

# LITERATURE REVIEW DIGITAL TEXTBOOKS

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## LITERATURE REVIEW DIGITAL TEXTBOOKS

### *At a Glance*

*Across the U.S., an increasing number of school districts are switching from print textbooks to digital textbooks. This Literature Review summarizes the advantages and disadvantages of digital textbooks. Research on the impact of digital textbooks on students' reading habits, reading speed, reading engagement, content retention, and academic achievement is reviewed. This report also contains a section detailing the costs associated with digital textbooks, such as electronic devices, digital content, infrastructure, and teacher training. A summary of issues that should be considered when transitioning to digital textbooks is included, based on the experiences of school districts that have adopted digital initiatives. Finally, examples of digital textbook programs being implemented across the U.S. are provided.*

An increasing number of school districts across the U.S. are switching from print textbooks to digital textbooks. The Federal Communications Commission and U.S. Department of Education's (FCC & USDOE, 2012) *Digital Textbook Playbook* called for all students to use digital textbooks by 2017. Education Secretary Arne Duncan has continued to urge educators to move quickly to adopt digital textbooks and materials (Davis, 2013; Lederman, 2012; Toppo, 2012; Saetern, 2009; Surdin, 2009).

Digital textbooks are electronic versions of paper textbooks that can be read on a computer, netbook, cell phone, or e-reader (an electronic device designed primarily for reading digital textbooks, such as Amazon's Kindle or Barnes and Noble's Nook). Digital textbooks allow students to highlight passages, take notes, and change font sizes. Many contain built-in dictionaries and calendars and include bookmarking and search capabilities. Today's devices have evolved from platforms displaying simple digitized versions of print textbooks to tools that support highly interactive, multimedia experiences (Brown, 2012; Chiong et al., 2012; Ash, 2011; Doiron, 2011; Murray & Pérez, 2011).

Although the K-12 textbook market is estimated to be over \$8 billion per year, digital textbooks made up only about 3% of that market in 2011 (Reynolds, 2012). However, spending on digital textbooks is on the rise. The Association of American Publishers (cited in Owen, 2012) reported that revenues from digital products increased by 46% between 2008 and 2010, to almost \$640 million.

Use of digital content is expected to grow at an annual rate of more than 100%, but even then, estimates suggest that schools will have just 19.5% adoption by 2014 and 50% by 2018 (Next is Now, cited in Fletcher et al., 2012). Project Tomorrow's (2010) survey of over 38,000 K-12 teachers representing almost 6,000 schools found that only 23% of teachers reported using digital textbooks. Scholastic's (2013) survey of over 1,000 U.S. children age 6-17 and their parents found that 46% of children reported that they had read an e-book in 2012; however, only 27% of children reported reading an e-book at school.

Hart Research Associates' (2012) nationwide online survey of 883 parents of K-12 public school children found that 82% of respondents agreed that it was very important for schools to make good use of technology. When asked which would be a better investment of \$200 per student for a school district, 76% of parents responded "Giving each student an Internet-connected device like a tablet computer," compared to 15% who answered "Purchasing new science textbooks."

### **Advantages of Digital Textbooks**

Researchers have concluded that digital textbooks have many advantages over print textbooks. A summary of benefits associated with digital textbooks is provided below.

- **Digital content is up-to-date.** Students have immediate access to current events and the latest scientific advances without having to wait years for the next updated edition of a paper textbook (Lee et al., 2013; Cargill, 2012; FCC & USDOE, 2012; Mardis et al., 2010; Nichols, 2009). Similarly, if a publisher needs to update content or correct mistakes in a digital textbook, it can electronically distribute new versions of the content instantaneously (Fletcher et al., 2012; Doiron, 2011; Mardis et al., 2010).
- **Multimedia features enhance the learning experience.** Electronic readers contain many interactive features that cannot be found in print textbooks. Multimedia features, such as hyperlinks, audio and video extensions, still and animated images, graphic simulations, virtual labs, interactive lessons, and education-based games, have been found to enhance the reading experience for many students (Lee et al., 2013; Fletcher et al., 2012; Puente, 2012; Ash, 2011; Doiron, 2011; Korat, 2010; Strout, 2010). The provision of multiple embedded tools, such as text-to-speech options, dictionaries, calculators, and note-taking capabilities, has also been found to support student learning (Cargill, 2012; Doiron, 2011; Mardis et al., 2010).
- **Teachers can customize learning.** Digital textbooks allow teachers to personalize students' learning experiences by using different modules that suit students' particular learning style, language, or level of skill, while adhering to local education standards (Lee et al., 2013; Ash, 2011; Hill, 2010). The State Educational Technology Directors Association concluded that digital content provides educators with greater flexibility in how instruction is delivered by allowing teachers to fit the content to the student, instead of fitting the student to the content (Fletcher et al., 2012).
- **Digital content more effectively supports a variety of learning needs.** Researchers have concluded that the interactive features of digital textbooks provide support for students with different learning needs. For example, students who have poor vision or who are physically unable to hold a book or turn pages may find digital textbooks easier to read. Students who are easily distracted can use digital textbooks' interactive capabilities to stay engaged and focused (Fletcher et al., 2012; Rock, 2012; Mardis et al., 2010). Verhallen and colleagues (2006) found that English language learners benefited from digital textbooks because the digital content provided them with access to

resources that enabled them to better derive the meaning of unfamiliar words and sentences.

