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RESEARCH ARTICLE

Electronic reading and digital library technologies: understanding learner expectation and usage intent for mobile learning

Jack A. Hyman · Mary T. Moser · Laura N. Segala

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Abstract Mobile information technology is changing the education landscape by offering learners the opportunity to engage in asynchronous, ubiquitous instruction. While there is a proliferation of mobile content management systems being developed for the mobile Web and stand-alone mobile applications, few studies have addressed learner expectations and usage intent in consuming digital documents from online content providers and digital libraries with specific emphasis on formal instruction. Understanding usage intent and actual usage of a mobile learning agent as a result of ease of use and usefulness of mobile devices will be addressed in this study. A research framework for instructional technology usage is proposed to help better articulate critical success factors in implementing formal learning using a mobile device, specifically an electronic reader or a tablet computer.

Keywords Mobile computing · Digital libraries · Usability · Knowledge management · Educational technology · Instructional design

Introduction

Electronic books (e-books) are print books that have been converted to a digital format or books that originated in a digital format. E-book readers and tablet computers equipped with electronic reader (e-reader) based software are handheld electronic devices that store a variety of e-books and other print materials. Some of these document formats are self-containing, while others are stored in a formal system of records such as a learning

J. A. Hyman (✉) · M. T. Moser · L. N. Segala
George Washington University, Washington, DC, USA
e-mail: jahyman@gmail.com

M. T. Moser
e-mail: mary.t.moser@gmail.com

L. N. Segala
e-mail: lsegala@gwmail.gwu.edu

management system. The growth and popularity of digital content in the form of e-books that are delivered to electronic reading platforms has been significant. In a Barron (2011) study, Amazon.com, the largest online retailer in the United States, now sells more e-books than print books. According to Rainie et al. (2012), over 20 % of American adults reported that they had read an e-book, for pleasure, personal research, or work. As the demand for portable reading devices rises, more authors are writing curriculum materials specifically for use on an electronic reading platform and are incorporating audio, video, and text-to-speech capabilities as part of their information delivery strategy (Corbeil and Valdes-Corbeil 2007).

In response to this growing demand, publishing and technology companies are providing an ever-increasing array of e-books and e-reader devices. Most producers of e-readers now produce multiple models of their products; for example, Amazon has the original Kindle (now known as the "Kindle Keyboard"), the Kindle DX with a larger screen, the Kindle Fire, and the Kindle Paperwhite. Other providers in the industry offer a variety of e-reader platforms: consumers can now choose from a plethora of e-reader or tablet-based devices running the Apple iOS, Google Android OS, or Microsoft Windows Mobile Platform (Brown 2012).

The growing acceptance and popularity of digitally formatted textbooks and instructional content by publishers and the consumption of electronic content using a mobile content in academia is having an impact on educational productivity for each major educational demographic. The U.S. Department of Education defines educational productivity as the ratio between costs and educational outcomes. This ratio can be improved in one of three ways: by reducing costs while maintaining outcomes, by improving outcomes while maintaining costs, or by transforming processes in a way that both reduces costs and improves outcomes (U.S. Department of Education, Office of Educational Technology 2012). The use of a platform delivering electronic reading materials of any kind, including digital documents, mobile books, tablet based applications, Nook or Kindle-based e-Reader PDF files, has the potential to impact both costs and educational outcomes as schools implement e- reader programs as a way to save money (Stephens 2012a, b, c), serve students with disabilities (Ludlow 2010; Shah 2011), teach reading (Larson 2010), teach research skills (Barron 2011), and more effectively engage students using a media type that they prefer (Brown 2012; Robinson and Stubberud 2012).

Electronic reading platforms for mobile learning

The uses of electronic reading platforms, which include e-readers and tablet computers, have been widely adopted by college students (Foasberg 2011). On the other hand, the adoption of such mobile information technologies seems to be gaining traction more slowly in the K-12 education market. Widely accepted adoption of digital books and instruction in higher education is attributed to the advantageous cost and portability. Since most higher education learners pay for their own instructional content, finding the most affordable and interactive platform for knowledge acquisition, maturation, and dissemination is instrumental in higher levels of personal consumption.

At the K-12 level, researchers are studying the efficacy of electronic reading platforms in mobile learning situations. Braun (2011) found that e-readers such as the Kindle help to encourage collaboration because students can highlight particular passages and make comments available for others to view. Using e-books on mobile devices may enhance students' ability to work and communicate collaboratively and asynchronously.

The use of e-books may already be having an impact on educational productivity, either by improving academic outcomes or reducing costs. Some studies suggest that electronic textbooks show promise in positively influencing academic achievement (Rieders 2011). Educators appreciate the advantages of e-books: portability, storage capacity, interactivity, and an expedited process for publishing and updating (Dixon 2012). Students are already more likely to search for references electronically, on their computers, or on a tablet such as an iPad, than to physically go to the library to conduct research (Tonkery 2010). Schools are finding that most of the classic literature they assign is located in the public domain and can be downloaded for free (Stephens 2012a, b, c).

While some electronic documents and books are presented in portable document format (PDF), others, known as book apps, have more functionality to enhance the user experience. Features include embedded videos, self-check quizzes, interactive crossword puzzles, and other high-interest resources (Leverkus 2012). The visual appeal of these features has the potential to engage students in a way that is not possible with traditional print books.

Electronic textbooks and instructional aids are quickly evolving beyond being simply the digital version of existing print product. Textbooks are becoming dynamic new technologies by integrating interactive videos, charts, animations, and collaborative features such as user comments and discussion boards in-text. Teachers are realizing that they can provide students with an entirely different reading experience using electronically formatted textbooks and documents, experiences that more closely align with constructivist-oriented learning techniques. Constructivism with electronic reading platforms is associated with supportive learning environments and activities that engage students with digital learning opportunities (Lee 2009). Lamb (2011) argues that reading on an electronic platform is a fundamentally different activity for students than reading in a traditional textbook, and will require teachers to change their very definitions of what it means to read. Reading an electronic text may involve far more than simply decoding text; for example, students may help to create the story as they move through the text, and stories may have branches rather than being linear.

