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ABSTRACT

New technologies create great opportunities as well as new challenges when libraries build their virtual collections. As e-book readers and other portable devices grow in popularity, collections can no longer be evaluated purely on the basis of content; their adaptability and ease of use on various platforms has to be taken to account. Collaboration between libraries, users and usability professionals is paramount in building virtual collections of the future. Only users can tell how these platforms are going to be used, as mobile tools for study or as entertainment devices. It is important to learn how usable the e-collections really are and what essential materials are currently incompatible with these devices. Digital rights management and technical compatibility issues should become standard considerations in all acquisition of electronic materials. This paper will present a study conducted in the Helsinki University of Technology Library, currently part of the Aalto University, from autumn of 2009 until summer of 2010. In collaboration with the Strategic Usability Research Group, various e-book readers were tested by both professionals and students. In the study, e-book readers were given to students for one study period with all the course material provided in electronic format. Feedback from the students was collected through discussions, study diaries and questionnaires. In the library, the e-book readers were tested in order to see what demands and restrictions they pose on e-materials and how well the current e-collections of the library are usable on these devices. Results suggest incompatibilities with many licensed e-materials, whereas most open access materials can be easily downloaded and used.

Keywords usability, human-computer interaction, e-books, e-readers, digital rights management, collection policy, academic libraries

INTRODUCTION

E-BOOKS AND E-READERS IN ACADEMIC LIBRARIES

Electronic books have been just around the corner for decades. Now finally, with the Amazon Kindle first leading the way (60 percent of US e-book reader market share in the beginning of 2010; The Tech FAQ, 2010), e-reader technology has taken off. E-book readers are becoming everyday technology and we can expect to see much more of them and their new competitors, the tablet computers, in our libraries (Rotman Epps and McQuivey, 2009). Some libraries are already lending out electronic material on e-readers, such as the Turku City Library in Finland (Turku City Library, 2010), the West Vancouver library in Canada (Hui, 2010) and the university libraries of the American University in Washington, DC (American University, 2010) and the North Carolina State University (NCSU Libraries, n.d.) in the US, just to name a few. The University of California Irvine School of Medicine has provided all of the incoming medical students with Apple iPad tablet computers which have already been loaded with the course material for the first year (Vasich, 2010). The Gushing Academy Library is taking it one step further and is getting rid of all printed material, with all the library resources to be used on laptops, tablet computers and e-readers (Abel, 2009).

How are these devices going to affect the way academic libraries offer material to users? Are they just a "passing fad or trend of the future?" as William C. Dougherty asked in his analysis of the current state and the future of e-readers (Dougherty, 2010)? He gives us no answers but raises important questions on policy, licensing, availability and technical issues that have to be solved before these devices can threaten the position of printed academic material. Karl Drinkwater (Drinkwater, 2010) emphasizes the importance of organizational content that can be loaded to the devices: lecturer's notes and library information packages, for example. But, he notes, while the readers can easily be filled with out-of-copyright or readily available material for English literature or contemporary fiction studies, there is a lack of available material in many other fields of study. He also brings up the issue of Digital Rights Management, which makes the use of some materials impossible on the readers, while other materials can require installations of new software with regular updates, creation of customer accounts and authorizing devices for them to work. Furthermore, e-books come in many different file formats, which causes incompatibility with the different platforms. Several universities have been testing the usability of e-readers and how these restrictions affect their use in academic libraries.

Penn State University Library teamed up with Sony to introduce the Sony Reader to the university community and to influence changes in e-book technologies with the viewpoint of academics and librarians (Behler, 2009). The library experimented how to best provide material on the 100 readers to the users and to work around the licensing structure of a device meant for private use. The readers were used by students on multiple courses to find out how well they were suited for academic work. It was found that the readers still lack many functionalities required for academic use, such as better interaction with the text, and that the devices were not at all suitable for use in the hard sciences, which require good representation of diagrams and color and utilize a more non-linear reading technique.

The Lloyd Sealy Library also studied the technical applicability of Sony Readers and student's views on the devices (Kiriakova et al., 2010). They found that the users expected the e-readers to have colour touch screens, like their PDAs or iPhones, and to be simple enough to be used intuitively, without looking at a manual or even brief instructions of use. They also noted the e-reader service's emphasis on individual users; most needed scholarly titles were not available and the content management and copyright issues faced by libraries had not properly been taken into consideration.

