CAN AN ELECTRONIC TEXTBOOKS BE PART OF K-12 EDUCATION?: CHALLENGES, TECHNOLOGICAL SOLUTIONS AND OPEN ISSUES

HeeJeong Jasmine Lee
School of Information Technology
Monash University
lee.hee.jeong@monash.edu

Chris Messom
School of Information Technology, Monash University
c.h.messom@monash.edu

Kok-Lim Alvin Yau
Faculty of Science and Technology, Sunway University
koklimy@sunway.edu.my

ABSTRACT
An electronic textbook (e-Textbook) is a digitized (or electronic) form of textbook, which normally needs an endorsement by the national or state government when it is used in the K-12 education system. E-Textbooks have been envisioned to replace existing paper-based textbooks due to its educational advantages. Hence, it is of paramount importance for the relevant parties (i.e. national and state governments, or school districts) to draw a comprehensive roadmap of technologies necessary for the successful adoption of e-Textbooks nationwide. This paper provides a brief overview of e-Textbooks and subsequently an extensive discussion on challenges associated with e-Textbooks in the pursuit of replacing traditional textbooks with e-Textbooks. This paper further provides an extensive review on how the challenges have been approached using existing e-Textbook technologies, such as multi-touch technology, e-Paper, Web 2.0 and cloud computing. Literature review and interview have been conducted to identify the challenges of e-Textbooks implementation in terms of e-Textbook usage levels and the reasons of its refusal. There were 180 students and 20 academic staff participated as a sample for interviews. Eight categories of key challenges were identified. Subsequently, assessment was performed on how the evolving e-Textbook technology has been applied to address the key challenges and problems. This article aims to provide a strong foundation for further investigations in e-Textbooks for successful adoption of e-Textbooks in school education.

INTRODUCTION

Electronic textbooks (e-Textbooks) or digital textbooks are digitized forms of textbooks that will potentially replace existing paper-based textbooks in the school curriculum. Compared to traditional textbooks, advantages of e-Textbooks have been reported in the literature (Boorsok & Higginbothan-Wheat, 1991; Ozsoyoglu et al., 2004; Kausar, Choudhry & Gujjar, 2008; Kayaoğlu, Akbaş & Öztürk, 2011). Firstly, the incorporation of multimedia contents, such as video clips, animations and education-based games, are some of the elements of e-Textbooks that have been shown to capture students' interest in study. Secondly, e-Textbooks allow teachers to "customize and produce content by re-purposing to suit what needs to be taught, using different modules that may suit a learner's learning style, region, language, or level of skill, while adhering to the local education standards" (CK-12 Foundation, 2008, Next generation textbooks section, para. 1). Thirdly, students are no longer carrying backpacks loaded with heavy textbooks to schools. Fourthly, e-Textbooks enable easy backup and replacement so that any losses can be easily replaced by new copies from e-Textbook servers. Fifthly, fast update and access to the latest content are possible.

E-Textbooks have been envisioned to be a preferred and common choice of teaching and learning tool in the very near future. Recently, schools in the UK, USA and Australia have started pilot testing using devices such as Apple®'s iPad and Amazon®'s Kindle® to convert the content of paper-based textbooks to e-Textbooks (Ipadacademy, 2010; Warschauer, 2011). While e-Textbooks are seen as promising, its introduction to the classroom is seen as a major challenge. A wide range of problems and issues (e.g. curriculum, pedagogy, assessment and infrastructure) associated with e-Textbooks must be addressed. This article focuses on the technological aspects of e-Textbooks, and provides extensive discussions pertaining to two main concerns. Firstly, proper selection of hardware and software components is necessary. Secondly, proper methods to enhance teaching and learning experience in the classroom for teachers and students using e-Textbooks are necessary.

While there are numerous reports and studies on e-learning (Haddad & Draxler, 2002; Kapp, 2003; Bates, 2005) and the advantages of e-Textbooks; a technical review that provides extensive discussion on the challenges, as

well as important technologies of e-Textbooks, is notably absent. Hence, the discussions in this article would be highly relevant to developing and distributing e-Textbooks in K-12 education (i.e. a term used to describe the duration of primary and secondary education). The research outcome in this study provides important suggestions on new features to be incorporated into e-Textbooks. This article also serves as a foundation for further investigations in this emerging research area.

The remainder of this article introduces research questions, and describes research methodologies used in this study. This article also details the major problems and issues stemming from the migration of paper-based textbooks to e-Textbooks, and subsequently, it proposes a comprehensive strategy framework to overcome problems and issues associated with e-Textbooks. Additionally, this article presents open issues. Finally, a summary of this article, limitations and future work are presented.

RESEARCH QUESTIONS

This research aims to explore two main research questions pertaining to the successful adoption of e-Textbooks in the national curriculum for K-12 education programme. The research questions are as follows:

- Research Question Q1 - What are the challenges and factors relevant to the adoption or refusal of e-Textbooks?
- Research Question Q2 - What are the technological solutions to the challenges and factors relevant to the adoption or refusal of e-Textbooks?

METHODOLOGY

This study involves extensive literature review and interview to gather and identify important information, such as the key challenges and the fundamental technologies associated with the introduction of e-Textbooks in classroom. Additionally, the key international market players of e-Textbooks are identified based on the current literature and through the University of Monash's library, including (a) IEEE Xplore, (b) the ACM Online Library, and (c) ScienceDirect. There are three main steps, namely problem analysis, technology review, and suggestion for the integration of this technology into e-Textbooks.