Reading an electronically formatted text may require instructors to teach students new literacy practices, such as digital note-taking and highlighting, searching, using virtual bookmarks and glossaries, manipulating screen resolution, understanding page orientation and text size preference setting, and turning text read-aloud features on. Struggling readers, in particular, may benefit from electronic text features such as hearing words spoken aloud and looking up word definitions by clicking on a word in the text. Thus, e-book readers can help teachers to differentiate instruction in their classrooms (Lamb 2011). Because of the multimedia features embedded in many electronic texts, teachers will no longer have to work quite as hard to create their own multimedia lessons from scratch. Instead, their objective will be to integrate artifacts into this multimodal format of learning for learner consumption. While print texts are primarily visual, electronic texts have the ability to engage more learning modalities, including aural and kinesthetic, thus enhancing student engagement and recall.

Reasons for electronic reading platform adoption

Current studies focus on two primary drivers of how the use of e-books can help learners to improve educational productivity: by improving reading comprehension and by increasing student motivation and engagement. The most commonly studied impact of electronically delivered content on elementary academic achievement specifically concentrates on

reading comprehension (Brown 2012; Ciampa 2012; Kasman Valenza and Stephens 2012; McClanahan 2012). Most studies found a positive correlation between reading comprehension and the use of electronic reading platforms. In particular, book apps, which are interactive books that can be read on a mobile device include text, illustrations, and narrations (Horne 2012), increase student motivation, engagement, and persistence. Each of these measures helps identify the behavioral intention to use a system and prerequisites for reading achievement. One study found that using e-readers and tablet computers without interactive functionality integration instead of printed materials did not have a significant impact on students' reading comprehension outcomes, but even this study found that the use of an electronic reading platform could be beneficial if the device provides the ability to track individual student learning processes, thereby aiding in designing better interventions for individual students (Huang et al. 2012).

Every study that looked at survey results about student attitudes found that students like using electronic reading platforms and find them motivating (Brown 2012; Robinson and Stubberud 2012) as long as they are easy to use, are useful, and achieve specific learning objectives. It is well known in educational research that there is a positive relationship between student motivation and academic achievement, although more research is still needed to draw a direct correlation between the use of electronic reading platforms and overall academic achievement.

Stephens (2012a, b, c) wrote about a pilot project in which Nook readers were distributed to fifty English students for a semester in order to study Dante's *The Divine Comedy* and other public domain titles. Students were surveyed about their experiences using the device. The study indicated that students liked the devices because they could store multiple titles, necessitating fewer trips to the library to check out titles. Student feedback about the devices was overwhelmingly positive, and breakage or loss of the devices was non-existent. McClanahan (2012) described a case study of a fifth grade student with autism who was given an iPad for a reading intervention. This student gained one full year's growth in reading comprehension during a six-week timeframe and also showed a marked improvement in confidence and self-efficacy. While this case study certainly cannot be generalized to state that all students with autism or other disabilities would benefit to this extent, it seems likely that the use of e-books with multimedia capabilities would help teachers to provide a variety of interventions for exceptional learners.

Challenges in electronic reading platform adoption

While electronic reading platform technologies and content have the potential to lower the expense of obtaining reading materials for students, especially for those materials that are in the public domain and beyond copyright, the initial capital expense of investing in implementing and upgrading a school's Internet infrastructure may seem formidable (Stephens 2012a, b, c; Tomassini 2012). Selecting a particular platform or device can be challenging, since different technologies may be more or less useful, depending on the particular instructional situation. While the implementation of the technical infrastructure may be prohibitive to the educational institution, the creation, assembly, and dissemination of usable content that is easily consumed by learners on multiple operating systems is just as daunting. Educators and end-users desire universal platforms and content for e-learning, but the current landscape of content platforms, different types of mobile devices (also known as mobile form factors), and content publishers creates a diverse, and not always

compatible environment for mobile learners. Furthermore, efforts to adopt electronic content for formal learning are met with a well-documented combination of intellectual property and usability barriers, including user preferences. Both platform creators and content providers must address these barriers before e-content can be fully integrated into formal learning and teaching practices.

Intellectual property

Digital rights management (DRM) refers to the access control layer of electronic content. Across studies discussing content consumption and sharing, DRM remains one of the largest barriers to electronic reading, primarily because it limits sharing among information consumers based on device, platform, and content. For libraries, whose access model is based on the idea that a product can be shared among many learners or citizens, DRM severely limits the lending process (Hoseth and McLure 2012). Richardson and Mahmood (2012) as well as Aaltonen et al. (2011) also indicate that the reproduction of digital content due to restrictions on printing or downloading products remains a barrier to learner adoption (Aaltonen et al. 2011; Hoseth and McLure 2012). Foasberg (2011) explained that content publishers rely on security mechanisms such as DRM to protect copyrighted materials.

DRM prevents multiple device platforms from sharing content, sometimes even for a single user. While libraries traditionally subscribe to databases and services that offer electronic content for public distribution, most e-books and e-book collections do not allow the same level of content sharing and mobile device delivery to which library users are accustomed. Most libraries cannot provide the same affordances to the content available through mobile device delivery. Some e-book providers require third party application downloads in order to access content. Additionally, select electronic reading platform devices require regular access to the Internet for authentication and authorization of content. A learner without access to a Wi-Fi network or data plan from a wireless provider might be prevented from accessing e-content on his or her mobile device (Hoseth and McLure 2012).

Usability

Several studies document the disappointment learners experience when they view instructional content, which includes textbooks, assignments, digital documents, or collaborative spaces, on an electronic reading platform. Learners expect electronic reading platforms to act like personal computers, and are thus frequently disappointed by them when their expectations are not met. In conducting a study of university students using electronic reading tools such as the Amazon.com Kindle, Barnes and Noble Nook, and Apple iPad, Aaltonen et al. (2011) found that user experiences with e-readers and tablet computers were quite different from what learners anticipated. Learners indicated that the devices were slow and cumbersome to use. Furthermore, learners anticipated that the user experience and interaction would be more computer-like. Berg et al. (2010) found that users expected e-books on tablets and e-readers to act like a typical Web page and were frustrated when those expectations were not met. Such behavior suggests that learners who have pre-determined expectations became frustrated, confused, and disappointed when accessing e-content on mobile devices. Because learners have become so familiar with ubiquitous online tools such as Google, Facebook, Twitter, PDF files, and Web-based email, a change in the learner mental model can result in resistance to technology adoption.