At a study conducted by the Open University and Cranfield University in the UK (Mallett, 2010) four Sony PRS-505 and two iPod Touch readers were given to students for testing during a three month period. The portability and light weight of the readers was found positive in both cases. The Sony was criticized for the slowness of navigation and the annotation tools. The lack of in-text linking and formatting issues were found to be a problem with both devices. The touch color screen, quick page turning and variety of functions were mentioned as the strengths of the iPod. Its weaknesses were found to be the smallness of the screen, the dependence on a wifi connection and the difficulty of uploading materials. On the whole laptops were still preferred by the students. Licensing issues were found to be a problem with library subscribed e-books.

The Amazon Kindle e-readers have been tested in several studies. University of Washington, Princeton University, Arizona State University, Case Western Reserve University, Pace University, Reed College and Darden School of Business at the University of Virginia participated in Amazon's Kindle pilot program for the term 2009-2010 (University of Washington, 2009; Arizona State

University, 2009). Princeton trialled Kindle DX's to try to cut down on the printing and photocopying done in the three pilot courses (Princeton University, 2010). They did succeed in cutting the printing in half compared to the control groups. They also wanted to test the current e-reader technology and its applicability in the classroom. They found that while the reading experience was good, the writing tool did not compare to old fashioned pen and paper. The preliminary analysis of the Darden trial (University of Virginia, 2010) shows that "Most Darden students prefer not to use the electronic reading devices in the B-school classroom." The readers were found to be too slow to be used for reference materials in the fast paced case studies.

Pattueli and Rabina (2010) studied LIS students' attitudes toward Kindle and were interested in the social and cultural impacts of the e-readers. They studied individual reading practises and found that the e-readers easily fitted into the daily routines of the students. Students reported on reading more due to the ease and portability, but commented on the limitations of sharing and transferring ebooks, the dependency on one company for content and the price of both the device and subscribed materials such as blogs. Also Clark et al. (2008) studied the usability of the Kindle and collected the views of 36 academic librarians about the e-reader. Their findings mirror the results from the other studies, regardless of the e-reader tested: "Analysis of the discussions indicates overall interest in the Kindle as a basic reading device for fiction. However, its use in an academic setting is limited due to content availability and licensing issues, graphic display capabilities, organizational issues, and its prohibitive cost." Other common findings were that the annotation tools were too cumbersome to use and moving within the text was too slow. As quickly checking previous information or references is essential in academic study, this was found to be one of the biggest disadvantages of the readers. The North West Missouri State University tested both the Kindle and the Sony Reader and decided they would instead focus on providing e-books to their students through the laptops they were already provided with (Rickmann et al., 2009) to avoid these serious problems with usability.

RESEARCH QUESTIONS AND SCOPE OF THE STUDY

From the library acquisition point of view it is no longer enough to consider which content is needed for the collections but also in which formats and on what platforms it is available. How does this new technology contribute to the way e-books are selected by the library? Until recently we have accepted the deficiencies of different platforms as long as the books were usable in one way or another. Most services required the installation of reader programs or plug-ins, some of which did not work with Linux, for example. As we start to use e-books as substitutes for print, we need to be more demanding. We should be able to provide the content the user needs on a platform he or she prefers.

How compatible are the current e-resources, which are originally meant to be used on a computer, with this new technology? Do the license agreements even allow the transfer of e-books to these devices? If the customers asked which of the e-readers worked best with the library resources, would one know how to reply? In the first place, would the customers want to use these new devices for study or work, or will they be used purely for entertainment?

This study was conducted to answer the questions above and in general to increase the knowledge on e-readers in the library. The five tested e-readers were chosen on the basis of availability at the time and the library testing focused on the licensed e-book material in use at the university. The user testing was set up to collect feedback from individual students on their general views of the e-readers as well as their applicability on delivering course materials. The number of participants was very restricted, but valuable information was collected to be used as a basis for further studies and to raise important questions in virtual collection development.

As was noted by the librarians at the Lloyd Sealy Library (Kiriakova et al., 2010), the scene of e-readers is changing rapidly and by the time any body of research is completed the devices in question are becoming obsolete or at least tired and old compared to the new ones that have come up during the process. When our testing was being done, only rumours of the upcoming iPad had been heard. The Aalto library bought an iPad as soon as it became available in Finland, but the student testing could not yet be repeated on this device. An overview of the compatibility of the iPad with the library resources is however included.

E-BOOK COLLECTIONS IN AALTO UNIVERSITY LIBRARY

Aalto University was newly created from the merger of the Helsinki School of Economics, the University of Art and Design Helsinki and the Helsinki University of Technology. The libraries of the three former universities have also merged and strive to provide the best resources for strong multi-disciplinary education and research. The University has three schools and campuses: the School of Art and Design, the School of Economics and the School of Science and Technology. The same electronic collections are now available on all three campuses. This study was begun in the Helsinki University of Technology Library and continued in the Aalto University Library, Otaniemi, which is situated on the campus of the School of Science and Technology.