In the first step, we performed problem analysis through a literature review in existing literature as presented in *challenges associated with e-Textbooks* section. Subsequently, we interviewed academic staff and students in order to identify the key challenges and problems pertaining to the successful adoption of e-Textbooks. We identified eight categories of key challenges. 20 academic staff and 180 students were selected as a sample for supporting interviews. The objective of the interview is to understand the perceptions of students and academic staff on the challenges of e-Textbooks in order to reinforce the key challenges and problems identified in the literature review. They were chosen through purposive sampling. This involves "those situations where the researcher already knows something about the specific people or events and deliberately selects particular ones because they are seen as instances that are likely to produce the most valuable data" (Denscombe, 2007, p. 17). Therefore, a purposive sample of 20 academic staff having experience in different status positions was taken (e.g. teachers, principals, head teachers etc.). The respondents were working in well-known schools in Bandar Sunway in Malaysia and had a better understanding of the challenges of e-Textbooks. Bandar Sunway is a suburban area in Selangor, Malaysia. It has good access to the metropolitan centres such as Kuala Lumpur and Petaling Jaya. The school embraces technology utilizing the *Smart board* system. It has a wireless internet, where each student uses their own laptop. A purposive sample of 180 students was chosen by teachers. These students were chosen because they may know the challenges and problems pertaining to the successful adoption of e-Textbooks. For the interview, firstly, a hands-on short tutorial was given to them about e-Textbooks including an explanation on how the e-book is different from the e-Textbook. Next, respondents explain their opinions associated with e-Textbooks. Interview was used in order to reinforce the key challenges and problems identified in the literature review. Therefore interview results were used as reference in this study.

In the second step, we performed an extensive technology review and assessment on the evolving e-Textbook technology in order to understand how the key challenges and problems identified in the literature review and the interview have been approached using the state-of-the-art technology in e-Textbooks.

In the third step, we performed assessment on how the evolving e-Textbook technology in Table 1 has been applied to address the key challenges and problems. The technology review was performed by collecting data from various official websites of major market players. There are four categories of market players, namely textbook reader, reading software, display and open education resource. Textbook readers are portable electronic devices for reading digital books. Reading software are the software applications, which are installed in the textbook readers, used to access e-Textbooks. Displays are output devices for enhanced or larger view of textbook readers. For instance, a textbook reader can be connected to large interactive display table. Open

educational resources (OER) are digital content of paper-based textbooks, which can be freely available through open licenses. The market players and off-the-shelf technologies of e-Textbooks are shown in Table 1. The selected websites in Table 1 provide an extensive information resource aimed at promoting e-Textbooks to end users. Data collection was performed from May 2010 to March 2012.

Table 1: Market players and off-the-shelf technologies of e-Textbooks

Category	Market player/ off-the-shelf technology	Website
Textbook reader	Amazon®'s Kindle® DX	http://www.amazon.com
	Apple®'s iPad®	http:// www.apple.com/ipad
	Samsung® Galaxy Tab	http://www.samsung.com/us/mobile/galaxy-tab
Reading software	EPUB	http:// en.wikipedia.org/wiki/EPUB
	CourseSmart	http://www.coursesmart.com
	iBooks® 2	http://www.apple.com/education/ibooks-textbooks
	Google Play Books	https://play.google.com/about/books
Display	LG® Display	http://www.lgdisplay.com
	Hyundai multi touch table	http://www.hyundai-displays.com
	iPhonetable	http:// iphonetable.blogsopot.com
Open education resource	Flexbook	http://www.ck12.org
	Discovery Education	http://discoveryeducation.com
	Connexions	http://cnx.org
	Wikibooks	http://wikibooks.org
	ReadWriteThink	http://readwritethink.org

CHALLENGES ASSOCIATED WITH E-TEXTBOOKS

This section addresses research question Q1: What are the challenges and factors relevant to the adoption or refusal of e-Textbooks? A wide range of issues covering technical, social, cultural and budget aspects must be overcome in the migration of paper-based textbooks to e-Textbooks. This section discusses a number of challenges discovered in previous studies (Catone, 2009; Sadon & Yamshon, 2011; Chen et al., 2011). In general, the challenges, together with the interview results, can be divided into eight categories, namely providing lower price, standardising format of content, improving service reliability, improving quality and accuracy of content, increasing life of ownership, reducing health risk and visual fatigue, improving readability, and protecting copyright. As interview used as reference, only selected interview data are included based on their relevance in eight categories. Identifying information (e.g. name, address) has been removed from the data.

Providing Lower Price

The migration from paper-based textbooks to e-Textbooks is expected to incur substantial investment, and so it is a primary concern. While the costs associated with paper-based textbook (e.g. printing, warehousing, selling and shipping) are eliminated; there are costs of going digital. The costs of e-Textbooks are associated with the fundamental elements of e-Textbooks, namely hardware and software components of e-Textbooks, network infrastructure and supporting equipment. Other costs are installation (or integration) of hardware and software components, internet access, maintenance and operational costs, upgrade and replacement costs, support and training. The costs may be high if frequent update is necessary; for instance, Apple® launched 3 generations of iPad® in 2 years although the software was broadly compatible.

Catone (2009) points out that students would not switch to e-Textbooks if the cost saving is minimal. Catone (2009) also points out that, "those cost savings will have to become more significant for students to start opting for electronic texts over printed ones" (Chapter 1, para. 3). Our interview shows that e-Textbooks must be cheaper than paper-based textbooks:

"Unless prices are drastically lower, no – one will adopt it." [Student 166]

"I want to use e-Textbooks, however they can't cost more than the ones at the bookstore or Amazon." [Student 120]

"When e-Textbooks become mandatory, they should be available for all groups of people without excluding children from poorer families." [Teacher 13]

Hence, further efforts are necessary to investigate a comprehensive budget plan so that the costs associated with migration to e-Textbooks become economical.

Standardising Format of Content

There are two kinds of compatibility, namely software compatibility and hardware compatibility. Software

compatibility is the ability of an application to run on different computers without the need to change its format; while hardware compatibility is the ability to connect different devices without the use of certain equipment or software (Dictionary.com, 2012). The inclusion of multimedia and interactivity features into various e-book formats (e.g. PDF, ePub, txt and html) has produced a wide range of e-Textbook formats. Additionally, different countries may use different formats. Hence, a student who purchases and installs a particular vendor lock-in reader may not be able to access contents from different vendors and countries, as well as to transfer e-Textbooks from one level (primary school) to another level (secondary school).