Electronic reading platforms are a disruptive technology to the learner. Many learners do not understand the difference between how to read, navigate, and utilize an electronically formatted text in comparison to print materials. Most learners expect to transfer their established print reading habits to a mobile platform by transforming their analog expectations to digital (Kostick 2011). Since there is no common electronic reading platform for content, learners have to cope with non-intuitive design, clunky and error-ridden navigation, and unfriendly device operations. The capabilities in electronic reading platforms vary greatly as well. Some e-readers and tablet computers only offer e-Ink technology, which does not permit colorful, interactive features that are seen in devices such as tablet computers, which utilize electronic reading platform applications to distribute full-color content.

Most learners are not cognitively prepared to engage in learning activities using mobile devices, particularly since the content and platforms are so diverse. E-content for mobile devices is sometimes formatted like a Website, while other times the design mimics a book. Studies show a lack of compatibility between reading on mobile devices, which is traditionally and most successfully done in a linear fashion, and reading in an academic context, which is rarely done in a linear fashion (Siegenthaler et al. 2012; Hoseth and McLure 2012; Foasberg 2011; Aaltonen et al. 2011; Berg et al. 2010).

Lack of a clear navigation, search facility, and interaction model for users has also made electronic reading platform and digital library use prohibitive in academic settings. A glaring omission of electronic reading platforms such as those presented by Amazon.com and Barnes and Noble is the lack of page numbers in Kindle and Nook e-books, which leads to difficulty citing those materials in academic work (Richardson and Mahmood 2012). Foasberg (2011), meanwhile, argues that e-reading devices rely on navigation strategies that are most effective for linear reading and highlights the difficulty of skimming or browsing a text on an e-reader or tablet. Learners engage with their instruction in both a linear and non-linear manner, but mobile devices do not always support a varied approach to content consumption. Hoseth and McLure (2012) discuss the inability to flip easily between multiple components of an electronic text at one time, a key component of the research and writing process; and Martinez-Estrada and Conaway (2012) also highlight the limited functionality of electronic reading platforms, especially for classes that require students to work problems out on paper, like engineering or mathematics.

While tablet computers can handle multi-functional reading support to some degree, most mobile devices, including e-readers, are designed for linear reading. Many students, however, only read portions of the assigned textbook or instructional content (Berg et al. 2010). In fact, Hoseth and McLure (2012) cite Levine-Clark, who found that only 7.1 % of 1,100 e-reader respondents indicated that their typical e-book use behavior was to read a title in its entirety. Students prefer to browse, scan, and skip around a text, suggesting a non-linear mental model and learning approach to reading electronic reading text of varying lengths (Berg et al. 2010; Aaltonen et al. 2011). Users do not read e-books sequentially, but e-readers are designed for sequential reading. With e-books and e-readers, browsing capabilities are limited due to the delay with page turns and jumps. Readers are additionally confronted with the lack of physical orientation in a text, allowing few cues about where exactly they need to jump. In a paper format, on the other hand, such cues and navigational assistance aids are evident in the physicality of the print book.

Depending on the mobile form factor, interactive functionality of content varies. If a course developer or instructor compiles the content for the class using an e-reader, significant loss of interactive functionality may result in a lack of e-reader adoption by students. If a platform does not allow the basic functionality equivalent to print texts, such as

bookmarking, note taking, or annotation, abandonment is highly predictable. While tablet computers offer much quicker and smoother navigation, they are not necessarily a perfect answer to the problem of academic functionality. Richardson and Mahmood (2012) noted that it is still difficult to take notes on large form factor-based tablets, such as the iPad.

Siau et al. (2003) indicated that the success and satisfaction of mobile technologies have been linked to a lack of standards; the impact a small screen size has on work efficiency; readability of content, limited screen resolution; limited processing capacities; and cumbersome input mechanisms due to a mobile device's small form factor. The screen size itself is prohibitive in the context of the electronic reading platform because users struggle to perform such tasks as executing information search strategies, fully viewing queried data, and manipulating text size and format; small screen size can also be an impediment to viewing images clearly (Churchill and Hedberg 2008; Jones and Brown 2011; Sanchez and Goolsbee 2010). A majority of academic literature, be it textbooks or documents, are delivered as PDF files. Depending on the type of e-reader used, limited screen resolution may result in a poor display of content due to inadequate content formatting, lack of ability to zoom or resize the screen, and the quality of the image on the display itself being pixelated (Foasberg 2011; Martinez-Estrada and Conaway 2012; Shelburne 2009).

The variety of both content providers and content platforms may present a barrier for the user, who is challenged both by learning the content and by taking full advantage of formal learning through e-books and mobile devices. As a result, the full potential of these devices and formats for reading and learning cannot yet be fully realized, based on the limitations of the content providers and devices. A primary challenge is the lack of standardization across delivery platforms, operating systems, and application platforms, confounded by the diversity of student learning styles. Such challenges require that a framework for learning organizations to follow for the successful full lifecycle development, implementation, and use of electronically formatted content on a mobile device.

Study model and hypothesis

Based on the literature review above, the conceptual research model is presented in Fig. 1. The model was derived using the Davis (1989) Technology Acceptance Model.