- **Digital textbooks better engage tech-savvy students.** Digital textbooks address the discrepancy between the types of literacy experiences students encounter at school (paper, pencil, and print textbooks) and those they use in their daily lives outside of school (Web 2.0) (Hill, 2010; Mardis et al., 2010; Center for Digital Education, 2009; Saetern, 2009; Surdin, 2009). The *Digital Textbook Playbook* (FCC & USDOE, 2012) stated, “There remains a profound disconnect between the learning that happens in school and that which takes place out of school.”
- **Digital textbooks can be accessed anytime, anywhere.** Digital content is available anytime, anywhere, both online and offline, and accessible when and where the student, teacher, or parent needs it. This unlimited access translates into less wasted instructional time due to forgotten or lost textbooks and assignments (Fletcher et al., 2012; Murray & Pérez, 2011; Mardis et al., 2010; Nichols, 2009).
- **Students do not need to carry heavy backpacks.** Digital textbooks decrease the physical burden placed on students who use print textbooks. A single electronic device can store hundreds of textbooks and eliminates the need to transport heavy print textbooks back and forth from home to school. The average weight of an e-reader or tablet is between 0.75 to two pounds. Print textbooks, on the other hand, can weigh over five pounds each (Lee et al., 2013; FCC & USDOE, 2012; ProCon.org, 2012; Mardis et al., 2010; Nichols, 2009). Scholastic’s (2013) survey of over 1,000 U.S. children age 6-17 and their parents found that both children and parents identified convenience (i.e., the ability to carry all books in one place) as the top benefit of digital textbooks over print books.

The Accreditation Council for Occupational Therapy Education recommended that children not carry more than 15% of their body weight, but studies have consistently found that children are carrying 17% or more of their body weight in backpacks which can weigh as much as 18.4 pounds. In addition to poor posture, backpacks that are too heavy or worn incorrectly can damage muscles and joints, leading to back, neck, and shoulder pain, or even scoliosis and abnormal curvature of the spine (Mardis et al., 2010). According to the U.S. Consumer Product Safety Commission (cited in ProCon.org, 2012), more than 13,700 students age 5-18 were treated for backpack-related injuries, such as contusions, sprains, fractures, and strain to the back and shoulders, during the 2011-2012 school year.

- **Digital textbooks are better for the environment.** Environmental benefits of digital textbooks include reduced deforestation, less pollution from printing and transporting books, and fewer costs related to paper textbook disposal and recycling (Mardis et al. 2010). ProCon.org (2012), a nonprofit public charity that strives to present unbiased information on educational issues, reported that digital textbooks reduce the amount of

paper that teachers use to print handouts and assignments. The authors of the report estimated that a school of 1,000 students spends, on average, between \$3,000 and \$4,000 per month on paper, ink, and toner.

### **Disadvantages of Digital Textbooks**

Despite the many advantages associated with digital textbooks, researchers and educators point to some clear disadvantages, summarized below.

- **Digital textbooks are not conducive to in-depth reading.** Some researchers have concluded that digital textbooks are more suited to leisure reading and do not fully support academic reading. Furthermore, reading on mobile devices can be difficult because of their small screen size, lack of display clarity, limited image size and complexity, restrictive keyboard and mouse functions, and diminished space for interactive elements (Valerio, 2012; Doiron, 2011; Mardis et al. 2010; Aamodt, 2009).
- **Multimedia features may interfere with students' reading comprehension.** Research suggests that some students find digital textbooks' interactive features distracting. Tablets such as the iPad and Kindle Fire offer links to videos, games, websites, and music, as well as frequent email alerts. (This is not an issue when students use an e-reader that lacks interactivity, such as a black-and-white Kindle.) (B. Greenfield, 2013; Chiong et al., 2012; Doiron, 2011; Korat, 2010; Moody, 2010). Bosman and Richtel (2012) stated that "a tablet offers a menu of distractions that can fragment the reading experience or stop it completely." They concluded that these distractions create "a reading experience that is more like a 21<sup>st</sup> century cacophony than a traditional solitary activity."
- **Standards for the quality and accuracy of digital content have not been established.** Some researchers believe that the content contained in digital textbooks is inferior to that of print content. Traditionally, changes to paper-based textbooks are carefully vetted by government bodies, but digital textbooks are not subjected to this process (Lee et al., 2013; Doiron, 2011; Surdin, 2009). Rock (2012) noted that between them, Apple and Google offer over one million educational apps. Educators therefore face a significant challenge when trying to select the best and most appropriate content for their students. The State Educational Technology Directors Association cautioned that the quality of free digital content is particularly inconsistent (Fletcher et al., 2012).
- **Content is not easily transferrable among different types of devices.** A large portion of digital content is formatted for a specific type of e-reader and can only be accessed on that one type of device. The result is that schools often purchase digital content but are then unable to transfer it from one type of device to another (for example, from an Amazon Kindle to an Apple iPad). Experts agree that further efforts are necessary in order to improve the accessibility of digital content and the compatibility of electronic devices. Until then, most schools will have to invest in multiple devices in order to

access content from all vendors (Lee et al., 2013; Ni, 2013; ProCon.org, 2012; Mardis et al., 2010).

- **Digital textbooks break easily and are costly to fix.** Many opponents of digital textbooks question their durability. Broken digital textbooks require repair by experienced technicians, which can be costly and time-consuming and put a strain on school districts' IT departments. In contrast, paper textbooks can usually be repaired with basic supplies such as tape or glue. In addition, digital textbooks' batteries need to be charged which increases the electricity demands on schools (B. Greenfield, 2013; Wilder, 2013; ProCon.org, 2012; Riippa, 2011). Scholastic's (2013) survey of over 1,000 U.S. children and their parents found that both children and parents identified "not worrying about charging a battery" as the top benefit of print textbooks.
- **Prolonged use of digital textbooks may increase the risk of several health problems.** Some researchers have voiced concerns about the side effects of long-term usage of digital devices on students' health. Frequent use of handheld devices, including tablets and e-readers, has been found to contribute to Computer Vision Syndrome, which causes eyestrain, headaches, blurred vision, and dry eyes. Frequent use of mobile devices has also been linked to a higher incidence of musculoskeletal disorders associated with repetitive strain on muscles, including carpal tunnel syndrome, neck pain, shoulder pain, and fibromyalgia (B. Greenfield, 2013; Lee et al., 2013; ProCon.org, 2012).