Catone (2009) and Sadon and Yamshon (2011) discuss the issue of incompatibility between e-Textbook content and the reading device, and that the *format* war for e-Textbooks is a hurdle that must be overcome. Our interview shows that e-Textbooks must be highly compatible:

"I won't buy anything if it's not compatible with all of my devices." [Student 47]

"E-Textbook reader device and content format incompatibility will be a problem." [Teacher 20]

"The "format" war for e-Textbooks is a hurdle that must be overcome." [Teacher 18]

Hence, further efforts are necessary to improve compatibility of e-Textbooks.

Improving Service Reliability

Reliability, which shares the same notion with trustworthiness and dependability, is defined as the degree of consistency among users when making observations of the same service (Mehrens & Lehmann, 1987; Worthen et al., 1993). Lack of reliability may lead to service failures that often result in inconvenience. When e-Textbook service failures occur, students are not able to access the learning material or learning history. This can be due to device failure, service failure or power interruption. A class will not function if there is no preparation for service failure. This may cause reservations amongst schools to go digital.

Rich multimedia textbooks are very attractive. However, high bandwidth consumption will be required for uploading and downloading large files to access the service. This may cause problems on bandwidth consumption and quality of service. Broken devices may lead to service failures, too. Parents would not be happy if they find that the device has been broken which may lead to service failures. Our interview shows that e-Textbooks must be highly reliable:

"Rich multimedia textbooks are a lovely idea. However, a lot of hardware space will be required. For example, some e-Textbooks need 2GB or more. The consumption of bandwidth will be a lot." [Teacher 2]

"I do not want to find that the device has been broken by a sports racket in my son's school bag." [Teacher 8]

Further efforts are necessary to ensure high reliability so that teaching and learning can be conducted without interruption at all times. Also, bandwidth requirement of each e-Textbook must be minimized.

Improving Quality and Accuracy of Content

Traditionally, any changes to paper-based textbooks must be carefully vetted by the governmental bodies (i.e. Ministry of Education). This ensures that the changes are accurate, and of the highest quality. Most importantly, the changes reflect the principles of the national school curriculum. Since digital content can be easily created, edited and delivered online, our interview shows that there has been great concern over the accuracy and quality of e-Textbooks:

"As digital content can be easily edited the content has to be accurate as they represent the national school curriculum." [Teacher 7]

Further efforts are necessary so that the traditional vetting process can go digital to ensure highest possible accuracy and quality of teaching and learning materials in schools. It may be necessary to have a formal review process for content if the right is granted to unauthorized personnel to modify content as well as to remove outdated content. This can be achieved with the help from editors to oversee the review process, which may involve peer review.

Increasing Life of Ownership

Life of ownership is defined as the duration of the ownership when people buy or rent a product. At the end of ownership, an e-Textbook will be returned. If the life of ownership is less than those required by the students, there may be several problems. Firstly, students will lose the notes they had made on the e-Textbook. Secondly, students have less sense of ownership of their e-Textbooks because the books, together with their own notes, will eventually be lost.

Catone (2009) and BISG (2011) point out that, it is easier to pass on a paper-based book to share with someone else compared to a digitally-locked version. Our interview shows that there has been great concern over the lifetime of ownership of e-Textbooks:

"Once you purchase a book either in print or in a digital format it should be yours until you decide to get rid of it." [Student 174]

"Ownership rights might be the biggest obstacle." [Student 78]

"It's easier to pass on a hard copy of a book to share with someone else compared to a digitally locked version." [Student 9]

"Regarding paper textbooks – they have a resale value at the end of semester." [Student 32]

Further efforts are necessary to investigate the effects of the lifetime of ownership on the adoption of e-Textbooks.

Reducing Health Risk and Visual Fatigue

There have been concerns about the side-effects of long-term usage of e-Textbooks on students' health. The problem is pronounced for some reading devices that have a small screen size. Our interview shows that there has been great concern over health and visual fatigue:

"It is exhausting to read a lot of content on the screen" [Student 108]

"Personally I do not understand why people want to read from a back lit screen for hours. Reading should be done without torturing themselves." [Student 121]

Further efforts are necessary to investigate possible side-effects of prolonged usage of e-Textbooks, as well as to reduce fatigue, particularly eye fatigue, when reading e-Textbooks.

Improving Readability

Readability is defined as "the ease in which text can be read and understood" (Patowary, 2011, para. 1). There have been concerns about the perceived difficulties and fatigue in reading electronic media. The issues of readability on electronic screen can lead to reluctance to engage with e-Textbooks (Mercieca, 2004). In other words, students feel that traditional paper-based textbooks are easier to browse and read (Mercieca, 2004; Warschauer, 2011). Research conducted by Nielsen and Krug shows that the reading process can be 25% - 40% slower from a screen compared to on printed page (Robinson, 2011). Another research project (Mercieca, 2004) shows that students have reluctance to use e-Textbooks due to perceived difficulty in reading electronic text. Our interview shows that there has been great concern over readability:

"It is difficult to read digital content outdoors." [Student 114]

"For many subjects, high definition images are critical." [Student 3]

"I think if digital readers incorporate the usual features of printed books, such as page flipping, familiarity would breed contentment and hence adoption." [Student 137]

Further efforts are necessary to provide most features found in paper-based textbooks, as well as to provide a printed-page-like reading experience to students.

Protecting Copyright

Copyright is "a legal concept, enacted by most governments, giving the creator of an original work exclusive rights to it, usually for a limited time" (Hasija & Narayanan, 2009, p. 36). Generally speaking, e-Textbooks can be downloaded from their servers to students' reading device (e.g. iPad®, laptop and PC) and reading software through the internet. The e-Textbooks can also be stored and distributed via storage media (e.g. USB drive and CD-ROM). Compared to a paper-based book, an e-Textbook is more likely prone to copyright issues for two main reasons. Firstly, it can be distributed in a large scale with very low cost. Secondly, photocopying a textbook may take much longer time, while copying an e-Textbook may happen instantly. Our interview shows that there has been great concern over copyright issue:

"I think piracy is a much bigger issue here. Photocopying a textbook takes several hours. Duplicating digital textbooks occurs in a flash." [Teacher 11]

"Once textbooks are digitized, they will be much easier to pirate." [Student 143]

Further efforts are necessary to uphold copyright on e-Textbooks because duplication and distribution of digital content have been much easier compared to paper-based textbooks. For instance, copyright issues, such as to prevent non-authors from modifying existing e-Textbooks for monetary gain, must be addressed.