To evaluate the model in its entirety, the following null hypotheses were proposed:

- **H_1** Ease of use, in the delivery of electronic content on a mobile device, positively increases the possibility of content consumption by the learner
- **H_2** A user who finds the electronic content presented on a mobile device to be useful positively increases the possibility of learner-based behavioral usage intent
- **H_3** A user who finds it easy to learn from readings or task-based activities on a mobile device positively increases the possibility of learner-based behavioral usage intent
- **H_4** Behavioral usage intent, based on a learner's positive experience in the mobile learning environment, significantly increases actual usage of an electronic reading platform

Variable definitions

Ease of use	The degree of effort required on the part of the user in order to complete an activity

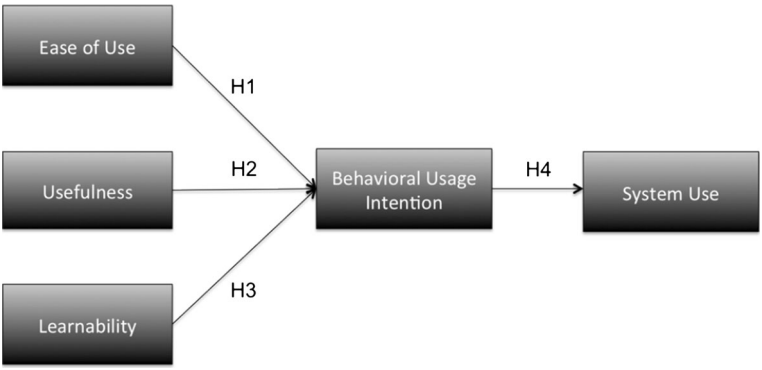


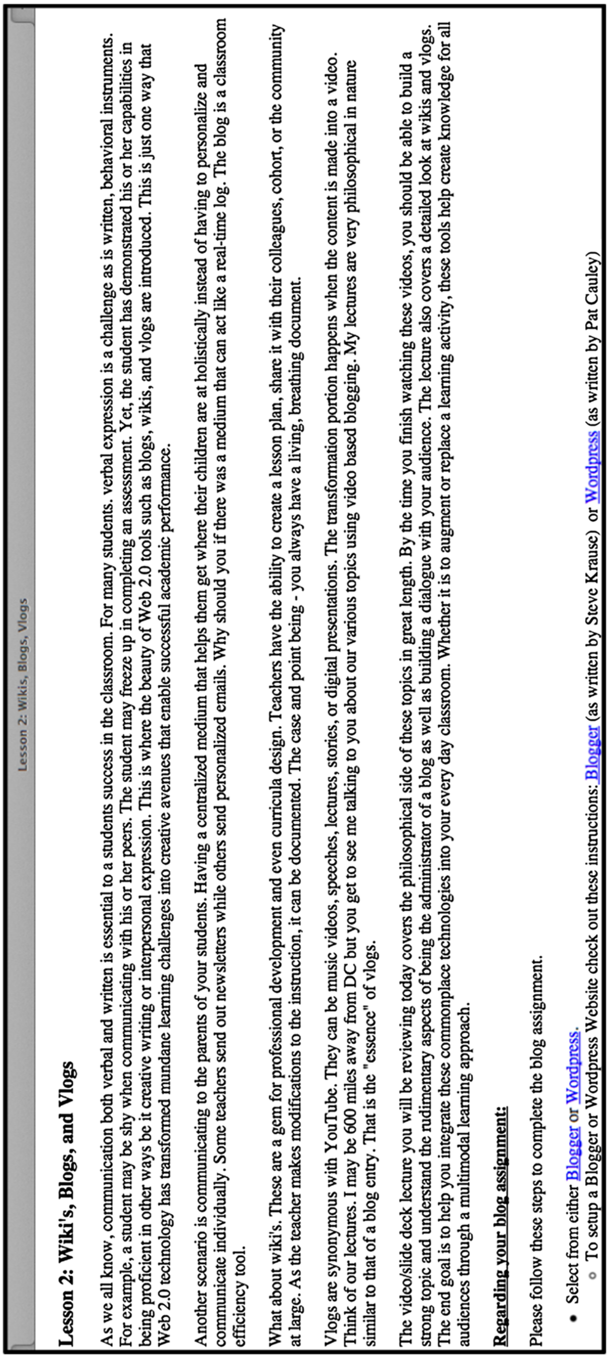
Fig. 1 Instructional technology usage (ITU) research model

Usefulness	The tendency to use or not use a system to the extent the user believes it will help them complete an activity successfully
Learnability	How easy the user may find it is to accomplish the required tasks upon interaction with the information platform
Behavioral usage intention	An indication of an individual's readiness and behavior to use a given system, given a specific set of circumstances and subjective norms
System use	The degree and manner in which a user exercises the capabilities of an information system. This measure includes the amount of use, frequency, nature of use, appropriateness, extent, and purpose

Methodology

Participants

Participants in this study include 140 graduate students who were a part of distance learning-based courses taught between the Summer of 2011 and Fall of 2012. All students who qualified in this study either owned a smartphone, a tablet computer, or an electronic reader. Students participating in this study were Master's Degree candidates seeking a Masters of Art in Education program. The traditional class delivery format was 100 % Web-based using Blackboard. The professor had a secondary option for students to acquire lecture materials, his own Website, which was mobile-enabled for the learner. The content for each lecture included a text-only lecture with various Website links (Fig. 2), a series of mobile-Web videos and PowerPoint files embedded into an HTML document (Fig. 3). The students were asked to read the lecture, review several Websites, and watch an online video lecture while following the PowerPoint slide deck. The student was also provided some text-based assessments, which required response to the instructor or using the Blackboard Learning Management System Discussions feature. The students were given the option to use either the traditional or mobile lecture format throughout the semester. During the course, there were two weeks where the students were required to complete one or more parts of their instruction on a mobile device form factor exclusively. The survey, which the



Lesson 2: Wikis, Blogs, Vlogs

Lesson 2: Wiki's, Blogs, and Vlogs

As we all know, communication both verbal and written is essential to a students success in the classroom. For many students. verbal expression is a challenge as is written, behavioral instruments. For example, a student may be shy when communicating with his or her peers. The student may freeze up in completing an assessment. Yet, the student has demonstrated his or her capabilities in being proficient in other ways be it creative writing or interpersonal expression. This is where the beauty of Web 2.0 tools such as blogs, wikis, and vlogs are introduced. This is just one way that Web 2.0 technology has transformed mundane learning challenges into creative avenues that enable successful academic performance.

Another scenario is communicating to the parents of your students. Having a centralized medium that helps them get where their children are at holistically instead of having to personalize and communicate individually. Some teachers send out newsletters while others send personalized emails. Why should you if there was a medium that can act like a real-time log. The blog is a classroom efficiency tool.

What about wiki's. These are a gem for professional development and even curricula design. Teachers have the ability to create a lesson plan, share it with their colleagues, cohort, or the community at large. As the teacher makes modifications to the instruction, it can be documented. The case and point being - you always have a living, breathing document.