South Korea halted its national plan to replace print textbooks with digital textbooks by 2015 because education leaders were concerned that students would become too dependent on technology. According to a government survey, approximately one in 12 (8.3%) South Korean students between the ages of five and nine are addicted to the Internet, meaning that they become anxious or depressed if they go without access (Harlan, 2012; Tomassini, 2012). Some experts believe there is a similar problem in this country. The American Academy of Pediatrics (2010) reported that between 8% and 12% of U.S. children show signs of Internet addiction.

### **Research on the Educational Effects of Digital Textbooks**

Since the introduction of digital textbooks into the classroom is relatively recent, researchers are just beginning to investigate their various effects. A summary of early studies conducted on digital textbooks is provided below.

**Amount of reading.** Scholastic's (2013) survey of over 1,000 children in the U.S. found that switching from print books to digital books did not have a negative impact on most children's leisure reading habits. Seventy percent of children age 6-17 reported that they continued to read the same amount of books and 21% said they read more digital books. Only 9% of children said they read fewer digital books.

On the other hand, Ip, Chu, and Sit's (2008) study of Hong Kong primary school students (ages 7-11) found that students reported that they spent more time reading when they used print textbooks than when they used e-readers (36 minutes per day vs. 13.5 minutes per day, respectively). The researchers also found correlations between reading habits of print books and e-books, regardless of gender or grade level. In other words, the more print books students read, the more digital books they read.

**Reading speed.** Studies have found that digital textbook users read 20-30% more slowly than users of print books. Researchers have hypothesized that the slower digital reading speed may be due to the many distractions online reading presents, including pop-up email notifications, advertisements, and links to other articles. Frequent task switching interferes with concentration and forces readers to re-read material, adding extra time to the reading experience (Crow, 2012; ProCon.org, 2012; Aamodt, 2009).

**Student engagement.** A number of studies confirm that students find digital textbooks more engaging than print textbooks. The interactivity of digital textbooks appears to lead to increased excitement about learning, an increased sense of participation and control in one's own learning, and higher levels of intellectual curiosity (Chiong et al., 2012; Coldiron, 2011; Doiron, 2011; Moody, 2010; Strout, 2010; Maynard & Cheyne, 2005).

**Content retention.** Several studies have reported that students using interactive digital textbooks recall significantly fewer narrative details than students who read the print version of the same story. These studies have found that students using digital versions of unfamiliar materials have to read the same text several times before they gain the same level of recall as print readers. Some researchers have hypothesized that digital textbooks may affect story recall because students focus their attention on interactive features more than the content itself (Chiong et al., 2012; Rock, 2012). Others have theorized that spatial context is particularly important in memorization. For example, to trigger a memory, a student might unconsciously recall whether he or she read the information at the top, middle, or bottom of the page, remember a corresponding picture on the page, or even a page number – essentially creating a mental bookmark that helps him or her recall the information. Digital textbooks provide fewer spatial landmarks than print textbooks. Finally, some studies have suggested that content is less memorable when it is viewed on smaller screens (Crow, 2012; Szalavitz, 2012).

**Student achievement.** The majority of studies have found that use of digital textbooks leads to increased reading comprehension. Interactive features of digital textbooks, such as sound effects and explanation of words, also appear to contribute to improvements in phonological awareness, vocabulary, word recognition, and writing skills, especially at the elementary level (Falk, 2013; Korat, 2010; Moody, 2010; Strout, 2010; Ip et al., 2008; Shamir & Korat, 2007; Maynard & Cheyne, 2005). In addition, one study reported that the use of digital textbooks had a greater impact on low-income children's emergent literacy skills, compared to middle-income children (Korat & Shamir, 2008). Researchers have concluded that interactivity helps to advance reading development because it allows students to control their own reading experience using features such as hot spots, illustrations, games, songs, and oral readings (Shamir & Korat, 2007; De Jong & Bus, 2003; Robinson, 2003; Doty et al., 2001).

Empirical Education, Inc., an independent research firm, investigated whether Houghton Mifflin Harcourt's *HMH Fuse: Algebra 1* had an impact on students' algebra achievement. *Fuse*, developed for the Apple iPad, is a full-curriculum algebra application that includes interactive lessons, explanations, quizzes, and problem solving. Teachers' seventh and eighth grade classes in four California school districts were randomly assigned to either the treatment group that used *Fuse* or the control group that used print textbooks. On average across the four school districts, the researchers found that *Fuse* had no impact on students' Algebra 1 California Standards Test (CST) scores or Algebra End-Of-Course Assessment scores. Students who used *Fuse* received scores on both assessments similar to those of their peers who used print textbooks. Additional analysis of data disaggregated by school district found that use of *Fuse* had a significant positive impact on students' CST scores at Riverside Unified School District. The researchers cautioned that teachers in Riverside were selected for the study on the basis of their experience with technology innovations and reported more time teaching with *Fuse* than most of the other teachers in the study. They concluded, therefore, that the impact of *Fuse* on student achievement was dependent upon local conditions (Toby et al., 2012).