Section Summary

With regard to the Research Question Q1 – "What are the challenges and factors relevant to the adoption or

refusal of e-Textbooks?", eight categories of challenges have been raised in this section. This question has been answered by conducting an extensive literature review, and subsequently conducting supporting interviews with teachers and students. After analysing the gathered data, the challenges associated with the migration of paper-based textbooks to e-Textbooks are identified.

STATE-OF-THE-ART

This section addresses research question Q2: What are the technological solutions to the challenges and factors relevant to the adoption and refusal of e-Textbooks? Fundamental elements of e-Textbooks are driven by various factors, such as the demand for new technology, their potential market value, and the complexity of the new technology (Miao, Liu & Sun, 2011). Selecting the right technology for each component is an ongoing challenge to the successful development and implementation of e-Textbooks. Developing the right roadmap for the development of e-Textbooks is essential; and a variety of performance and cost considerations must be made. This section addresses the challenges, which has been identified in the *challenges associated with e-Textbooks* section by adopting the following technologies. Table 2 shows how the challenges of e-Textbooks have been approached using various solutions in e-Textbooks (i.e. hardware technology, software technology and low-cost and Open Educational Resources).

Table 2: The Challenges faced when moving toward e-Textbooks and its solutions

Challenge	Hardware Technology	Software Technology	Low-cost and Open Educational Resources
Providing Lower Price			• Connexions (http://cnx.org) • Wikibooks (http://wikibooks.org) • Flexbook (http://ck12.org)
Standardising Format of Content		• Reader Applications	
Improving Service Reliability	• Flexible Display	• Cloud computing	
Improving Quality and Accuracy of Content		• Web 2.0 • Web services • Cloud computing	
Increasing Life of Ownership		• Web 2.0	• Connexions (http://cnx.org) • Wikibooks (http://wikibooks.org) • Flexbook (http://ck12.org)
Reducing Health Risk and Visual Fatigue	• Electronic Paper	• Visual-syntactic text formatting	
Improving Readability	• Multi-touch Technology • Electronic Paper	• Visual-syntactic text formatting	
Protecting Copyright		• Digital rights	

Hardware Technology

This section reviews various types of hardware technologies (Chung & Shon, 2009), as well as their potential applications in the classroom, which are essential to display and read e-Textbooks.

Multi-touch Technology

Multi-touch technology enables a user to interact with e-Textbooks through an input surface (or screen), which can detect two or more points of contact (Dalvi & Amor, 2010). Examples of mobile devices with multi-touch technology are iPhone® and iPad® tablet. The multi-touch screen, which has a high degree of user interactivity, is becoming the preferred choice of input method for consumer electronics (Piggott, 2010). Teachers and students can write and draw directly onto any document electronically using this method (Berque et al., 2008). The multi-touch technology, which is interactive in nature, is attractive to a wide variety of learning styles (e.g. visual learning or auditory learning), and it can improve readability because of the speed, efficiency and responsiveness of the technology.

Teachers can transmit live lessons and quizzes to students' computers during class, and students can respond and answer on their devices using multi-touch screen. Therefore, the students can concentrate on the concepts presented by their teacher, rather than copying from the blackboard. The use of multi-touch screen has been shown to improve students' learning experience. As an example, a Japanese or Chinese language teacher can show the order of strokes while illustrating how to write a character (Mantgem, 2008). Traditionally, a teacher writes the character on a blackboard; and the students often lose their concentration on the order of the strokes while copying the character on a handwriting paper. Using a multi-touch screen, the order of a character can be shown on the screen, and the students can slide their fingers on the screen itself following the order of the strokes.

An interactive whiteboard, which is a large multi-touch screen (or table), enables a user to use hands, instead of fingers, to interact with e-Textbook. The use of interactive whiteboards encourages collaboration among students, which provide added advantages compared to PCs in which only a single student can control a mouse (Piggott, 2010). For instance, students can share their ideas and work together to create a presentation using an interactive whiteboard.

Electronic Paper

Electronic paper (e-Paper), which is a display technology, mimics traditional handwriting paper in which the display resembles ink on paper (Pattison, 2008). There are a number of off-the-shelf electronic papers: Pixel Qi modifies LCD display to develop e-Paper; Qualcomm designs e-Paper based on the study of biometrics, which is inspired by the vividness of the reflection of light that bounces off a butterfly's wings; Fujitsu Frontech develops colour e-Paper for its e-book reader (The eBook Reader, 2011); and LG® has already rolled out 6-inch e-paper display on a large scale basis (Kee, 2012).

Unlike most displays, e-paper is soft on the eyes, and it achieves the same appearance of the traditional printed paper. Without backlight, e-paper would appear less glaring, and so reading on e-paper is like reading a paper-based book. This helps to improve readability and to reduce health risk and visual fatigue.

As an example, E-Ink®'s Vizplex™ uses electrophoretic technology, which provides a relatively thin and lightweight display with very high resolutions suitable for sharp and crisp fonts (Yang et al., 2011). Without backlight, e-Paper with low or near-zero power consumption has also been demonstrated (Arar, 2010; Yang et al., 2011).

With the commercial success of monochrome e-Paper, further efforts are necessary to develop the next-generation device, particularly coloured e-Paper with multimedia enhancements including video (Heikenfeld et al., 2011).

Flexible Display

A flexible display is a paper-like device in which the display, which is made of a sheet of plastic material (Davison, 2009), can be bent or flexed. During use, the display can be rolled out of the device, and so flexible display improves service reliability. Note that, e-Paper is also a flexible display, however it uses a different hardware technology that typically manipulates a material in the laminate to change its colour or contrast in order to create an image. While flat panel display, such as Liquid Crystal Displays (LCDs) and Plasma Display Panels (PDPs), is the dominant display devices (Martin, 2008), flexible displays are gaining popularity because of its convenience, portability and lightweightness. The flexible display provides the following advantages:

- Save paper, and so it is environmental friendly
- *Feel* like paper, and so drawing and editing can be made just like on a sheet of paper
- Consume low power, and so it requires less time for charging the device
- Lightweight, and so it reduces the weight of students' backpacks
- Robust, and so it increases resistance to breakage due to its flexibility
- Allow expansion of display, and so users can extend their display with larger width

Software Technology

This section reviews various types of software technologies that address the challenges, which are presented in *challenges associated with e-Textbooks* section, as well as their potential applications in classroom.

