Design and Adoption Recommendations for K12 e-Textbooks

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Introduction

At the dawn of the 21st century, e-Textbooks (and Digital Educational Resources) are perceived as an integral part of the educational process regardless of their form and functionality or the type of instructional process which they support and facilitate (Gomez et al., 2019). With the proliferation of e-Textbooks in the K12 and their ever-evolving nature due to related technological advancements, this study proposes specific research-based recommendations for the design, selection and adoption of K12 e-Textbooks: an extremely important, though rather under-researched topic especially for its impact on student learning.

Defining e-Textbooks

Digital textbooks are mainly viewed as an electronic/digital version of the traditional printed book made accessible with the help of appropriate hardware and e-textbook reading software. The different definitions put forward in the literature seem to be related to the different features of the digital textbooks as these may be related to hardware, software or content. In addition, the terms electronic and digital are used interchangeably when referring to the format, form and text of e-textbooks.

Although “a plausible definition does not seem to exist” (Mahatma Ghandi Institute, 2019, p. 32), the following definitions are advanced as the most comprehensive ones to date:

- An electronic textbook (e-Textbook, or Digital Textbook) is a “digital learning tool that contains a systematic and complete presentation of the subject or part of it, ensuring the completeness of the didactic cycle of the learning process, creating an individualized active educational environment (Makarova, 2019; Abuzjarova, 2018; Ashmarov, 2018; Aminova & Tsakhaeva, 2018; Badakhova, 2017; Bolotin et al., 2017; Borisov, 2018 in Sergeeva et al., 2020, p. 3)
- “The main feature of the electronic textbook is that it includes not only the content of education, but also the selected learning technology. An electronic textbook is an automated training system that includes didactic, methodological, and informational reference materials for an academic discipline, as well as software that allows using them in a comprehensive way to obtain and control knowledge independently” (Sergeeva et al., 2020, p. 5).

Research Context and Methodology

This research project was conducted as part of the Education Modernization Project (Ministry of Education and Science of the Republic of Kazakhstan), and implemented through the technical and financial support of the World Bank. The author’s role within the consulting team, focused on the development of e-textbook evaluation for the K12, and the capacity-building of K12 e-textbook experts. In this chapter, we will present phase 1 of the project, namely, the literature review and ensuing research-based recommendations.
The literature review presented here spans the period 2001-2021, and has examined books, research articles, policy reports, and other relevant, scholarly material. Of the aforementioned body of extant literature, 91 sources have been utilized to describe and explain the current status of digital textbooks in K12 education globally.

The underlying goal was to identify research-based answers to the following questions:
1. What are the learning outcomes of the digital textbooks as those as utilized at (a) different subject areas; (b) university, secondary, elementary, and PreK-12 education levels?
2. What criteria are utilized internationally in the design process of digital textbooks?
3. What criteria are utilized internationally in the selection and adoption processes of digital textbooks?

**Learning Outcomes - What the research suggests**

Digital textbooks’ learning outcomes, as well as related student and teacher perceptions, preferences and attitudes have been popular, Higher Education research topics for over a decade. This is owed to the fact that such research has quite a significant impact on the processes of design, selection, adoption, transition to, and evaluation of digital textbooks which in turn impacts student learning. A review of research on the PreK-12 learning outcomes follows below.

- No significant difference in learning has been identified between print textbook and e-book (Blazer, 2013; Murray & Pérez, 2011; Weisberg, 2011; Woody, Daniel, & Baker, 2010). In other words, student performance is not significantly impacted by format or way of delivery. These results suggest that reading can happen effectively in a variety of presentation formats (Margolin et al., 2013). Regarding the elementary school however, it was found that when controlling the experimenters’ behavioral protocol in the two media, the print format fared better than the digital textbook on literacy measures that benefited from child-adult interaction (Kozminsky & Asher-Shadon, 2013).

- Digital textbooks represent a technological advance from a two-dimensional to a three-dimensional information tool, replacing the page with the screen and enlivening text with rich imagery, sound, and animation (Kress, 2003). As such, digital textbooks have the potential to provide a non-linear experience with multiple pathways for students to navigate and explore, due to their connection to a plurality of multimedia (concept maps, videos, etc.) which in turn can improve learning outcomes (Huang, Chen & Ho, 2014). According to these researchers, concept maps in particular, if utilized as advanced organizers of the layout of a digital textbook, can “not only reduce learners’ cognitive load, but increase their learning outcomes in three different domains, that is, cognition, affection, and psychomotor performance” (p. 614).