### **Costs Associated with Digital Textbooks**

There is heated debate over whether digital textbooks actually save school districts money. In order to realize long-term financial benefits, school districts must first invest in many resources, including electronic devices, digital content, supporting equipment, network infrastructure, maintenance and repair costs, upgrade and replacement costs, IT support, and teacher training (Lee et al., 2013; FCC & USDOE, 2012; Fletcher et al., 2012).

Some experts estimate that it will cost large school districts over \$1 billion to transition to digital textbooks. School administrators cite cost savings as the main reason they select digital textbooks over print textbooks, but districts using digital textbooks say it is too soon to tell how much money they will save in the long run (Wilder, 2013; Cargill, 2012; Tomassini, 2012; Mardis et al., 2010; Surdin, 2009; Tucker, 2009; Allen, 2008).

The *Digital Textbook Playbook* (FCC & USDOE, 2012) estimated that digital textbooks would result in a savings of \$60 per student. However, some experts maintain that digital textbooks are ultimately more expensive than paper textbooks and that any savings from free online content will be lost to technology expenses (Tomassini, 2012; Tucker, 2009). Wilson (2012), a technology industry veteran with experience at companies such as Apple and Pearson, analyzed costs involved with both digital and print textbooks and concluded that it would cost a school 552% more to use iPad textbooks than it does to use paper textbooks. He estimated that the annual cost per student per class was \$14.26 for a paper textbook and \$71.55 for an iPad textbook. In his analysis, Wilson considered the costs of electronic devices, digital content, management (getting the right materials to the right student), network infrastructure, and teacher training.

A brief review of some of the costs associated with digital textbooks is provided below.

- **Electronic devices.** School districts must consider the cost of purchasing or leasing an electronic device, such as a Kindle or iPad, for every student (Wilder, 2013; Borelli, 2012; Fletcher et al., 2012; Fortenbury, 2012; Lederman, 2012; Riippa, 2011). Fortunately, the price of electronic devices continues to drop. Tablets cost on average \$489 in 2011, \$386 in 2012, and are projected to cost \$263 in 2015. In addition, Apple offers lower prices for bulk purchases and older iPad models with less memory and connectivity (ProCon.org, 2012; Tomassini, 2012).

In North Carolina's Mooresville Graded School District, considered by experts to be one of the most successful digital school districts in the U.S., laptops are leased, instead of purchased, from Apple. According to Mooresville's chief technology officer, leasing spreads the cost of devices out over multiple years and guarantees that the district will not be saddled with obsolete equipment in the future (Farrell, 2013).

- **Content.** Introduction of digital textbooks in the classroom requires that school districts acquire digital content. There are three general sources for digital content and most districts mix and match among them (Davis, 2013; The Orange Grove, 2013; Ash, 2012; Brown, 2012; Fletcher et al., 2012; Tomassini, 2012; Doiron, 2011; Hill, 2010; Nichols, 2009).
  - Digital content can be purchased from publishers. The three largest K-12 textbook publishers are Pearson, Houghton Mifflin Harcourt, and McGraw-Hill. All three publishers are developing new products and new methods for educators to use their products. Wilson's (2012) analysis, however, determined that it is more expensive for school districts to purchase digital content for the iPad than paper textbooks. He calculated that when a school buys a \$60 textbook, they use it for an average of 5-7 years for a per-student cost of about \$10. When a school buys an iPad textbook, it costs at least \$14.99 per student, per year.
  - A number of non-profit organizations offer free open educational resources (OER). Content becomes "open" when its copyright holder grants usage rights to the public through an open license. This typically includes the right to revise, reuse, remix, and otherwise customize OER to meet specific instructional needs. Examples of organizations where OER content can be obtained include the CK-12 Foundation's "flexbooks," The Orange Grove digital repository's open textbook collection for Florida educators, free content from iTunes University, and free or low-cost online library collections.
  - Some districts create their own digital content. For example, teachers at the Vail School District in Arizona and those from partnering districts create digital and video lessons that are stored and shared on a server. In Utah, the state works with school districts to create their own digital materials.
- **Infrastructure.** Most school districts are struggling to find the money to build or update the infrastructure needed to support digital textbooks, including wireless networks that have the capacity to support the bandwidth when thousands of students access it at the same time (Ni, 2013; Lederman, 2012; Ash, 2011; Mardis et al., 2010). A 2010 FCC

study (cited in ProCon.org, 2012) found that nearly 80% of K-12 schools reported that their broadband connections were inadequate to meet their needs. Wilson (2012) estimated that network infrastructure and bandwidth needs will cost each school at least \$21,750 per year, depending on the quality of their existing infrastructure (additional costs are incurred if schools need major upgrades and modifications to their infrastructure). School districts must also ensure that there are enough electrical outlets to charge devices (Owen, 2012).

- **Maintenance and repair.** Electronic devices require periodic upgrades and maintenance. There are always costs for broken, misplaced, and defective devices as well (Wilder, 2013; Brown, 2012; Mardis et al., 2010). One Los Angeles teacher argued that digital textbooks are a risky investment. She noted that all new paper textbooks come with a CD of the text and that 90% of the CDs are lost within the first month of school (Nichols, 2009).

Officials at North Carolina's Mooresville Graded School District helped reduce repair costs by requiring students to use a school-issued backpack with a laptop sleeve, in addition to another protective case, for transporting their laptop between home and school. Students and their families are required to take classes at the beginning of each school year to ensure that they understand how to care for their laptops (Farrell, 2013).

- **Teacher training.** Transitioning to digital textbooks requires teachers to be trained on how to use the technology and how to incorporate the digital content into their classroom practice (Wilder, 2013; Brown, 2012; Nichols, 2009). Wilson (2012) estimated the cost of teacher training at \$6.94 per student for digital textbooks, compared to \$1.88 per student for paper textbooks. He determined that additional teacher training is required when school districts use digital textbooks because their content is updated so much more frequently.