The Aalto University Library acquires e-books through 13 services, shown in table 1. About 50,000 of the e-books are subscribed to on an annual basis, while perpetual access has been bought for 830 titles. In addition to these numbers, the Finnish consortium FinElib has provided access to the vast ECCO (Eighteenth Century Collections Online) and EEBO (Early English Books Online) collections of historic material. Some of the services, such as Ebrary, provide big package deals, while others, like DawsonEra and Myilibrary are used to select individual titles. Acquisition of new e-books is done mostly to the platforms that allow individual title purchases.

CUSTOMERS OF AALTO UNIVERSITY LIBRARY

Aalto University Library is a scientific library that is open for all, from within and without the university. It recognizes the life cycle of its customers and their information needs and strives to create high quality customer-oriented services and processes. The library integrates into the research and learning processes of the university and values openness and social impact. One of the important missions of the library is to acquire world class electronic and printed collections for the use of the university staff, students and other customers. (Aalto University Library, 2010)

The target group in this study are the customers of Aalto University Library, Otaniemi. In the year 2009 there were over 8300 active clients using the services of the library. The three largest client groups were Aalto University students (67.5 percent), Aalto University staff (9.7 percent), and industrial clients (8.2 percent). The researchers and student of the university have remote access to the electronic materials in addition to on-campus use. (Aalto University Library, 2010)

E-READERS

Five different e-book readers were selected for the study and two copies of each were purchased for the library. The main criteria for the devices were their availability and reasonable pricing; consumer products in the 200-300 Euro range were chosen, i.e. devices designed for professional usage were not considered. The five evaluated devices were:

- * Foxit eSlick (http://www.foxitsoftware.com/ebook/eslick_eol.html)
- * Bookeen CyBook Opus (<http://www.bookeen.com/en/>)
- * BeBook (<http://mybebook.com/>)
- * Amazon Kindle (<http://www.amazon.com/Kindle>)
- * Sony Reader Touch Edition PRS-600 (<http://www.sonystyle.com/>).

Their main characteristics can be seen in Table 2.

All of the devices use the same E Ink Vizplex technology. They also can all hold over 1,000 books, so the memory capacity was not an issue, especially when they all also had slots for memory cards.

THE IPAD

The library also purchased an iPad as soon as it became available in Finland. The iPad (<http://www.apple.com/ipad/>) is a tablet computer, which is now seen as an alternative to dedicated e-book readers. It differs from the readers in basic technology: it is a computer with multiple functionalities and a colour screen which is not based on the eye-friendly eInk technology. As a computer it also uses up much more electricity than the actual e-readers, but 10 hours of operation is promised on a full battery. The dimensions of the iPad are 242.8mm × 189.7mm × 13.4mm with a 9.7 inch display and a weight of 680g. This makes it considerably larger than the tested e-readers.

COMPATIBILITY OF E-MATERIALS WITH E-BOOK READERS

E-BOOKS, LICENSES AND DRM

For the library, e-books provide many improvements over print books. Usually many customers can use them simultaneously, each making their notes and highlights in their own virtual version, not in the only printed copy. They cause no physical storage problems and do not wear and tear with time. They can also be cost effective, providing more access with less funds. The publishers see this quite differently: the physical book is easy to manage as only one person can have it at a time and there is no easy way to copy and distribute it to others, whereas the electronic book is potentially easily redistributed to any number of people.

Digital Rights Management (DRM) is a general term for technologies which restrict access to or use of digital content (Wikipedia, 2010). Its applications in the music and film industries are well known but some publishers and distributors also apply DRM to e-books. Many e-book services have strict terms of use for use on any type of platform. Limitations on downloading, copying and printing frequently cause frustration in library users. The DRM solutions can also limit the usability of materials on e-readers.

As in the entertainment industry, the use of DRM in e-books is controversial, limiting usability in ways which often seem unfair to users (Dickson, 2010; Drinkwater, 2010; Beschizza, 2007; Slusher, 2004). The buyer no longer really owns the book, only the right to use it on a given device until the device is lost or breaks, the technology becomes old or some other reason renders the book unusable. As for library materials, if the library provides access to a given title it should not matter if the material is read online, printed out or transferred to a reading device.

QUESTIONNAIRE FOR E-BOOK PROVIDERS: E-BOOK COMPATIBILITY WITH E-READER DEVICES

In order to assess the availability of electronic material for the e-book readers, a questionnaire was sent to 17 publishers or e-book providers about the usability of their materials on e-book readers. The questions were:

1. Do your library licence agreements allow for the books to be used on e-book readers?
2. What DRM is included in your e-books?
3. Which e-readers are the e-books compatible with?
4. Which extra programs are needed to use/transfer the e-books to the e-readers?
5. Does the e-reader require an Internet connection to allow the e-book to be read?
6. Will the e-books be usable on the iPad?
7. If the e-books are not yet compatible with any e-readers, are there plans to make them available during the next few years?