Vlogs are synonymous with YouTube. They can be music videos, speeches, lectures, stories, or digital presentations. The transformation portion happens when the content is made into a video. Think of our lectures. I may be 600 miles away from DC but you get to see me talking to you about our various topics using video based blogging. My lectures are very philosophical in nature similar to that of a blog entry. That is the "essence" of vlogs.

The video/slide deck lecture you will be reviewing today covers the philosophical side of these topics in great length. By the time you finish watching these videos, you should be able to build a strong topic and understand the rudimentary aspects of being the administrator of a blog as well as building a dialogue with your audience. The lecture also covers a detailed look at wikis and vlogs. The end goal is to help you integrate these commonplace technologies into your every day classroom. Whether it is to augment or replace a learning activity, these tools help create knowledge for all audiences through a multimodal learning approach.

Regarding your blog assignment:

Please follow these steps to complete the blog assignment.

- Select from either Blogger or Wordpress.
  - To setup a Blogger or Wordpress Website check out these instructions: Blogger (as written by Steve Krause) or Wordpress (as written by Pat Cauley)

Fig. 2 Text-based lecture for mobile devices

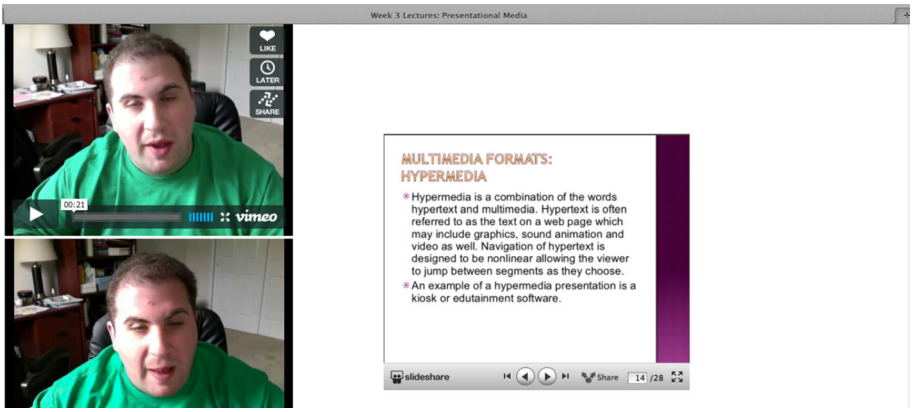


Fig. 3 Video and powerpoint mobile ready lecture

study results were derived from, was distributed the last week of class (Week 7). The questions asked to the students as part of the class-wide instruction feedback are presented in Table 1. The average age of the student in this study was 34.8 years. Representation of gender was 54 % female and 46 % male. All participants had previously owned a mobile device for a minimum of one year.

Instrumentation

An online survey was distributed containing 11 research questions. Questions were formatted using a five-point Likert scale where participants chose from options including Strongly Disagree, Disagree, Neutral, Agree, or Strongly Agree. The researchers developed a framework to better understand the interplay among variables using a form of Structure Equation Modeling (SEM) called Partial Least Squares (PLS). SEM enabled the researchers to test both the measurement model and the structural model. The measurement model consisted of measuring the relationship between the constructs.

Constructs and associated research statements

Table 1 presents the list of constructs and associated research questions asked to the survey participants.

Analysis and interpretation

Internal consistency reliability was measured by applying Cronbach's alpha test to evaluate the overall reliability measure of the constructs. Based on the calculated results, the reliability level was equal to (.775), which is considered an acceptable level of reliability (Sekaran 2002).

The mean of each variable was also extracted to explore the interaction between the independent and dependent variables. Using a 5-point Likert Scale, the value of 5 was associated with Strongly Agree and 1 was associated with Strongly Disagree. In this study, a value greater than 3 shows that the participants' level of agreement with each of the

Table 1 Construct, survey value, and research statements

Construct	Value	Statement
Ease of use	EOU1	Viewing instructional content using an electronic reading platform is easy.
	EOU2	Completing a learning-based task on an electronic reading platform is easy.
Usefulness	USE1	Using a mobile device to augment classroom instruction is useful.
	USE2	Including resources to third-party sources in an electronic reading platform is useful.
	USE3	Including multiple forms of navigation within an electronic reading platform is useful.
Learnability	LEAR1	An electronic reading platform allows me to read digital content quickly.
	LEAR2	An electronic reading platform allows me to complete learning tasks quickly.
Behavioral usage intention	BUI1	I expect that an electronic reading platform will tailor instruction to my personal preference.
	BUI2	I expect that content will be easy to read and a task will be easy to complete on an electronic reading platform.
System use	SU1	I am likely to use an electronic reading platform if the instruction is interactive.
	SU2	I am likely to use an electronic reading platform if the instruction is intuitive.

statements was high. A value of 2 and 2.99 is representative of medium agreement among participants. A mean value below 2 indicates a low agreement level among participants. Table 2 shows the mean between each of the variables and the categorization among variables.

Usage intent and expectation is high if the system is easy to use.
Usage intent and expectation is high if the system is useful.
Usage intent and expectation is high if the user can accomplish the required tasks upon interaction with the information platform.
Usage intent and expectation is high if the behavioral usage intention is also high.
Usage intent and expectations are met and highly probably if the user uses the system.

Partial least squares analysis

The structural model can be assessed by complete examination of explanatory power of the variables and the size and the significance of the path coefficients. The path coefficient of each dependent variable (ease of use and usefulness) describes the direct effect of that variable on the mediating variable (behavioral usage intention) and the independent variable (system use). The use of PLS makes less rigid assumptions compared to other methods (Compeau et al. 1999) in that it accepts latent constructs under conditions of non-normality in small to medium sample sizes (Chin 1998). PLS analyzes how the items load on their constructs simultaneously with estimating all the paths in the model. Gefen et al. (2000) indicated that PLS is designed to explain variance, whereby it is vital to examine the significance of the relationships as in linear regression. As a result, PLS is more suited for predictive applications and theory building in contrast to covariance-based SEM. PLS is appropriate for the analysis of small data samples and for data that do not necessarily exhibit the multivariate normal distribution required by covariance-based SEM (Chin 1998; Gefen et al. 2000).