### **Suggestions for School Districts that are Introducing Digital Textbooks**

A summary of issues that should be considered when transitioning to digital textbooks follows, based on the experiences of school districts that have introduced digital initiatives.

- **Start small.** Experts recommend limited launches so that district administration is able to obtain constructive feedback before introducing a full digital textbook initiative. Some districts initially provide digital textbooks in one subject area or grade level rather than all subject areas or grades at once (Doiron, 2011; Hill, 2010).
- **Secure increased flexibility in textbook adoption policies from state lawmakers.** The difficulty of changing how K-12 textbooks are adopted and purchased is one reason why many digital textbook publishers work primarily with higher education institutions rather than public school districts. States' textbook adoption cycles are geared to purchasing one textbook a year and then keeping that book in schools for 5-10 years. Experts recommend that state laws be expanded to include digital content in the

definition of textbooks and broaden the types of content available for use in schools (Owen, 2012; Puente, 2012; Ash, 2011; Mardis et al., 2010). The State Educational Technology Directors Association stated, “The business model for the creation, acquisition, distribution, and use of instructional materials in K-12 education is more than a half-century old and has become a barrier to innovation” (Fletcher et al., 2012).

- **Select high-quality content.** Given the variability of materials on the Internet and the fact that digital content can be easily created, edited, and delivered, special care is needed to avoid the selection of inferior quality digital content. District staff should ensure that the digital content selected is accurate, bias-free, aligns to standards, and adheres to state and local laws (Lee et al., 2013; Fletcher et al., 2012).

Experts suggest that school districts move away from the “one book per content area per grade level per student” model and select the highest quality content from a variety of sources. Digital content can be acquired in smaller pieces (i.e., chapters or lessons) and those pieces can be assembled and used throughout the K-12 curriculum (Davis, 2013; Fletcher et al., 2012). Lederman (2012) noted, “School districts may be able to pick and choose their curriculum buffet-style. A district might choose one publisher’s top-notch chapter on Shakespeare, but follow it with another publisher’s section on Nathaniel Hawthorne’s *The Scarlet Letter*.”

- **Address licensing and re-use rights.** In spite of the virtual nature of digital content, it is subject to the same licensing and copyright constraints as print textbooks. Before digital content is downloaded, staff should determine if there is a limit on how many devices the content can be downloaded onto, if the licensing agreement has an expiration date, and if the content is purchased or leased. Copyright issues, such as laws that prevent non-authors from modifying existing content, must also be addressed prior to downloading digital content (Lee et al., 2013; Fletcher et al., 2012; Hamilton, 2012).
- **Decide whether the district will provide students with electronic devices or implement a Bring Your Own Device (BYOD) model.** Most schools transitioning to digital textbooks provide a standardized device for all students. Advantages to using district-provided devices include control over device capabilities, functions, and security settings; guaranteed compatibility with content and programs; and assurance that all students, regardless of income level, have access to the same device. The main disadvantage of district-provided devices is the cost of purchasing or leasing a device for every student (FCC & USDOE, 2012).

If the school district is providing e-readers to all students, portability and durability should be considered when choosing a device. Students must be able to comfortably read for long periods of time. Devices must provide sufficient lighting, choice of font size, and text-to-speech capability. Bookmarking, highlighting, and search features should also be available (FCC & USDOE, 2012; Hamilton, 2012).

Some researchers recommend that school districts invest in more than one type of device so that students can access a variety of digital content. There is as yet no one standard format for digital content and many textbooks can only be accessed on one type of device. When schools have different types of devices, they ensure that all content is available to their students (Ni, 2013; ProCon.org, 2012; Ash, 2011; Mardis et al., 2010).

A number of school districts have successfully implemented BYOD programs. Advantages of the BYOD model include significantly reduced district costs; the opportunity for families to select the device that best suits their needs; and ownership benefits (i.e., students who have an ownership interest take better care of their devices). The biggest disadvantage associated with the BYOD model is that low-income families may not be able to purchase devices. Schools must be prepared to give or loan devices and pay for network plans when families cannot afford them. Other disadvantages of the BYOD model include incompatibility (i.e., having a variety of devices that are incompatible with the school's chosen operating platform, content, and even connectivity systems) and loss of control over how students use the devices, including what programs they install (FCC & USDOE, 2012).

- **Determine schools' infrastructure needs.** School districts need to plan for a network and infrastructure sufficient to enable simultaneous use of devices by students, faculty, and staff for instruction, assessment, and school operations. Not all schools need the same infrastructure and schools may want certain classrooms and facilities to have more bandwidth than others (FCC & USDOE, 2012; Fletcher et al., 2012).
- **Ensure that all students have equitable access to digital textbooks and home Internet connectivity.** Digital textbook initiatives have the potential to negatively impact students from low-income backgrounds. Less affluent districts and schools are less likely to be able to afford digital textbooks than higher-income districts and schools (Brown, 2012; J. Greenfield, 2012; ProCon.org, 2012; Puente, 2012; Mardis et al., 2010). In addition, lack of Internet connectivity at home leaves low-income students even further behind. Although school districts may find funds to provide every student with an electronic device, most cannot afford to absorb the cost of home Internet connectivity (Borelli, 2012; Jordan, 2012; Riippa, 2011; Mardis et al., 2010). According to the *Digital Textbook Playbook*, about one-third of Americans do not have access to broadband Internet at home (FCC & USDOE, 2012).
- **Provide teachers with professional development.** Studies have found that districts often do not invest in the teacher training programs needed to ensure the success of digital textbook initiatives. Teachers must be trained on how to use electronic devices and integrate digital content into their lessons, and they must be provided with time to work with colleagues to restructure lesson plans and teaching materials (Puente, 2012; Hill, 2010; Mardis et al., 2010). A nationwide online survey of 812 K-12 public school teachers found that most teachers reported that they were not prepared to use digital

content in their classrooms. Only 13% of the respondents said they received all of the training and professional development they needed on how to use electronic devices and integrate technology into the classroom (Hart Research Associates, 2012).