At the time of writing, full responses had been received from Elsevier, RSC, Ellibs, Morgan & Claypool, SPIE Digital Library, DawsonEra, Ebrary and Mylibrary.

DawsonEra replied that it is possible to read their e-books on iPhones, but not on e-readers. All the other respondents stated that use of their materials on e-readers is allowed. However, this issue has not usually been separately considered in the license agreements. Furthermore, contradictory information may be obtained from the license agreement text, the web pages and the company representatives. For example, on the pages of one of the providers it is said that saving or uploading material to any other storage device is not allowed, but when asked, the representatives of the company said that use on e-readers is allowed. It is not always clear how the terms apply to this new technology and it is best to check directly with the publisher/provider.

Elsevier, RSC, Morgan & Claypool and SPIE use no DRM in their e-books. These platforms also allow the material to be downloaded in PDF form, which makes them compatible with most e-readers, including those assessed in this study. The DRM-free PDFs can be downloaded to an e-reader via a computer with Internet connection and then used offline.

Ellibs uses the Adobe Content Server 4 DRM protection. Their e-books are compatible with many readers such as the tested BeBook, Bookeen CyBook and Sony Reader. Downloading the books requires that the user creates and uses an Adobe account and the authorization of the e-reader for the Adobe DRM. This is done after connecting it with the Adobe Digital Editions software running on a PC or Mac. After the authorization procedure the e-book can be downloaded to the reader and used offline. The Ellibs books use a loaning model and only one user can use a copy at a time. After the lending time expires the book will stop operating on the e-reader.

Ebrary and Mylibrary do not allow the downloading of the e-books and use strict DRM to restrict printing and copying of the material. They are only compatible with devices that have an Internet connection and can make use of the original online platforms.

E-books from all of the platforms except Ellibs are available with the iPad, because of the Internet connection and web browser that allow the online use of the materials. Ebrary is planning for an application for the iPad and Elsevier is planning to launch an iPhone/iPad application to further improve the usability of the materials on these platforms. The Adobe DRM on the Ellibs books is not compatible with iPad, but Ellibs is discussing other DRM solutions with the publishers in order to offer the material on new platforms, including the iPad.

Many of the respondents pointed out that current e-readers are designed for reading novels and are not well suited for academic material including charts, tables, equations and colour graphics. The smaller displays are also too small for comfortably viewing PDFs, which is the most common format of academic papers. It was also recognized that users prefer to use their materials on laptops due to the better functionality.

USABILITY OF THE LIBRARY RESOURCES ON E-READERS

In order to get a more comprehensive view on how much of the library's electronic materials could be used on e-readers, 13 different e-book and several e-journal platforms were studied.

For all the enthusiasm about e-books on e-readers, the most used resources for research in the Aalto University are the journals. These are acquired in electronic format whenever possible and the library currently provides access to over 15,000 journals. Articles from these can almost without exception be downloaded as PDFs, which makes them easily usable resources.

Apart from Kindle, all of the tested e-readers allowed easy drag and drop addition of PDFs to the devices and had zooming functionalities enabling the use of PDFs. The tested version of Amazon Kindle did not directly allow the use of PDFs, but had a service to transform PDFs to a Kindle compatible format. However, at the time, no zoom options for PDFs were available on the Kindle and it was also excessively difficult to transfer the material to the reader. Similarly to the journal papers, the electronic books, which could be downloaded in PDF format without restrictive DRM, worked well on all of the other devices, apart from the Kindle.

Problems were found, however, when trying to download and save e-books using DRM solutions. The DawsonEra books could not be used without a network connection as there was no way to retrieve the required DRM certificate to the e-reader. The books could in fact be moved to the readers, but the file would not open for use. The DRM on the Mylibrary, Ebrary, Safari and WSOY platform prevented the downloading of the material in the first place, so it was impossible to transfer the material to the readers.

Only one provider with DRM, Ellibs, supported the downloading of e-books to readers. However, other restrictions made the use of this service complicated. Two additional computer programs (Adobe Digital Editions and Sony Reader e-book library software) were required to download, save and transfer e-books to the reader. This process required several steps and stages (installation, configuration, connection, download and transfer of material with DRM) that one cannot expect ordinary library users to master.

The results of the testing are presented in Table 3. The table excludes the EEBO and ECCO packages, because of their historic nature, which makes them of lesser priority for the Aalto University. Including them in calculating the percentages of the full university collection that the service providers represent, would give misleading results.