Convergent and discriminant validity

The researchers tested the items and constructs evaluated in the survey for convergent and discriminant validity using confirmatory factor analysis. Chin (1998) and Sekaran (2002) explain that convergent validity verified that a study questionnaire, such as the one participants completed after the task activity, had items measuring corresponding constructs that were related, highly correlated to each other, and showed a strong correlation to the construct they were intended to measure. Factor loading measures the strength between each item and among constructs. In Table 3, factor-loading values that exceed 0.50 fulfill the acceptable minimum value (Chin). Such a measure provided evidence of a strong correlation between each item and the corresponding construct.

Since all values exceeded the minimum threshold of 0.500, the results show a strong convergence among variables. Gefen and Straub (2005) and Sekaran (2002) discuss how discriminant validity could be used as a way to verify that the items in a study demonstrate convergent validity. Table 4 shows the discriminant validity does not have a strong correlation with any other constructs in this study. A highly negative value, such as that represented by the relationship of USE and SU1 (−0.001) or SU and EOU2 (−0.009) indicate that some aspect of usefulness and system usage or system usage and ease of use are unlikely to share a relationship. On the other hand, a relationship such as USE1 and

Table 2 Mean, AVE and std. deviation of study variables

	Mean	SD	AVE	Category
Ease of use	3.30	0.91	0.51	High
Usefulness	3.48	1.04	0.88	High
Learnability	3.36	0.98	0.62	High
Behavioral usage intention	3.40	0.90	0.56	High
System use	3.01	0.99	0.75	High

Table 3 Convergent validity

	EOU	USE	LEAR	BUI	SU
EOU1	0.713				
EOU2	0.709				
USE1		1.134			
USE2		0.796			
USE3		0.845			
LEAR1			0.879		
LEAR2			0.684		
BUI1				0.812	
BUI2				0.676	
SU1					0.635
SU2					1.042

USE (1.134) or SU2 and SU (1.042) were indicative of a highly correlative relationship that is close to the value of 1.

PLS model evaluation

In order to evaluate the framework described in Fig. 1, the researchers estimated the path coefficients between the constructs. PLS also helped the researchers measure the variances between the dependent and independent constructs. Figure 4 shows the results calculated for the proposed framework. The figure presents the constructs and the associated measurement items with factor loadings for all five constructs: ease of use, usefulness, learnability, behavioral usage intention, and system use.

Based on the path coefficient, t statistics, and the calculated critical value, the results indicate:

The path coefficient between the construct *ease of use* and the construct *behavioral usage intention* is significant at 0.377 (*t* statistic: 4.558, Critical Value: 1.977). H_1 should be rejected.

The path coefficient between the construct *usefulness* and the construct *behavioral usage intention* is significant at 0.165 (*t* statistic: 2.698, Critical Value: 1.977). H_2 should be rejected.

The path coefficient between the construct *learnability* and the construct *behavioral usage intention* is significant at 0.415 (*t* statistic: 4.354, Critical Value: 1.977). H_3 should be rejected.

Table 4 Discriminant validity

	EOU	USE	LEAR	BUI	SU
EOU1	**0.713**	0.052	0.149	0.421	0.227
EOU2	**0.709**	0.166	0.180	0.175	−0.009
USE1	0.177	**1.134**	0.042	0.290	0.288
USE2	0.040	**0.796**	0.123	0.188	0.180
USE3	0.092	**0.845**	0.024	0.162	0.105
LEAR1	0.173	0.081	**0.879**	0.410	0.292
LEAR2	0.177	0.017	**0.684**	0.388	0.186
BUI1	0.383	0.110	0.417	**0.812**	0.409
BUI2	0.345	0.246	0.340	**0.676**	0.386
SU1	0.047	−0.001	0.318	0.306	**0.635**
SU2	0.280	0.301	0.254	0.574	**1.042**

The bold values are indicative of convergent validity

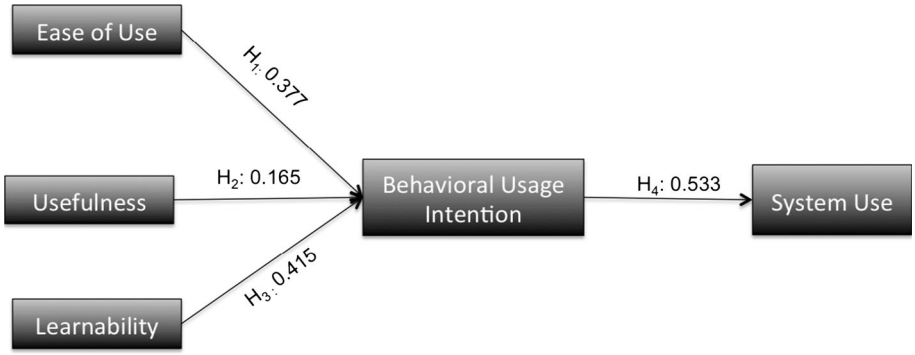


Fig. 4 Testing of the instructional technology usage (ITU) research model

The path coefficient between the construct *behavioral usage intention* and the construct *system usage* is significant at 0.533 (*t* statistic: 9.101, Critical Value: 1.977). H_4 should be rejected.

The framework results articulate that in order for a learner to adopt an electronic reading platform, it must be easy to use based on the assigned requirements. During this class, activities included standalone reading of static text, perusing a textbook in a PDF or digital distribution format, and working through a task-oriented video/presentation based lecture activity. Electronic reading platforms and the content delivery mechanism must clearly offer a sensible interaction model for reading and task-oriented to be deemed easy to use and useful. Students excelled when the instructional interaction was linear in nature. Linearity represents reading the basic lecture instructions, pursuing through a electronic file or document which was inclusive of all course formats, or completing a single activity at a given time (i.e. watching a lecture video). When the student had to multi-task on the electronic reader or tablet, this was either exceptionally difficult because the form factor did not permit such interaction or because the form factor size was not conducive for multiple simultaneous interactions.