### **Examples of Digital Textbook Initiatives in the U.S.**

Many districts and states, including Florida, have begun transitioning from paper textbooks to digital content. According to the State Education Technology Directors Association, 22 states have implemented digital textbook initiatives, launched open educational resource initiatives, and/or introduced measures that increase the flexibility of the textbook adoption process (Fletcher et al., 2012). Examples of digital textbook programs being implemented across the U.S. and brief descriptions of each initiative are provided below.

#### **Alabama.**

In May 2012, Alabama's Governor signed the Alabama Ahead Act, creating a \$100 million bond issue to replace paper textbooks with digital textbooks in Alabama's public schools. The state originally planned to offer pilot programs in fall 2013 in select school districts throughout the state, beginning with ninth graders, and to provide digital textbooks to all high school students over the course of four years. However, in May 2013, Alabama's Legislature failed to pass a bill that would have allowed the bond sale to proceed (Rawls, 2013; Fletcher et al., 2012; McKiernan, 2012).

Alabama's Huntsville City Schools collaborated with Pearson Education to transition to digital textbooks beginning in 2012-2013. The school district leased 11,000 new laptops for all students in grades 5-12, while fourth graders inherited the netbooks that fifth graders received the previous year. Classrooms were equipped with Wi-Fi capacity to accommodate the new technology. Parents and students signed a contract and paid a \$35 fee for a laptop (students on free or reduced price lunch were not required to pay the fee). Federal e-rate reimbursements helped to pay for the digital transition. Huntsville's Superintendent said that the school district had previously paid about \$5 million per year for paper textbooks. He estimated that digital textbooks would cost the district about \$3.2 million in the first year, \$4.2 million in the second year, and \$2.5 million per year in succeeding years (CBS 8 News, 2012; Decatur Daily, 2012; Pae, 2012).

#### **Arizona.**

Arizona's Vail School District launched the Beyond Textbooks initiative in 2008. Beyond Textbooks is an extensive database of digital content built around state standards with formative assessments linked to each standard. Vail teachers, and those from partnering districts, collaborate to identify, acquire, and create digital content. Content is selected from multiple sources that most closely match the district's instructional goals. The majority of course materials are free and/or generated by teachers, but some premium content is available from services such as Discovery Education, ABC-CLIO, and BrainPOP. Funds previously used to buy paper textbooks are now used to purchase MacBooks, iPads, iPod Touches, Hewlett-Packard netbooks, interactive whiteboards, and document cameras for the classroom. Vail

partners with over 70 school districts and schools across Arizona that are also implementing the Beyond Textbooks program, reaching an estimated 90,000 students statewide (Beyond Textbooks, 2013; Tomassini, 2012).

### **California.**

In May 2009, then-Governor Arnold Schwarzenegger implemented the Free Digital Textbook Initiative, which called for submissions of free, open source digital textbooks for high school science and math classes. The California Learning Resource Network coordinates the review of digital content for adherence to state standards. Content is obtained from publishers such as McGraw-Hill, Pearson, Teachers' Curriculum Institute, CK-12 Foundation, and Connexions (Fletcher et al., 2012; Nichols, 2009).

In March 2013, the Los Angeles Unified School District allocated \$50 million to fund a one-to-one technology program. The district will pilot the program at 47 K-12 schools, most of them Title I, in 2013-2014. The technology initiative will be phased in at the district's remaining 786 K-12 schools during the 2014-2015 school year. Schools will be allocated laptops or tablets and funds for teacher professional development, but it is not clear if individual schools or the district's central office will pay for digital content. The project is expected to cost \$500 million by the time it is completed. Funding comes from capital raised by Proposition 30 which increased sales taxes by a quarter-percent for the next four years and raised taxes on higher-income individuals (Barack, 2013; Lambrecht, 2013).

Riverside Unified School District, located 60 miles east of Los Angeles, started its digital textbook initiative in May 2009. Riverside was the first district in California to adopt digital textbooks. The district purchased a variety of devices, including iPads, Kindle Fires, and Hewlett-Packard netbooks. About 40% of the digital content used by the district is free and 60% is purchased. Funding sources include money from private donations, grants, Title I funding, and English language-learner aid (Tomassini, 2012; Ash, 2011).

San Diego Unified School District's Integrated 21<sup>st</sup> Century (i21) Interactive Classroom program is a five-year, phased plan that began during the summer of 2009. Through i21, each classroom receives an interactive whiteboard, audiovisual cabinet, teacher presentation station, document camera, DVD player, and wireless voice amplification system. The program also provides a laptop for each teacher and principal and a netbook for each student. The district distributed 78,000 netbooks and other mobile devices to teachers and students in 2011 and purchased an additional 25,700 iPads in 2012. The transition from paper textbooks to digital textbooks is being financed through a \$2.1 billion voter-approved bond measure that allotted approximately \$480 million for technology and infrastructure upgrades. The district uses eRate funds and stimulus funding to pay for ongoing professional development, system maintenance, and other costs (San Diego Unified School District, 2013; FCC & USDOE, 2012; Tomassini, 2012; Devaney, 2011).