- Potential benefits of using digital textbooks have been reported (Bikowski & Kasal, 2018) as: multimodality (Vaarala & Jalkanen, 2010), a more enjoyable learning process (Blazer, 2013; Gu, Wu, & Xu, 2015), increased motivation (Huang, 2013; Jang, Yi & Shin 2016), and, if implemented correctly, hypertextuality (DeStefano & Lefevre, 2007).

- The potential of digital e-textbooks to serve as interactive learning environments thereby facilitating more effective teaching and learning processes, can have a positive impact on student cognition and motivation (Ghaem et al., 2018) and may lead to higher-level learning (Dennis et al., 2016).
Digital textbooks appear to have a positive impact on reading comprehension and particularly on elementary school students’ emergent literacy skills (Blazer, 2013; Korat, 2010; Korat & Shamir, 2008; Segal-Drori et al., 2010) which is also owed to the multimedia affordances of digital textbooks (Grimsaw et al., 2007). The impact of digital content of student algebra performance was found to vary depending on the learning conditions. Yet, research (Huang et al., 2012) also suggests that a customized digital textbook learning system could achieve a better personalized learning experience for elementary school students.

While the impact of digital content of student algebra performance was found to vary depending on the learning conditions (Blazer, 2013), learning outcomes on the subject of chemistry outperform those based on print textbooks (Chiu, Cheung & Lau, 2017). Nonetheless, these researchers report that no significant difference was found in the psychomotor domain.

According to Jang, Yi and Shin’s meta-analysis (2016) on the effects of digital textbook use on students’ learning outcomes in South Korea, the effects on student motivation are higher than the effects on achievement. These findings indicate that digital textbooks can be utilized to increase student motivation. To fully realize the educational potential of digital textbooks, the researchers suggest deregulation of the rigid digital textbook review and approval policy.

In the context of K-12 education system, Luik and Mikk (2008) sought to identify those characteristics of electronic textbooks that correlated with knowledge acquisition by learners of different achievement levels. Their research findings suggest that not only the content of digital textbooks, but also the design of the associated software should be adapted according to the different achievement levels of students.

According to Blazer’s (2013) review, several studies have reported that students using digital textbooks read slower than those reading print textbooks. In addition, student retention of learned material is poorer than that of students’ reading the print version of the same text.

It has been argued that the interactive features of digital textbooks when operating as distractors, may be responsible for the slower reading speed, and for the reduced content retention (Blazer, 2013; Chiu, Cheung & Lau, 2017). Similarly, De Jong and Bus (2003) point out that the so-called “edutainment” features in children’s storybooks, may hinder instead of promoting learning. Roskos et al. (2011) argue that an important research task is to understand not only how these educational affordances impact particularly early literacy development and learning processes, but also how to use them well.

It is equally important to address the effect of design on learning outcomes which is implicitly related to selection and usability. Due to the increasingly heightened familiarity and involvement of students -- so called digital natives (Prensky, 2001) -- with digital material, Huang, Chen, and Ho (2014) suggest that availability of a variety of digital alternatives is essential. The researchers also emphasize the importance of collaboration between subject matter experts and teachers toward the improvement of the quality of the digital textbook. In order to increase learning outcomes, the digital textbook should not be utilized as a supplement, but as an extension and enhancement of the printed textbook (Huang, Chen, & Ho, 2014; Lau, 2008).

Despite the fact that student performance is not significantly impacted by format or way of delivery, studies have shown that students prefer print textbooks over their digital
counterparts (Chou, 2016; Woody, Daniel, & Baker, 2010). Yet, according to deNoyelles and Raible (2015; 2017), students have become more receptive and accepting of using digital textbooks over the recent years while at the same time the use of the latter has increased and become broader demographically. On the other hand, despite the rapid and continuous advances of technology, and the digital textbook trend in education, the teacher’s role does not seem to have changed significantly (Wang, 2015). This is why further professional development including increased awareness, instruction, and active modeling is called for (deNoyelles & Raible, 2015).