The packages fully compatible with the readers, which allowed the material to be easily transferred and used, were Elsevier, Knovel, Lecture Notes in Computer Science (Springer), OECD and Morgan & Claypool, the first four downloadable chapter by chapter, the last one as single documents. The digitized material from ECCO could be also downloaded with up to 50 pages in one PDF document, whereas the images in EEBO could only be downloaded one page at a time.

The providers whose books could not be used at all were DawsonEra, Ebrary, Mylibrary, Safari and WSOY. The Ellibs service could not be used with reasonable ease. This meant that only 17 percent of the library's e-books were compatible with the tested devices.

When these materials were tested on the iPad all except the Ellibs books could be used. The Adobe DRM used in the Ellibs books prevents their use on this platform. Unfortunately the iPad does not support easy drag and drop of PDFs. All documents have to be used online or saved using various applications, such as iTunes.

USER EXPERIENCE OF E-READERS IN STUDY WORK

From the library customers' viewpoint, the new e-readers build bridges between traditional books and electronic texts. Most of the e-reader devices utilize some kind of electronic ink technology that emulates the look and feel of paper with printed text on it. The e-readers make two promises (selling arguments) to the users: 1) mobility and 2) convenience. The mobility argument is directed towards electronic texts. E-readers emancipate the users from offices and desktop computers by allowing them to read anywhere they want. The convenience argument is directed towards both traditional books and electronic texts. The e-readers allow users to carry tens, hundreds or even thousands of books with them all the time. In addition the e-readers with their electronic ink displays promise to provide better reading experience than normal computer screens (electronic ink technology should cause much less eye fatigue than LCD screens, for example).

In order to understand whether the promises of e-readers come true in study work and how the e-readers work with current electronic materials available at the Aalto University library, an e-reader user experience study was conducted. The study was carried out during January-March 2010 at Aalto University School of Science and Technology. In the study, five masters' students from two study programmes (information networks and computer science) were recruited to test e-book readers in their studies during one study period of seven weeks. The aim of the study was to evaluate the potential usefulness and usability of e-book readers in an academic environment as well as the compatibility of the e-book readers with the electronic material provided by the university's library, e.g. electronic versions of books, conference proceedings and journal articles.

The fields of human-computer interaction (HCI) and user-centred design (UCD) were the methodological foundations of the study. HCI and UCD are interested in the quality of the interaction between the studied system and its users. The main concepts related to the interaction are usability, the fit between the system and its users, and user experience, the users' perceptions and responses resulting from the interaction (International Organisation for Standardisation, 2010). Usability is linked to the effectiveness, efficiency and satisfaction of usage and is often translated in everyday speech to ease of use. User experience is a broader concept that takes into account how users' earlier experiences, state of mind and perceptions impact on the success of the interaction (Hassenzahl, 2010). There exists a plethora of methods for studying usability and user experience of products and services (see for example Kuniavsky, 2003). The common suggestion is to combine interviews, questionnaires or other indirect methods with direct observations of users performing their actual tasks. In addition special methods for tackling situations where observations are hard or impossible to conduct have been developed.

The task of studying or reading happens mainly in the student's or reader's mind. Thus, it is quite easy to observe as one reads, but it is very difficult to understand what is actually happening during the reading just by looking at the external activities (e.g. page turnings, underlining, etc.). In addition, studying is a very comprehensive activity for full time university students. It is hard to predict the exact moments when students for example learn new things or encounter problems. As a result, an adaptation of probes methods was selected to the study. Probes are self-documenting packages given to users for a certain amount of time to use and play with. Probes are a useful approach in cases where the studied phenomena are irregular and hard to predict (Nieminen and Mannonen, 2005). Usually probes are used for gathering information about users' feelings and experiences and thus their usage has been focused on free time activities (Mattelmäki, 2003). However, probes have been adapted also to work settings (e.g. Nieminen and Mannonen, 2005). The probes are usually used together with interviews (Boehner et al., 2007).

In this study, the e-readers acted as technology probes. The students were asked to try out the e-readers in their studies and not to reset the devices when they returned them to the researchers. Thus using the devices, i.e. transferring documents into them and making notes, constituted self-documenting. In addition, the students were asked to write their feelings, comments and opinions about the devices to blogs during the test period. Afterwards a group interview session was arranged. In the group interview the themes that the researchers had picked up from the students' blogs as well as from the device usage were discussed. A group interview was chosen instead of individual interviews, since pair interviews have been reported to better facilitate conversations as the interviewees not only answer questions but also ask questions of other interviewees (e.g. Mannonen, 2003; Nieminen and Mannonen, 2005; Höysniemi, Hämäläinen and Turkki, 2004).