## **Florida.**

Florida is the first state in the nation to mandate the purchase of digital content in all public schools. The state has adopted legislation requiring all school districts to spend at least half of their instructional materials allocation on state-adopted digital content by the 2015-2016 school year. Districts will retain flexibility in how they spend the remainder of their materials allocations (Davis, 2013; FCC & USDOE, 2012; Fletcher et al., 2012; Florida Department of Education, 2012; State Education Policy Center, 2012; Wieder, 2012).

The state's policy does not provide guidance on the types of devices to be used for accessing digital content nor does it indicate how districts will finance the purchase of these devices. Furthermore, the state does not address the issue of students without home Internet access. Many districts are concerned about how they will comply with what they call "another unfunded state mandate" that is estimated to cost at least \$1 billion statewide (WESH 2 News Orlando, 2013; Wilder, 2013; Borelli, 2012; Brown, 2012; Jordan, 2012; Rockwell, 2011).

The Florida Legislature created the Digital Instructional Materials Work Group to help lead the transition from paper textbooks to digital materials. The nine-member panel is comprised of parents, principals, educational leaders, and a businessman and will provide reports, plans, and updates to the Governor, Legislature, and State Board of Education on a regular basis (Wilder, 2013; Jordan, 2012).

In 2010, Clearwater High School in Pinellas County, Florida was the first school in the nation to offer all of its 2,100 students a Kindle e-book reader to replace most of the school's paper textbooks. All students were given Internet access through the Kindle, whether or not their parents had home Internet access (Brown, 2012; Puente, 2012). Rockwell (2011) stated, "Lawmakers concerned about equal access should consider the Clearwater High experiment . . . It was a great equalizer."

## **Indiana.**

Prior to 2009, Indiana's State Board of Education required school districts to apply for a waiver if they wanted to select instructional materials that were not included on the Board's approved list of textbooks. To provide districts with increased flexibility in the selection of instructional materials, the State Board of Education introduced a blanket waiver in 2009 that allowed Indiana's school districts to select their own materials and spend all or part of the money they had previously spent on paper textbooks on the purchase of digital content or devices. The waiver became state law in 2011. However, the state found that most districts did not rush to take advantage of the waiver. A survey conducted by the Indiana Department of Education reported that only 11% of Indiana school districts used the blanket waiver to buy digital devices and content during the 2010-2011 school year (Fletcher et al., 2012; Wieder, 2012).

## **North Carolina.**

In March 2013, Governor Pat McCrory signed a bill into law that called for public schools to allocate more money for digital textbooks. School districts have until the 2017-2018 school year to make the transition to digital content. The bill does not allocate state funds for digital devices,

but legislation is pending that would allow lottery funds to be used for the technology. In the meantime, school districts have the flexibility to use state money designated for paper textbooks or local technology funds. Additional funding sources include private grants and parental contributions. Some districts are looking toward federal grants, such as Race to the Top, to help finance the initiative. Districts are also permitted to adopt a Bring Your Own Device policy that would save money by allowing students and teachers to use their own devices in the classroom (Ed Tech Times, 2013; Jenkins, 2013; Walker, 2013).

According to *The New York Times*, Mooresville Graded School District (MGSD), located 20 miles north of Charlotte, has become the “de facto national model of the digital school” (Schwarz, 2012). MGSD started planning for their Digital Conversion in 2007. Over 4,500 laptops have been distributed to every fourth through twelfth grade student and all licensed staff. Students and staff have access to the laptops 24 hours a day, seven days a week, for all 180 school days. Students take their laptops home daily to complete homework assignments and projects. Laptops are leased from Apple for \$215 per year, including warranty; an additional \$100,000 per year is spent on software. All of the district’s kindergarten through third grade classes have received digital, interactive SMART Boards, SMART Slates, and SMART Response Devices (Mooresville Graded School District, 2013).

Mooresville uses a variety of funding sources, including local, state, and federal monies, as well as grants. Although the district received a \$250,000 start-up grant from Lowe’s, it funds 98% of the digital conversion costs through its operating budget, reallocating resources to help support the digital initiative. Families pay \$50 per year to subsidize computer repairs, though the fee is waived for those who cannot afford it (about 18% of families). The district negotiated a deal so that those without broadband Internet access at home could buy it for \$9.99 per month. According to MGSD officials, about 15% of homes do not have Internet access, so the district worked with town officials to secure agreements for free Wi-Fi in parks, at the local library, and in all municipal buildings (Farrell, 2013; Mooresville Graded School District, 2013; Schwarz, 2012).

### **Texas.**

Texas was the first state to change its definition of a textbook to include digital content and the technology to access and use that digital content in 1987. In 2011, Texas state educators once again modified how instructional materials could be purchased by school districts. Prior to 2011, school districts received a separate technology allotment (capped at \$30 per student) for digital learning resources, but could spend unlimited funds on paper materials as long as they were purchased from a state-approved list. The passage of the 2011 legislation combined paper textbook money and the \$30 student technology allotment into a single Instructional Materials Fund. Districts receive a per pupil amount – the Instructional Materials Allotment (IMA) – from this fund. The State Board of Education still approves a list of materials, but the new law also gives districts the ability to select their own resources. According to the State Educational Technology Directors Association, digital content makes up 30% of Texas school districts’ orders for instructional materials. In addition, the state has set aside \$10 million for a technology lending program which allows districts to provide digital devices to students who cannot access

technology at home. Districts are also permitted to use funding from the IMA to pay for professional development and technical support (Fletcher et al., 2012; Scott, 2012).