Reader Applications

Due to a wide range of formats of content for e-Textbooks (see *standardising format of content* section), defining a standard format for interoperability may be a complex and distant goal. Hence, reader applications

should be able to read various formats, such as PDF, ePub, txt and html. Additionally, there are software applications, such as 2epub and Calibre, that convert various formats to more popular formats, particularly pdf and ePub format.

Web 2.0 in Education

Web 2.0 provides an extension to the traditional Web 1.0, which provides static information on web pages, through incorporating interactive features. Hence, Web 2.0 enables information sharing, interoperability and collaboration among users on the internet (Hayati et al., 2010). There are a number of applications that demonstrate the fundamental concepts of Web 2.0, such as information sharing, user-centred and interoperability, and they are already being used in school education (Ullrich et al., 2008). Examples of interactive tools provided by Web 2.0 are blogs, wikis, social networking sites (Wu et al., 2012), live polling service, evernote and video sharing, and these tools possess great potential to change teaching and learning environments radically (Chatti et al., 2008) through expanding students' education outside of the classroom. For instance, students can post questions on blogs, which are linked to e-Textbooks, so that their peers and teachers can respond and comment on posts that are publicly available. Web 2.0 addresses the challenges of the accuracy of content and the lifetime of ownership. For instance, collaboration among users, including teachers and students, enables them to create and update content, as well as to share knowledge among peers. With a stronger sense of community, the accuracy of content is expected to improve over time, while the ownership of the content would be given to the community.

Web Services

The W3C working group defines a "web service" as "a software system identified by a URI, whose public interfaces and bindings are defined and described using XML" (Noji et al., 2002, section 1.1, para. 2). As an example, using web service, a user can readily invoke and use online applications or exchange information through their APIs without prior understanding and creation of application logic. As another example, an e-Textbook can use a web service that searches for the right education resources to gather teaching and learning materials; and this tool is necessary as the internet is overwhelmed with teaching and learning materials (Ullrich, 2004). Various web services, such as immediate assessment results, instructional animations and videos, as well as audio-visual dictionary, can be customised based on personal preference and needs (Warschauer, 2011). Hence, students with different learning capabilities (i.e. talented students may choose to learn in a faster pace) can choose suitable types of web services in order to suit their learning styles. The web services can be extended to include other functions, such as providing immediate feedback in interactive exercises and intelligent assistants. The quality and accuracy of the content is ensured because users can revoke web services from the original or trusted sources.

Cloud Computing

Over time the methods to deliver music to people has changed consistently, from discs to cassettes to CDs and MP3s. There has been a constant movement. So far the delivery mechanisms for textbooks have not kept up to the experience of latest technology format. They will rapidly accelerate once it can be delivered to students in an electronic device that they like.

Cloud computing provides on-demand delivery of information technology services whereby shared resources, software, and information are delivered as a utility over a network. The delivery mechanism of e-Textbooks can be integrated into a cloud architecture in order to achieve three main advantages (Pocatilu, 2010): virtualisation, centralized data storage, and monitoring of data access. Virtualisation enables users to access content remotely. Additionally, virtualisation reduces the number of servers required to maintain e-Textbooks, and so the maintenance cost of servers can be minimised. Centralized data storage enables users to retrieve e-Textbooks easily from the cloud, and this improves service reliability because users may have less worry about losing a textbook. The quality and accuracy of the content is ensured because users retrieve e-Textbooks from the cloud. Monitoring of data access becomes easier because monitoring all e-Textbook servers is not necessary while managing a cloud, which provides an entry point to all shared resources. For examples, a teacher can monitor students' performance and keep track of frequency of access to e-Textbooks through cloud computing remotely.

Visual-Syntactic Text Formatting

Brown (2001) suggests that a user's reading styles may change while interacting with digital text. Suggestions have been made so that the content is *chunked* or broken down into smaller sections, which are easier to skim read (Mercieca, 2004).

A new reading format called visual-syntactic text formatting (VSTF) has been developed by Walker et al. (2007) that reorganises the conventional block-shaped text (see Figure 1, left) into cascading patterns (see Figure 1,

right) in order to help readers to identify the grammatical structure of a sentence. This improves readability and reduces visual fatigue. Walker et al. have carried out a sequence of studies (2005, 2007) using e-Textbooks among high school students. It was found that students who read using the VSTF format have seen improvement in academic achievement and long-term reading proficiency.

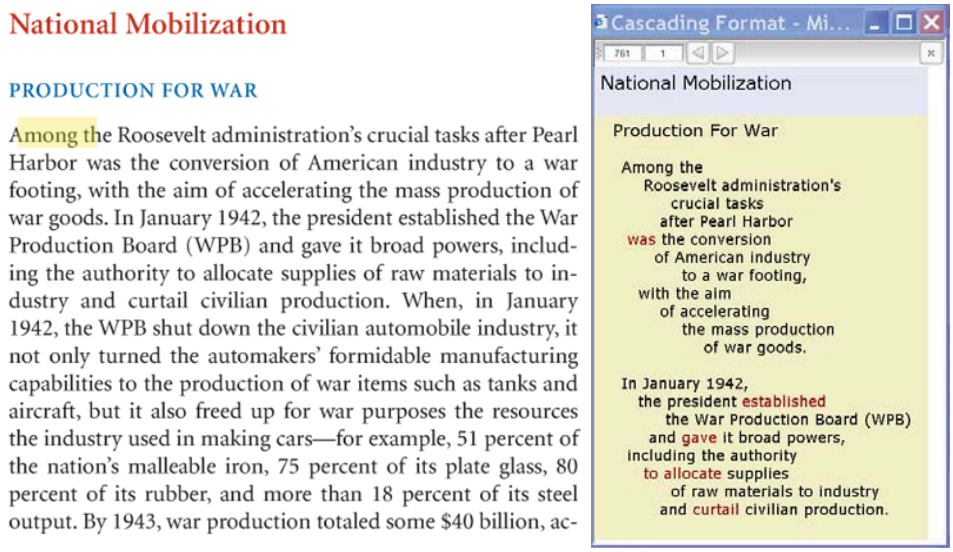

Figure 1. Example of visual-syntactic text formatting (Source from liveink.com)

