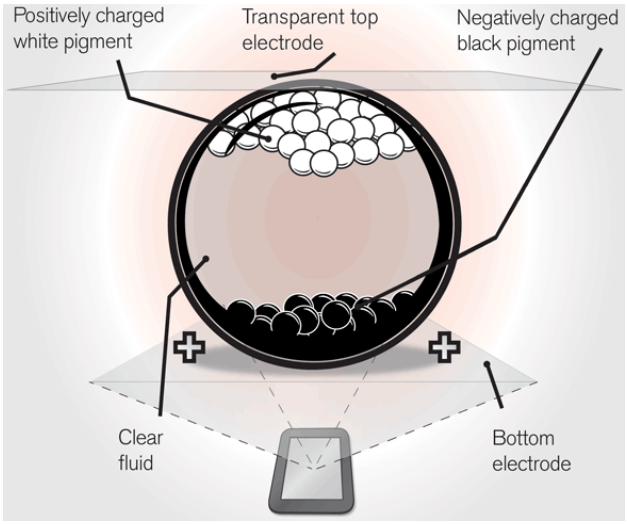


Fig. 3 e-Ink technology [12]

The screens on our eReaders are bistable and display an image without power, which is only consumed when the display is changed, and thus leads to quite low power consumption. The e-Ink screens are reflective, and ambient light is used for reading, and consequently these screens are usable in direct sunlight.

IV. Procedure, Scenario and Results

These were the instructions to participants:

> You have been given an e-reader as an unexpected gift, and you haven't opened the box until now, you have had it since last year sometime. You find a slip of paper which says "Important check registration deadline – device not usable if not registered by this date" and tells you to open the "Somedevice XY User Guide" document and find section 3, paragraph 2, and find the model number, and then look for that number in the "Dates-2013" document to check how long you have to register the e-reader. You have no manual for the device, so you just have to try and figure it out as you go along.

A. Participants

Twelve participants took part, with a mean age of 24.8 years, standard deviation of 3.2 years. The single female subject was the only one to not report their age. Five of the participants expressed familiarity with eReaders. The subjects were 3rd or later year Computer Science students, hence explaining the gender disparity.

The tasks were undertaken by participants in pairs, with one of them operating the device, and the other acting as a scribe, and then they would swap and repeat the tasks with another device. Thus, there were 6 sets of survey forms completed during the experiment, each reflecting the evaluation of 2 eReaders. That is, each of the eReaders was evaluated three times. The survey forms listed the tasks to undertake, with a number of Likert scale evaluations of each device on each task. The role of the scribe was to record the joint decision of the pair of users for each task on each device.

B. Results

Only a single task produced results which were statistically significant at the 0.05 level. This task was to navigate to the 3rd section of a document which had been found already as part of a previous task, and to report some information from the short 2nd paragraph of that section. Table 2 shows the scores for each device on this task. The "question" being answered is to evaluate the devices on this task.

Participants circled their selection on a Likert scale displayed vertically: V. good / Good / OK / Bad / V. bad. These were mapped to 5 / 4 / 3 / 2 / 1 for statistical analysis.

TABLE 2
eReaders labelled A-D in order of arrival

Nook	Kobo	Kindle	Sony
A	**B**	**C**	**D**
2	5	3	2
1	3	4	3
1	4	3	1

By inspection of Table 2, we can see that device A is clearly the worst, and that devices B and C are similar, with device D being somewhere between the best two devices and the worst device. The ANOVA results are shown in Table 3.

TABLE 3
Statistical analysis results

Summary

Groups	*Sample size*	*Sum*	*Mean*	*Variance*
A	3	4.0	1.3	0.3
B	3	12.0	4.0	1.0
C	3	10.0	3.3	0.3
D	3	6.0	2.0	1.0

ANOVA

Source of Variation	*SS*	*df*	*MS*
Between	13.333	3	4.444
Within	5.333	8	0.667
Total	18.667	11	

F	*p-level*	*F crit*
6.667	0.014	5.901

We calculated the paired Student's t-test comparisons, and only the comparison of devices A and B are significant at the 0.05 level, giving a $p = 0.0153$, though A to C and C-D have p values which are "close to significant".

V. Discussion, Conclusions and Future work

Our study used a scenario based approach, based on a new user to eReader devices, perhaps received as a gift. We believe users will evaluate such devices quickly, superficially, and simplistically. Our scenario is meant to emulate such a setting and evaluate a number of eReaders focusing on non-reading tasks. There are many studies which have shown that once users are reading there are only minor differences in devices, though this may be a function of engagement with the reading material and not a real similarity. Such considerations are well beyond this study. Our study relates more to technology adoption.

Clearly, we need more subjects to determine if the "close to significant" comparisons will be significant. In our experiments with twelve participants, we found that one task, navigating to a particular section, was significant, and that pairwise comparisons on that question yielded a statistically significant result between the worst and best devices.

In our background section, we described a previous comparison which created an ideal eReader called the *Acola*. That device is very similar to our device A, the Nook (1st Edition). This device was clearly the worst in our study, and highlights the difficulty of designing an abstract device. We report two free form comments about device A: "Key pad is horrible, not intuitive" and "Touch screen small even for a female's fingers".

We note that in the literature there is a progression from early studies taking a heuristic evaluation approach (drawing on HCI design principles) through studies that are task-based and finally studies (such as ours) that use a scenario-based evaluation approach. We consider such task based approaches most suitable in this area.

Acknowledgment

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