STUDY SETUP

Of the five selected devices only four were thoroughly evaluated. The Amazon Kindle testing was cancelled during the study as the process of transforming documents to a format suitable for the reader turned out to be too slow and cumbersome and the student did not wish to continue the testing.

In the beginning of the study a meeting with the students was arranged, in which the e-book readers were presented and the goals of the study were explained. Also technical support was promised to help the students in any problem situations throughout the testing period. During the meeting all the students were quite enthusiastic about the testing of the devices. None of the students had previous experience in e-book readers or e-ink technology.

During the two-and-a-half-month e-book reader testing period, the students were required to keep an informal experience diary (a weblog). The aim of the diaries was to allow researchers to keep track of students' actions with the devices and provide help in using the devices as well as ask questions about details of the usage.

After the testing period, another meeting was arranged to discuss the use experience of the devices. In the beginning of the meeting the students filled in a short questionnaire about their feelings and comments about the e-book reader they had tried out. The rest of the meeting was organized as a semi-structured group interview. Each of the students presented his or her opinion of the tested device, as well as their comprehension of its operations, to the interviewer and other students. The aim of the protocol was to allow students to compare their own device-specific experiences to other users' experiences with other e-book readers. Additionally, to facilitate enhanced sharing of experiences, a short amount of time was also allocated for generating ideas for an ultimate e-book reader that would serve the students' needs perfectly.

RESULTS

The e-book readers proved to be quite different from the students' expectations. The electronic paper technology (e-ink) was much more rough and non-display-like than the students had thought beforehand. As a result the students evaluated the devices as very slow and cumbersome to use. All of the students had expected the devices to be more computer-like in their interaction possibilities and capabilities.

The strengths of the e-ink technology, i.e. low power consumption resulting in good battery performance and a paper-like reading experience, were appreciated by the students, but these strengths were not enough to transform the use of the devices into positive experiences.

Only one of the students would have considered buying the device he tested after the testing period. On the other hand, all but one student would consider buying a similar device in the near future for free time use after the most pressing technical problems are solved.

In a more detailed level the study provided information from three different perspectives relating to university studies and the university library's services; electronic paper as a technology in study use, technological maturity of current e-book reader devices and their capabilities in study use, and the use of electronic study materials in the university.

Electronic paper as technology. The study showed that the current software in e-book readers as well as the electronic paper technology incorporate major problems when used in a studying context. Students have a habit of browsing the reading material back and forth with both books and shorter articles. Browsing is used to get an overview of the material but it is also used during normal reading. In many cases there was, for example, a need to jump to a different part of a book to check how a previous piece of information fitted with the new one. While the technical solution in all of the tested devices allows the user to jump to any of the pages of the document, the jumping takes 1-3 seconds. However, the students did not usually know the exact page to which to jump. Therefore, they were required to jump and turn pages multiple times. This took too much time to get to the intended page. In leisure time usage, when reading a novel sequentially from the beginning to the end, there is no need for jumping from one page to another. Thus, the devices provide a better user experience for that purpose. The fact that most of the students considered purchasing an e-book reader for leisure time use in future, but did not see the devices suitable for studying purposes, supports this reasoning.

While turning pages was experienced to be too slow, the e-ink as a reading medium was considered to be very good and the experience was very similar to paper. Interestingly, the limited graphical capabilities of the devices, for example, the quite low resolution for images and no colour screen, did not seem to bother the students. However, the interactive features, such as making bookmarks and notes, were considered to be as cumbersome as the page turning. These results indicate incompatibilities between the students' mental models and the functionality of the e-book readers.

Current e-book reader devices. Although the devices in this study were not first generation e-book readers, the students felt that there were a lot of amateurish bugs in them. Since the devices and their displays are quite small and most of the study material was designed for A4 or other large page sizes, students had a recurring need to zoom in to parts of the pages. The zooming function varied a lot between devices but none of them tackled the problem in a good enough way. For example, one device lets the user zoom in on a page and navigate to different parts of the page, but not to turn to the next page while zoomed in. In addition to zooming, also basic studying methods such as underlining and making notes were very cumbersome or lacking in the devices.

Another big issue with the devices was their interoperability with digital rights management (DMR) solutions used by service providers of electronic books. Different service providers use different DRM solutions and currently the e-book readers have problems with most of them. The major technological bottleneck is the lack of network connection. The current situation means that it is very difficult to get any DRM material other than that designed specially for a specific device to work with other devices. As a result, the majority of the libraries' electronic books were not available on the devices.

Getting the reading material into the devices was considered a slow and somewhat annoying task. The materials needed to be first downloaded to a computer and then transferred from there to the devices.