Digital Rights

Protecting digital rights helps to prevent unauthorized modification, duplication and distribution of e-Textbooks. To tackle copyright issues, many organisations and companies have been involved in the development of standards and technologies including digital watermarking, Digital Rights Management (DRM), Electronic Book Exchange (EBX), MPEG-21, Open Digital Rights Language (ODRL), DOI (Digital Object Identifier), Open e-Book (OEB) and Extensible Rights Mark Up Language (XrML), etc. (Jones, 2007). For example, the DRM system provides secured editing and authoring processes in order to prevent unauthorized duplication and distribution of e-Textbooks, and it also provides an automatic review processes in order to inform the editor regarding any copyright issues, particularly digital rights violation.

Low-cost and Open Educational Resources

This section reviews various open educational resources that address the challenges in the previous section, namely the *challenges associated with e-Textbooks* section. Compared to traditional paper-based books and e-books, e-Textbooks follow the national school curriculum, and so they can be distributed free of charge or at a subsidised rate with unlimited lifetime of ownership. For instance, students may log in to their LMS (Learning Management System) to obtain course materials, including e-Textbooks, for free or for a small fee. With cost savings, students are encouraged to adopt e-Textbooks.

There are several examples of open-source e-Textbook projects. For example, the California Open-Source Textbook Project has started in 2002 and released science and mathematics textbooks. Many experts are willing to accept peer recognition in place of payment for their knowledge contributions to Wikibooks (http://wikibooks.org). Open Educational Resources (OER) provides free course materials, which can be modified and redistributed. Teachers can choose modules to be included in their course without any charges. Flexbook (http://ck12.org), ReadWriteThink (http://readwritethink.org) and Connexions (http://cnx.org) are examples of OER sites.

Section Summary

With regard to the Research Question Q2 – "What are the technological solutions to the challenges or factors relevant to the adoption or refusal of e-Textbooks?", a wide range of state-of-the-art e-Textbook technologies have been reviewed in this section. This question has been answered by conducting an extensive literature review on how the challenges have been approached using existing e-Textbook technologies, such as multi-touch technology, e-Paper, Web 2.0 and cloud computing.

OPEN ISSUES

The findings of this study provide guidance for subsequent research dealing with e-Textbook challenges and the

solutions. Further efforts to improve e-Textbooks have been suggested in the *challenges associated with e-Textbooks* section. More open issues are raised in this section for future research.

In-depth Study on Copyright Issues
The legal implications in the development and usage of e-Textbooks should be considered. Copyright issues are particularly relevant especially when combining content from various sources because the sources may be constrained by commercial licensing restrictions and the rights of user-created content in a particular context (Abdullah, 2007). Alternative licensing models, open education resource initiatives (Brown & Adler, 2008), as well as the potential to mix content from different sources whilst respecting copyright should be investigated.

E-Textbook Readiness
Deciding whether a country is sufficiently equipped for the adoption of e-Textbooks is important. Various aspects must be planned, including the initial investment, the essential infrastructure, and the continuous needs to change the education policy (Kapp, 2005; Yesser, 2005), and so careful considerations must be made.

Further research could be pursued to investigate a systematic approach to diagnose the status of e-Textbook readiness at various levels, particularly the school and country levels. This helps schools and countries to plan well, and subsequently achieves their respective goals.

Other Research Questions
Further research could be pursued to investigate other research questions: "What are the future trends of e-Textbook technology?", "What are the significant ICT policy issues for e-Textbooks?", "What are the projects to be launched at different stages in order to incorporate e-Textbooks into K-12 education?", and "What are the roles of the governments and schools in the adoption of e-Textbooks in K-12 education?" By addressing the open issues associated with these research questions, the migration of paper-based textbooks to e-Textbooks will be much smoother.

CONCLUSION

The objective of this article is to highlight the challenges and their potential solutions associated with e-Textbooks for K-12 education. This article reviewed the hardware and software technology, as well as free e-Textbooks and open educational resources, that offer insights into how the challenges can be approached. Two research questions being raised in this article have been answered as follows:
In relation to Research Question Q1, namely "What are the challenges and factors relevant to the adoption or refusal of e-Textbooks?" has been answered by conducting a literature review and supporting interview. The challenges associated with the migration of paper-based textbooks to e-Textbooks are: providing lower price, standardising format of content, improving service reliability, improving quality and accuracy of content, increasing life of ownership, reducing health risk and visual fatigue, improving readability, and protecting copyright.

In relation to Research Question Q2, namely "What are the technological solutions to the challenges and factors relevant to the adoption or refusal of e-Textbooks?" has been answered by conducting an extensive literature review. Technologies such as multi-touch, e-Paper, Web 2.0 and cloud computing have been identified as potential solutions to overcome those challenges.

The following limitations and assumptions apply to this study:

- Researchers (Zadoks & Ratner, 1996; McFall et al., 2006) have carried out case study on the usefulness of the e-Textbooks and their impact on learning. They have found that e-Textbooks have the potential to address some of the shortcomings of paper textbooks. Although investigating effects of e-Textbooks is an important research topic, this study focuses on the challenges of e-Textbooks and the technological solutions to the challenges. It does not examine the value of using e-Textbooks in lessons and its pedagogical issues to learning and teaching. And it does not set out to examine the relative merits of different types of e-Textbooks, or to discuss the particular features of different e-Textbooks.
- This study involves interviews with selected academical staff and students, however the interview results used only as reference. Hence, the interview results are shown in a less systematic way and they do not provide precise information such as the venue and time of interviews, length of interviews, nature of interviews (e.g. structured, un-structured), demographic characteristics of participants (e.g. their experience using e-Textbooks), school context (e.g. information about schools included in the study and the technologies integrated). The descriptive statistics such as methods of analysing data, and quality issues (e.g. reliability and validity), compare views of teachers with views of students

were not included in this paper.