Ease of use for mobile learning is therefore synonymous with print-based solutions because delivery is clear, concise, and orderly so that the learner's mental model can focus on the learning objective versus technical needs. From our understanding of what the students considered easy to use, usefulness can be defined as instruction that is consumed and understood easily by the learner without encountering technical challenges or tackling a multi-modal learning activity on a mobile device. Although learners partially make their decision on which platform they prefer given our understanding of ease of use and usefulness to varying degrees, the study supported the researchers notion that learnability is the strongest indicator, whereas platform usefulness presents the weakest indicator. If the formal instruction presented through e-content on mobile devices meets learning objectives as required by the instructor or institution by using the device exclusively or concurrently with traditional Web systems, retention, reuse, and future adoption is greater.

Retention, reuse, and future adoption are all proxy measures of behavioral usage intention and system use. Whether the instruction integrates multi-modality or is print-to-text ready, learner expectation drives adoption, primarily based on usability measures. The learner must be able to find what they are looking for, navigate to and from the content, and customize the user experience for personal accessibility.

Study limitations

The learner was presented with electronic content on a mobile device in several different formats throughout the course. The instructor also prepared some lectures to be entirely static text or used downloadable documents (i.e. documents in Adobe PDF or Microsoft Word). Other weeks, the instructor presented content that required more technical sophistication (i.e. web-based PowerPoint slide decks rendered on a mobile device, video files streamed from YouTube or Vimeo, mp3 files downloadable from the instructors website). The variety of content should have enriched the learning experience on the mobile device; however, it became a hindrance. Because the learners used their own mobile devices and each device is configured differently, no two students experienced the multi-modal learning activities consistently. While trying to be device agnostic in the development of instruction, the presentation of some electronic content was not suitable for certain mobile device form factors including e-readers and older tablet computers. As such, future studies may want the researchers to consider normalizing on one or two mobile operating system platforms and device form factors.

The other study limitation was the length of the course. The learners were required to complete the entire course in 7 weeks. The average length of an academic course at the university is 13 weeks. Because the learner was required to complete double the amount of instruction to fulfill the learning requirements, the instructional presentation of content on the mobile device may have become unwieldy at times because of sheer volume. While learners indicated on the end of semester evaluation that the traditional delivery of content using the Blackboard learning management system exceeded expectations, there was a disparity in impressions because the mobile delivery was significantly lower. The instructor received a score of 94.3 % satisfaction (130/140 students) with the learning management system based delivery versus 62.8 % (88/140 learners) mobile delivery of instruction. Learners were able to provide prose-based feedback as to what they felt would improve the course. Of the 140 learners in the course, 84 provided supplementary feedback (60 %). The most common supplementary message indicated the length of the course was (a) not long enough to accomplish all the learning objectives (b) the mobile delivery format

while innovative, overwhelmed the learner due to the quantity of content a learner must review each week without a clear sense of order. Therefore, future delivery of mobile instruction should be more refined to meet the course time constraints.

Conclusion

An increasing number of studies are finding a difference in reading comprehension and learning experience when students read on a digital device presenting content in a linear fashion versus a printed text (Taylor 2011; Weisberg 2011). Connell et al. (2012) found that while print books generated the fastest reading time, there was no difference in reading comprehension between e-readers and tablet computers. The differentiator among device platforms has been the ease of use, usefulness, and learnability of the content on the device. Interactivity and multi-modal learning engagement increases user adoption as long as the device and content are easy to understand and help the user accomplish clearly identifiable goals. In both the literature review and in the study, tablet computers were preferred over dedicated e-reader devices. Because e-readers do not offer multi-modal functionality, lack strong search and navigation topologies, and present learners with several mental-model issues that they must overcome, usage is determine by end-user need and the user experience offered to the learner. Expectations and usage intent is strongly correlated with mobile usability and instructional soundness of the content on the mobile device. The ITU framework presented a model for educational institutions to consider when developing formal instructional content or implementing learning management platforms that include various content formats.

Several research themes should be considered for future research. First, researchers should consider evaluating the cognitive processes learners take when selecting and adopting an electronic content platform. It may be helpful to understand why learners may prefer one format to another or if the device, instructional requirements, or the learners real-time needs are the only usage differentiators. A second research theme that should be further evaluated is better understanding how learner satisfaction and success differ based on the content type relative to the learners experience with mobile technologies as well as preferred learning style. Finally, mobile learning adoption varies greatly around the world. Learners in European and Asian Pacific countries have come to adopt mobile technologies for learning and commerce more quickly than those in North and South America. By being able to understand why adoption is greater on other continents besides North and South America may help the instructor comparison of international versus domestic user expectation and usage intention with various mobile form factors and delivery formats.

References

Aaltonen, M., Mannonen, P., Nieminen, S., & Nieminen, M. (2011). Usability and compatibility of e-book readers in an academic environment: A collaborative study. *IFLA Journal, 37*(1), 16–27.

Barron, P. (2011). E-readers in the classroom. *Transformations, 22*(1), 133–138.

Berg, S. A., Hoffmann, K., & Dawson, D. (2010). Not on the same page: Undergraduates' information retrieval in electronic and print books. *The Journal of Academic Librarianship, 36*(6), 518–525.

Braun, L. W. (2011). Reading that is global and social. *Voice of Youth Advocates, 34*(1), 38–39.

Brown, R. (2012). Preliminary findings from a survey of student acceptance and use of e-textbooks in higher education. *Allied Academies International Conference: Proceedings of the Academy of Educational Leadership (AEL), 17*(2), 1–5.