The most positive surprise with the devices was the almost everlasting battery. The students are accustomed to mobile devices that need recurrent charging and the e-book readers provided a positive surprise as they were consuming very little energy and needed charging only once in a while. One student even said that he did not recharge the device once during the test period.

Use of electronic study materials. Although the study focused on e-book readers and their possibilities in study use, a lot of comments and information about the current state of electronic study materials in general was also obtained. The most interesting finding was the students' habit of reading most of the material from computer displays. Usually computer displays are considered to provide quite a bad reading experience as the back-lit display easily strains the eyes. However, as a big part of studies is about finding specific information from a large pile of documents, the strengths of electronic material, i.e. search functionalities, fast scrolling, and ability to handle very big amounts of documents, became more important than slight discomfort for the eyes.

When reading for studying, an important issue is the possibility to annotate the material. This is done by emphasizing important parts of the text: underlining text and jotting down one's own notes relating to the reading. Since students considered the e-book readers as replacements for laptop computers, they missed the possibility to write their own notes about the material they had read. This lack of functionality (or degraded usability compared to laptops) in the e-book readers may be considered to be a bigger issue than the paper-like e-ink screen. This could result in favouring the use of computers for handling study-related electronic material. A big theme related to electronic study materials was the numerous different sources the students had to use to obtain the material. The lecture slides and material were provided from an online teaching portal, many of the books and academic articles were provided by the library from different article databases and e-book services, and in many courses there

was also material that was from some free Internet service. By far, the most cumbersome and disliked services were the e-book services with complicated DRM solutions. In many cases the students seemed first to see if the same material could be found freely from somewhere on the Internet, before reading it from an DRM-protected e-book service.

CONCLUSIONS AND DISCUSSION

Our study points out similar results as studies done in other academic surroundings. E-readers are currently great for reading novels, but lack the functionality required for academic reading, annotating, and note-taking. The long battery life and easy reading are advantages in any use, but the inability for easy browsing, navigating, searching and zooming make the devices slow to use in non-linear reading. In addition, the readers are not well suited for material with colour graphics, tables, pictures and equations. In academic use students and researchers do use multiple resources and need the ability to jump from one document to another, making use of links and cross-references. This is not yet possible on most e-reader devices.

This study with Aalto University students gave useful information about the advances in e-book technology required before e-book readers can be used efficiently for study and research purposes. It also showed that the students still prefer to read e-material on their laptops, instead of the more eye-friendly e-readers, because of the more versatile functionality of computers. However, the students did show interest in using the e-reader technology for entertainment purposes, which is in accordance with earlier results.

From the viewpoint of the library services, many of the current academic e-resources are not compatible with the current e-readers. While the readers are not good enough in functionality to warrant materials being chosen purely on the basis of compatibility with these devices, the incompatibility does raise some important issues. Materials with strict DRMs limit the use of the materials in many ways, restricting also printing, downloading and other use of the materials as well as use on e-reader devices.

E-book services that provide e-books from many different publishers appear to have the most restrictive DRM. When purchasing the books directly from the publishers, one can often get much better usability also on the laptops. In addition to being available on the same familiar platforms as the e-journals, many publishers, such as Elsevier, RSC, Morgan & Claypool, Springer, OECD and SPIE use no DRM on e-books when purchased directly. This should definitely be considered when selecting new e-book suppliers. Many publishers do require minimum purchases or only sell packages, but if enough suitable material can be found, it can be worthwhile to acquire e-books directly from the publishers.

FUTURE WORK

What needs to change before more widespread utilization of electronic academic material can happen in scientific libraries? Understandably, students are not that willing to spend much money on special devices that can be used only for restricted amounts of material and activities: they will not start investing in new e-book readers unless most (if not all) study materials are available for the target platform. These do not consist solely of books and scholarly papers, but also lecture notes and presentations. This indicates new collaborative material production activities between the library and faculty staff. However, if the device can provide more versatile uses, the usage of electronic material can happen as a byproduct of other important activities.

The growing popularity of tablet computers may affect the situation. Their connectivity, portability, color screens, and computer-like operation with specialized content-adjusted applications (audio, video) may supersede the hindrances that relate to shorter battery duration and the not-so-paper-like reading experience. New devices such as the Apple iPad or Samsung Galaxy Tab make new resources available through the Internet connection and seem to meet many of the user's needs. However, the new platforms also bring new incompatibilities; for example the iPad does not support Adobe DRM and books bought for one device cannot be moved to another. The future of the formats will also influence the scene if one of the formats, for instance ePub, is made an industry standard. This will affect the DRM solutions and more generally compatible devices and DRMs can be expected.