- Technology is changing at a rapid rate, and as a result, many of the specific technologies mentioned in the *state-of-the-art* section may be out-dated in the future. Generalisations for this study are limited to the conclusions/decisions derived from the data collection period (Spring 2010 to Spring 2012).
- For the purpose of this study, eight categories of challenges have been identified and shall be included. But future research may expand on the number of areas.
- E-textbooks are more popularly used in higher education than those used in K-12 education. However this study aims to explore two main research questions pertaining to the successful adoption of e-Textbooks in the national curriculum for K-12 education.

The findings of this study provide guidance for subsequent research dealing with e-Textbook challenges and the solutions. Further efforts to improve e-Textbooks have been suggested in *challenges associated with e-Textbooks* section. More open issues are raised in *open issues* section for future research.

The potential of e-Textbooks to reform education should not be underestimated or overestimated. Although e-Textbooks have great potential to enhance the education system, the greatest hurdle remains on how stakeholders, including governments, schools, parents and students, make full use of these technologies. Certainly, there is a great deal of future work in the adoption of e-Textbooks in school curriculum, particularly the open issues raised in this article, such as in-depth study on copyright issues and e-textbook readiness.

REFERENCES

Abdullah, N. (2007). *A Study into usability of tools for searching and browsing e-books with particular reference to back-of-the-book index.* PhD, University of Strathclyde.

Arar, Y. (2010). Your Next E-Book Reader: Color and Video--and Nearly Unbreakable. Retrieved from http://www.pcworld.com/article/191113/your_next_ebook_reader_color_and_videoand_nearly_unbreakable.html

Bates, T. (2005). *Technology, e-learning and distance education*: Routledge.

Berque, D., Evans, E. J., Hammond, T., Mock, K., Payton, M., & Sweeney, D. S. Tablet PCs in K–12 Education. Retrieved from http://www.iste.org/images/excerpts/TABLET-excerpt.pdf

BISG. (2011). College Students Want Their Textbooks the Old-Fashioned Way: In Print, from http://www.bisg.org/news-5-603-press-releasecollegestudents-want-their-textbooks-the-old-fashioned-way-inprint.php

Boorsok, T. K., & Higginbothan-Wheat, N. (1991). Interactivity: What is it and What Can it do for Computer-Based Instruction. *Educational Technology, 31*, 11-17.

Borrell, B. (2009). Open-Source Textbooks a Mixed Bag in California Retrieved 3 June 2012, 2012, from http://www.scientificamerican.com/article.cfm?id=open-source-textbooks-mixed-bag-california

Brown, G. J. (2001). Beyond print: reading digitally. *Library Hi Tech, 19*(4), 390-399.

Brown, J. S., & Adler, R. P. (2008). Open education, the long tail, and learning 2.0. Retrieved from https://open.umich.edu/oertoolkit/references/mindsonfire.pdf

Catone, J. (2009). Digital Textbooks: 3 Reasons Students Aren't Ready Retrieved 1 Dec 2011, 2011, from http://mashable.com/2009/08/17/digital-textbooks/

Chatti, M. A., Dahl, D., Jarke, M., & Vossen, G. (2008). *Towards Web 2.0 Driven Learning Environments.* Paper presented at the 4th International Conference on Web Information Systems and Technologies, Madeira, Portugal.

Chen, J. W., Luo, D., Hsieh, C.-C., & Lu, C.-C. (2011). *A Comprehensive Strategy Framework for e-Textbook in the Coming Digital Society for Learning*. Paper presented at the The Fifth International Conference on Digital Society.

Chung, K. S., & Shon, J. G. (2009). Digital textbooks, the latest overseas trends and main implications *KERIS issue report*: KERIS.

CK-12 Foundation. (2008). Our Mission Retrieved 12 Dec 2011, 2011, from http://www.ck12.org/about/our-mission/

Dalvi, F. I., & Amor, S. (2010). *Presentation on Human-Computer Interaction*. Doha, Qatar. http://www.contrib.andrew.cmu.edu/~fid/coursework/15-129/files/paper.pdf

Davison, R. (2009). Flexible Displays Coming to Your Cell Phone Soon Retrieved 20 May, 2012, from http://www.brighthub.com/engineering/electrical/articles/46021.aspx

Denscombe, M. (2007). *The Good Research Guide for small-scale social research projects*. New York: McGraw Hill.

Dictionary.com. Retrieved 25 Sep 2012, 2012, from http://dictionary.reference.com/browse/compatibility?s=t

Haddad, W. D., & Draxler, A. (2002). *Technologies for Education – Potentials, Parameters and Prospects*. Washington, D.C: Paris & Academy for Educational Development.

Hasija, K., & Narayanan, B. (2009). Risk model for open source software: Valuing hidden costs. *PositionIT*.
Hayati, P., Potdar, V., Talevski, A., Firoozeh, N., Sarenche, S., & Yeganeh, E. A. (2010). *Definition of Spam 2.0: New Spamming Boom*. Paper presented at the Digital Ecosystems and Technologies (DEST).
Heikenfeld, J., Drzaic, P., Yeo, J.-S., & Koch, T. (2011). Review Paper: A critical review of the present and future prospects for electronic paper. *Journal of the Society for Information Display, 19*(2), 129-156.