Chin, W.W. (1998). Issues and opinion on structural equation modeling. *MIS Quarterly, 22*(1), vii-xvi.
Churchill, D., & Hedberg, J. (2008). Learning object design considerations for small-screen handheld devices. *Computers & Education, 50*, 881–893.
Ciampa, K. (2012). Reading in the digital age: Using electronic books as a teaching tool for beginning readers. *Canadian Journal of Learning and Technology, 38*(2), 1.
Compeau, D., Higgins, C. A., & Huff, S. (1999). Social cognitive theory and individual reaction to computing technology: A longitudinal study. *Management Information Systems Quarterly, 23*(2), 145–158.
Connell, C., Bayliss, L., & Farmer, W. (2012). Effects of e-book readers and tablet computers on reading comprehension. *International Journal of Instructional Media, 39*(2), 131–140.
Corbeil, J., & Valdes-Corbeil, M. (2007). Are you ready for mobile learning? *EDUCAUSE Quarterly, 30*(2), 51–58.
Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319–340.
Dixon, A. (2012). From touchstones to touch screens: The evolution of a book lover. *Horn Book Magazine, 88*(2), 69–71.
Foasberg, N. M. (2011). Adoption of e-book readers among college students: A survey. *Information Technology & Libraries, 30*(3), 108–128.
Gefen, D., & Straub, D. (2005). A practical guide to factorial validity using PLS-Graph: Tutorial and annotated example. *Communications of the Association for Information Systems, 16*(1), 91–109.
Gefen, D., Straub, D., & Boudreau, M. (2000). Structural equation modeling and regression: Guidelines for research practice. *Structural Equation Modeling, 4*(1), 7–84.
Horne, L. K. (2012). Apps: A practical approach to trade and co-financed book apps. *Publishing Research Quarterly, 28*(1), 17–22.
Hoseth, A., & McLure, M. (2012). Perpsectives on e-books from instructors and students in the social sciences. *Reference & User Services Quarterly, 51*(3), 278–288.
Huang, Y., Liang, T., Su, Y., & Chen, N. (2012). Empowering personalized learning with an interactive e-book learning system for elementary school students. *Educational Technology Research and Development, 60*(4), 703–722.
Jones, T., & Brown, C. (2011). Reading engagement: a comparison between e-books and traditional print books in an elementary classroom. *International Journal of Instruction, 4*(2), 5–22.
Kasman Valenza, J., & Stephens, W. (2012). Reading remixed. *Educational Leadership, 69*(6), 75–78.
Kostick, A. (2011). The digital reading experience: Learning and interaction design and UX-usability experts. *Publishing Research Quarterly, 27*(2), 135–140.
Lamb, A. (2011). Reading redefined for a transmedia universe. *Learning & Leading with Technology, 39*(3), 12–17.
Larson, L. C. (2010). Digital readers: The next chapter in e-book reading and response. *Reading Teacher, 64*(1), 15–22.
Lee, G. (2009). From e-reading to e-learning: A pedagogical framework for online learning. ANZMAC. Retrieved from http://www.duplication.net.au/ANZMAC09/papers/ANZMAC2009-416.pdf.
Leverkus, C. (2012). The expanding book apps market. *Library Media Connection, 31*(2), 26–27.
Ludlow, B. (2010). The future of reading. *Teaching Exceptional Children, 43*(1), 4.
Martinez-Estrada, P. D., & Conaway, R. N. (2012). E-books: The next step in educational innovation. *Business Communication Quarterly, 75*(2), 125–135.
McClanahan, B. (2012). A breakthrough for Josh: How use of an iPad facilitated reading improvement. *Techtrends, 56*(4), 20–28.
Rainie, L., Zickuhr, K., Purcell, K., Madden, M., & Brenner, J. (2012). *The Rise of E-Reading*. Washington: Pew Research Center's Internet & American Life Project.
Richardson, J. V, Jr, & Mahmood, K. (2012). E-book readers: User satisfaction and usability issues. *Library Hi Tech, 30*(1), 170–185.
Rieders, W. (2011). ATG special report: Looking beyond e-textbooks and tapping into the personal learning experience. *Against The Grain, 23*(3), 42–44.
Robinson, S., & Stubberud, H. (2012). Student choice of course materials. *Allied Academies International Conference: Proceedings of the Academy of Educational Leadership (AEL), 17*(1), 41–45.
Sanchez, C. A., & Goolsbee, J. Z. (2010). Character size and reading to remember from small displays. *Computers & Education, 50*, 1056–1062.
Sekaran, U. (2002). *Research Methods for Business: A Skill Building Approach*. New York: Wiley.
Shah, N. (2011). High-tech service unlocks books for pupils (cover story). *Education Week, 31*(10), 1–11.
Shelburne, W. A. (2009). E-book usage in an academic library: User attitudes and behaviors. *Library Collections, Acquisitions, & Technical Services, 33*, 59–72.

Siau, K., Sheng, H., & Nah, F. (2003). The value of m-commerce to customers. *HCI Research in MIS, 3*(1), 65–69.
Siegenthaler, E., Bochud, Y., Wurtz, P., Schmid, L., & Bergamin, P. (2012). The effects of touch screen technology on the usability of e-reading devices. *Journal of Usability Studies, 7*(3), 94–104.
Stephens, W. (2012a). Deploying e-readers without buying e-books. *Knowledge Quest, 40*(3), 40–43.
Stephens, W. (2012b). In a more digital direction. *Young Adult Library Services, 10*(4), 28–30.
Stephens, W. (2012c). One semester circulating e-readers: One high school library's pilot project. *Library Media Connection, 31*(1), 40–41.
Taylor, A. K. (2011). Students learn equally well from digital as from paperbound texts. *Teaching of Psychology, 38*(4), 278–281.
Tomassini, J. (2012). Educators weigh e-textbook cost comparisons. *Education Week, 31*(30), 1–19.
Tonkery, D. (2010). The iPad and its possible impact on publishers and libraries. *Searcher, 18*(8), 39–42.
U.S. Department of Education, Office of Educational Technology, (2012). *Understanding the implications of online learning for educational productivity*. Washington.
Weisberg, M. (2011). Student attitudes and behaviors toward digital textbooks. *Publishing Research Quarterly, 27*, 188–196.

Jack A. Hyman is an Adjunct Professor of Educational Technology in the Graduate School of Education & Human Development at George Washington University, Washington DC. Jack earned his PhD in Information Systems from Nova Southeastern University, Ft. Lauderdale, FL. Jack's professional credentials include leading a pre-sales strategy team for a Global 100 technology organization based in the United States. His areas of research expertise focus on mobile computing, instructional technology, and human computer interaction. Jack resides in Atlanta, Georgia.

Mary T. Moser is a graduate of the Educational Technology Leadership Program which is in the Graduate School of Education & Human Development at George Washington University. Mary serves as the Lead Instructional Library at Babson College, Massachusetts. Mary resides in Boston, Massachusetts.

Laura N. Segala is a current Master's Degree candidate in the Educational Technology Leadership program which is in the Graduate School of Education & Human Development at George Washington University, Washington DC. Laura serves as an Instructional Consultant for Connections Learning. Laura resides in Minneapolis, Minnesota.