According to the Change Wave Research (Choney, 2010) the iPad and the Kindle are leaving all other devices far behind, with the iPad marginally in the lead. However, the Kindle is mostly used for reading books while the iPad is used more for reading newspapers, magazines, blogs and newsfeeds. Will the iPad take over or will more innovative platforms such as the Copia, which makes reading social and allows the sharing of notes for example, or the Blio, with the fully new display technology for books, be the next big thing (Griffey, 2010)?

Further studies are proposed to follow not only the changing e-reader scene but also the increasing popularity and use of the tablet computers. The studies on the applicability of the devices in this academic environment will be continued as well as studies to chart the use of the new technologies by the university students and researchers.

ADDED MATERIAL

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Table 1. E-book services in use and their characteristics

Service	Amount of e-books	Subscription or perpetual use	Package or individual titles
	in use at Aalto University		
DawsonEra http://www.dawsonera.com/	44	Perpetual use	Individual titles
Ebrary http://www.ebrary.com/corp/	45000	Subscription	Package
ECCO (Eighteenth Century Collections Online) http://gdc.gale.com/	150000	Perpetual use	Package
EEBO (Early English Books Online) http://eebo.chadwyck.com/home	100000	Perpetual use	Package
Ellibs http://www.ellibs.com/	80	Perpetual use	Individual titles
Elsevier http://www.elsevier.com	400	Perpetual use	Package
Knovel http://why.knovel.com/	1800	Subscription	Package
LNCS (Springer) http://www.springer.com/computer/Incs	6900	Subscription	Package
Morgan & Claypool http://www.morganclaypool.com/	108	Perpetual use	Package
Myilibrary http://www.myilibrary.com/	200	Perpetual use	Individual titles
OECD http://www.oecd-ilibrary.org/books	20	Subscription	Package
Safari http://www.safaribooksonline.com/	100	Subscription	Individual titles
WSOY http://www.wsoypro.fi/	22	Subscription	Package

Table 2. Main characteristics of the evaluated devices (sources: device packages, manuals and company web-pages).

Device	Bookeen CyBook Opus	Foxit eSlick	BeBook
Screen	5", 76 × 102 mm ^[sup2]	6", 90 × 120 mm ^[sup2]	6", 90 × 120 mm ^[sup2]
Size/mm	151 × 108 × 10	188 × 118 × 9.2	184 × 120.5 × 9.9
Weight/g	ISO	ISO	220
Document type support	OEB-XHTML, TXT, HTML, PDF, EPUB, JPG, GIF, PNG, MP3	PDF/TXT/Any printable document (after pdf conversion with included program), GIF, BMP, JPEG and PNG, MP3	PDF, MOBI, PRC, DOC, LIT, EPUB, HTML, PPT, BMP, JPG, PNG, GIF, TIF, DJVU, FB2, WOL, CHM, MP3
Battery Life	8 000 pages	8 000 pages	7 000 pages
Memory Expansion Slots	MicroSD card	SD card	SD card
Supported DRM Formats	Adobe (EPUB/PDF)/ Mobipocket	None	Adobe Digital Editions
Note taking/ highlighting/ underlining	No	No	No
Device	Amazon Kindle	Sony Reader Touch Edition PRS-600	
Screen	6", 90 × 120 mm ^[sup2]	6", 90 × 120 mm ^[sup2]	
Size/mm	203 × 135 × 9	175 × 122 × 9.7	
Weight/g	289	285	
Document type support	Kindle (AZW and TOPAZ), PRC/ MOBI, TXT, MP3, Audible (Format 4, Audible Enhanced (AAX))	BBeB (LRF/LRX), PDF, EPUB, TXT, RTF, JPG, BMP, GIF, PNG, MP3, AAC	
Battery Life	Two weeks	7 500 pages	
Memory Expansion Slots	SD/MMC	MMC/SD/ SDHC. Memory Stick Pro Duo	
Supported DRM Formats	AZW and TOPAZ	Marlin DRM (BBeB), Adobe ADEPT (EPUB/PDF)	
Note taking/ highlighting/ underlining	Yes	Yes	

Table 3. Compatibility of the Aalto University e-book collections with the tested e-readers.

Service	% of the Aalto University e-book collection	Compatibility with the e-readers
DawsonEra	< 1%	Not compatible
Ebrary	82%	Not compatible
Ellibs	< 1%	Compatible, but very difficult to use
Elsevier	1 %	Fully compatible, easy to use
Knovel	3%	Fully compatible, easy to use
LNCS (Springer)	13%	Fully compatible, easy to use
Morgan & Claypool	< 1%	Fully compatible, easy to use
Myilibrary	< 1%	Not compatible
OECD	< 1%	Fully compatible, easy to use
Safari	< 1%	Not compatible
WSOY	< 1%	Not compatible

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