Ipadacademy. (2010). Retrieved 22 Feb 2011, 2011, from http://ipadacademy.com/2010/09/university-of-adelaide-will-replace-science-textbooks-with-ipads
Jakob, N. (2000). *Designing web usability*. USA: New Riders.
Jones, C. (2007). *Using a digital repository for managing digital rights and copyright information.* Paper presented at the Ascilite Singapore 2007, Singapore.
Kapp, K. M. (2003). Five Technological Considerations When Choosing an E-Learning Solution.
Kapp, K. M. (2005). E-Learning Readiness Assessment Questions Retrieved 3 June, 2012, from http://www.karlkapp.com/questions.pdf
Kausar, T., Choudhry, B. N., & Gujjar, A. A. (2008). A comparative study to evaluate the effectiveness of computer assisted instruction (cai) versus class room lecture (crl) for computer science at ics level. *The Turkish Online Journal of Educational Technology, 7*(4).
Kayaoğlu, M. N., Akbaş, R. D., & Öztürk, Z. (2011). A small scale experimental study: Using animations to learn vocabulary. *The Turkish Online Journal of Educational Technology, 10*(2).
Kee, E. (2012). LG Display mass produces first e-paper display in the world Retrieved 31 March, 2012, from http://www.ubergizmo.com/2012/03/lg-e-paper-display/
Krug, S. (2000). *Don't make me think: a common sense approach to web usability*. USA: Que.
Lee, H. J., Messom, C., & Yau, K.-L. A. (2012). The three types of e-Textbooks with their characteristics and open issues. *Journal of Computing, 4*(9).
Mantgem, M. v. (2008). *Tablet PCs in K–12 Education*: International Society for Technology in Education.
Martin, P. J. (2008). Recent Patents on Liquid Crystal Alignment. *Recent Patents on Materials Science*, 21-28.
McFall, R., Dershem, H., & Davis, D. (2006). *Experiences Using a Collaborative Electronic Textbook:Bringing the "Guide on the Side" Home With You*. Paper presented at the SIGCSE'06.
Mehrens, W. A., & Lehmann, I. J. (1987). *Using standardized tests in education*: Longman Publishing Group.
Mercieca, P. (2004). *E-book acceptance: What will make users read on screen?* . Paper presented at the VALA 2004 Breaking Boundaries: Integration and Interoperability, Melbourne, Australia
Miao, J.-y., Liu, C.-y., & Sun, Z.-h. (2011). Study on the Method of the Technology Forecasting Based on Conjoint Analysis *Information Systems Development* (pp. 425-435): Springer.
Noji, K., Dürst, M. J., Phillips, A., Suzuki, T., & Texin, T. (2002). Web Services Internationalization Usage Scenarios.
OECD. (2007). Giving Knowledge for Free: THE EMERGENCE OF OPEN EDUCATIONAL RESOURCES: OECD.
Ozsoyoglu, G., Balkir, N. H., Ozsoyoglu, Z. M., & Cormode, G. (2004). On Automated Lesson Construction from Electronic Textbooks. *IEEE Transactions on Knowledge and Data Engineering, 16*(3), 317-331. doi: 10.1109/TKDE.2003.1262184
Patowary, K. (2011). Test Your Document's Readability in Microsoft Word Retrieved 7 Oct 2012, from http://www.instantfundas.com/2011/09/test-your-document-readability-in.html
Pattison, J. (2008). *Problems and prospects for e-books in education - An innovation perspective.* Master, University of Sheffield.
Piggott, T. (2010). Touch Screens in Education. 8. Retrieved from THOMAS PIGGOTT USER EXPERIENCE DESIGN website: http://thomaspiggott.com/portfolio/TouchScreensInEducation_Piggott.pdf
Pocatilu, P. (2010). Using WiMAX Technology for E-Learning Solutions. *Oeconomics of Knowledge, 2*(3), 6-10.
Robinson, S. (2011). Student use of a free online textbook. *Academy of Educational Leadership Journal, 15*(3).
Sadon, R., & Yamshon, L. (2011). The State of the E-Textbook *PCWorld*.
TheAmazonKindleteam. (2011). Introducing the all-new Kindle family: Four new Kindles, four amazing price points Retrieved 24 Sep 2012, from http://www.amazon.com/forum/kindle?_encoding=UTF8&cdForum=Fx1D7SY3BVSESG&cdPage=1&cdThread=Tx3DL5IUGC73UUL
The Ebook Reader. (2011). E Ink and Electronic Paper Retrieved 21 Oct 2011, from http://www.the-ebook-reader.com/e-ink.html
Ullrich, C. (2004). *Description of an Instructional Ontology and its Application in Web Services for Education*. Paper presented at the ISWC2004.
Ullrich, C., Borau, K., Luo, H., Tan, X., Shen, L., & Shen, R. (2008). *Why Web 2.0 is Good for Learning and for Research:Principles and Prototypes*. Paper presented at the International World Wide Web Conference

Committee(IW3C2), Beijing, China.
Walker, R. C., Schloss, P., & Vogel, C. A. (2007). *Visual-Syntactic Text Formatting:Theoretical Basis and Empirical Evidence for Impact on Human Reading*. Paper presented at the Professional Communication Conference.
Walker, S., Schloss, P., Fletcher, C. R., Vogel, C. A., & Walker, R. C. (2005). Visual-Syntactic Text Formatting:A New Method to Enhance Online Reading *Reading Online An Electronic Journal*
Warschauer, M. (2011). *Learning in the Cloud: How (and Why) to Transform Schools with Digital Media*. New York: Teachers College Press.
Wikipedia. Copyritght Retrieved 25 Sep 2012, 2012, from http://en.wikipedia.org/wiki/Copyright
Worthen, B. R., Borg, W. R., & White, K. R. (1993). *Measurement and evaluation in the school*: Longman Publishing Group.
Wu, S.-Y., Wang, S.-T., Liu, E. Z.-F., Hu, D.-C., & Hwang, W.-Y. (2012). The influences of social self-efficacy on social trust and social capital – a case study of facebook. *The Turkish Online Journal of Educational Technology, 11*(2).
Yang, S., Heikenfeld, J., Kreit, E., Hagedon, M., Dean, K., Zhou, K., . . . Rudolph, J. (2011). Electrofluidic displays: Fundamental platforms and unique performance attributes. *Journal of the SID, 19*(9). doi: 10.1889/JSID19.9.608
Yesser. (2005). *Supporting plans and methodologies: (a) E-Readiness assessment methodology for government organizations*. Riyadh, Saudi Arabia: E-government Program.
Zadoks, R., & Ratner, J. (1996). Developing Electronic Textbooks. Retrieved from http://www.osti.gov/bridge/servlets/purl/206888-MMip4Y/webviewable/206888.pdf