McAllen Independent School District is investing \$20 million in local and federal funds over five years to purchase more than 25,000 iPads for all of its students, grades three and up. The \$20 million investment includes funds for upgrading the infrastructure needed to support the new technology, training staff, and purchasing content for the devices. The program is financed through a combination of local funds, federal grants, stimulus money, private donations, and the federal E-rate program, which provides discounted telecommunications services to schools. The district encouraged local businesses to offer Wi-Fi so students could use their devices outside of the classroom. Parents are required to pay a \$40 refundable deposit in two payments for the iPads, but can receive financial assistance if necessary. More than two-thirds of the district's students are considered economically disadvantaged (Holeywell, 2012; Scott, 2012; Sherman, 2012; Tomassini, 2012).

### **Utah.**

In January 2012, Utah's Office of Education established the Open Textbook Project, a program that makes open source textbooks available to Utah schools in key areas, including secondary language arts, mathematics, and science. The state encourages districts and schools throughout the state to adopt the open source textbooks, but ultimate decision-making rests with local education agencies. The Open Education Group at Brigham Young University works with districts to help them develop their own custom versions of digital textbooks. Every summer, local teachers update the digital content. Where infrastructure allows, the books can be used digitally at no cost. For schools and districts where e-reader availability is limited, the district can print out copies of the text to distribute to each student at a cost of about \$5 each. The program is supported by the Open Education Group at Brigham Young University, the CK-12 Foundation, and the William and Flora Hewlett Foundation (Utah Open Textbook Project, 2013; Fletcher et al., 2012).

Utah expects the Open Textbook Project to result in substantial cost savings. According to a state analysis, one \$80 paper textbook (used for six years) for 5,000 students costs a district about \$400,000, or \$13.33 per student per year. Digital textbooks, in comparison, were estimated to cost districts about \$152,000, or \$5 per student per year (based on four teachers working 60 hours over the summer to update digital content, at \$30 per hour over six years, plus printing expenses) (Fletcher et al., 2012). An early and very limited study conducted by the Utah Open Textbook Project (2011) found that open textbooks allowed Utah's schools to save substantial amounts of money while maintaining the learning outcomes of their students.

### **Virginia.**

In the 2012-2013 school year, Fairfax County Public Schools contracted with three publishers (Pearson, Holt, and McGraw-Hill) to provide online mathematics textbooks for all students in grades K-12 following successful trials of similar projects for social studies classes. The district spent \$7.7 million on digital content. However, numerous problems were encountered with the digital textbooks. First, many students did not have access to computers at home. Second, the

digital materials were inaccessible in locations without Internet service and parents complained about the expense of the faster DSL service they were required to purchase. Third, many students were unable to complete homework assignments during and after Superstorm Sandy due to widespread power outages. Finally, the digital textbooks had software compatibility issues with popular products like the iPad and could not be transferred to stand-alone e-readers, such as the Kindle or Nook. In December 2012, the district decided to once again make paper textbooks available to students, at a cost of about \$2 million (Cushing, 2013; Fairfax County Public Schools, 2012; Hoffelder, 2012; Shapiro, 2012; Ward, 2012).

### **Summary**

An increasing number of school districts across the U.S. are switching from print textbooks to digital textbooks. The advantages and disadvantages associated with digital textbooks were summarized in this paper. Advantages include up-to-date content, multimedia features designed to enhance learning, 24/7 availability, and the ability to better engage tech-savvy students. In addition, digital textbooks considerably lighten students' backpack loads because they weigh much less than paper textbooks. In spite of these benefits, some researchers point to clear disadvantages. For example, studies suggest that digital textbooks may not be conducive to in-depth reading and that their interactive features may interfere with students' content retention. Experts have also found that the quality of content in digital textbooks is inconsistent because it is often not subjected to the same vetting process as the content in paper textbooks. Furthermore, schools are often required to invest in multiple types of electronic devices because a large portion of digital content can be accessed on only one type of device.

This paper reviewed research conducted on the impact of digital textbooks on students' reading habits, reading speed, reading engagement, content retention, and academic achievement. Since the introduction of digital textbooks into the classroom is relatively recent, researchers are just beginning to investigate their various effects. Research findings from early studies include:

- Studies comparing the amount of reading students do on digital vs. paper textbooks have produced mixed findings.
- Some studies have found that many students using digital books read slower than those reading print books.
- A number of studies have confirmed that students find digital textbooks more engaging than print textbooks.
- Several studies have reported that students using digital textbooks recall fewer details than students who read the print version of the same text.
- Research suggests that digital textbooks have a positive impact on reading comprehension and particularly on elementary school students' emergent literacy skills.
- The impact of digital content on students' algebra achievement was found to vary, depending on the conditions under which it was used.
- Some researchers have hypothesized that the distracting nature of digital textbooks' interactive features may be responsible for slower reading speed and reduced content retention.

Some experts estimate that it will cost large school districts over \$1 billion to transition to digital textbooks. A digital textbook initiative requires that school districts invest in many resources, including electronic devices, digital content, network infrastructure, maintenance and repair costs, and teacher training. A brief description of these costs was provided.

A summary of issues that should be considered when transitioning to digital textbooks was included in this review, based on the experiences of school districts that have adopted digital initiatives. Before implementing a digital textbook program, experts recommend that districts select high-quality digital content, address licensing and copyright issues, decide if the district will provide electronic devices to all students or implement a Bring Your Own Device model, determine schools' infrastructure needs, ensure that all students have equitable access to digital textbooks and home Internet connectivity, and provide teachers with professional development.

Twenty-two states are implementing digital textbook initiatives, launching open educational resource initiatives, and/or introducing measures that increase the flexibility of the textbook adoption process. Examples of digital textbook efforts being implemented across the U.S. and brief descriptions of each initiative were provided.

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