Design Recommendations

If e-textbooks are to play a leading part in reforming technology-based education (Yu & Kim, 2019), they need to clearly “differ from printed textbooks in terms of design, usability, content, didactic concepts, and features that support learning. Only digital learning applications auguring clear added value beyond printed textbooks, fulfilling the needs and learning objectives of today’s users, and designed with regard to users’ capabilities and motivational factors, will be widely utilized (Schulmeister, 2013). This view is supported by the expectancy-value theory (Wigfield & Eccles, 2000)” (Behnke, p. 12, 2021).

In light of the above, the following research-based recommendations on e-textbook design are proposed with specific reference to the K12:

- The content of an e-textbook should present methodological, declarative, procedural knowledge in the associated subject area, and knowledge of information retrieval, techniques and methods of search, processing and use of information when making decisions (including information literacy) (Ivanova & Osmolovskaya, 2016). It should also facilitate the development of declarative and procedural memory, consolidate understanding, attract and sustain attention (Flores, Ramos, & Escola, 2015).
- Interactivity must be both embedded and fully functional (Behnke, 2021; Flores, Ramos, & Escola, 2015; Grönlund, Wiklund, & Böö, 2018; Zhang, et al., 2006; Preradovic, Lauc, & Panev, 2020).
- A consistent implementation of all learning process components in the e-textbook information educational environment (i.e. motivational-targeting, content, operational-activity, evaluative- resulting) should take place, and be reflected in all steps of the learning process and requisite components of the online educational environment. The entire sequence of the learning process from setting goals to achieving results shall be implemented as well: a module – a hypertext – interactive tasks – evaluation of educational achievements. This way, an e-book can operate at an advanced level as an information and educational environment that facilitates interaction between teacher and students (Nurgaliyeva et al., 2019).
- There must be an alignment between the contents of the e-textbook and teachers’ lesson plans and overall teaching value of the lesson (Behnke, 2021; Flores, Ramos, & Escola, 2015; Grönlund, Wiklund, & Böö, 2018).
- The e-textbook must be of high-quality regarding on-screen text readability and comfort to the human eye (Abuloum et al., 2019; Harjono et al., 2020); interoperability of content across platforms, and lifespan of technical support must be ensured (Chapman et al., 2016; Lokar et al., 2011); subject information with pedagogical content knowledge guiding the design of the e-textbook (Ivanova & Osmolovskaya, 2016) should be provided; and, the design must be carefully
considered to be both visually attractive and behaviorally interactive (Shangguan et al., 2020).

- Considerations regarding technical and functional satisfaction of the end user (i.e. the student) should be taken into account in the design stage. These involve easy and consistent orientation and navigation; clear interfaces; easy access to important information; user-friendly note-taking and bookmarking; multimodality through text, video and animations; adaptation in support of student needs and disabilities; inclusion of learning support tools (dictionaries), teacher tools, communication and collaboration tools (Chapman et al., 2016; Dutkiewicz et al., 2018; Flores, Ramos, & Escola, 2015; Grönlund, Wiklund, & Böö, 2018; Xie et al., 2018).

- Good e-textbook quality (as described above) may help the reader avoid superficial (vs. deep) information processing which typically occurs as a result of on-screen reading during the limited class time (Delgado & Salmerón, 2020).

- Programmers or ICT specialists need to be involved in the design and development of the e-textbook, especially as technology advances rapidly and AI, machine learning, and voice/natural language technologies start making their way into the e-textbook in order to improve student learning further (Leddo et al., 2020).

**Selection and Adoption Recommendations**

In closing, a few adoption recommendations can be advanced with implications for both educators, students, and publishers.

It is important to include student and teacher input in the design of digital textbooks for they are end users, as such they know better how to improve weaknesses of this educational resource. Student and teacher input should be surveyed without linking it to any specific software or hardware (Sheen & Luximon, 2015). This way the pedagogical (vs. the technological) experience will become the crux of the matter.

Digital literacy skills and their development need to come into the discussion (Gillen, 2014) particularly since many students are not sufficiently trained on learning in such media-rich environments (Avgerinou, 2021; Avgerinou & Moros, 2020; Bikowski & Casal, 2018).

As Alsadoon (2020) aptly suggests, with the movement toward digital books, we need to expend more effort to help students enjoy reading from e-books and to value their advantages. More research is needed to explore ways in which e-books can meet students expectations and make the learning experience with them more enjoyable. In line with the aforementioned, Schreurs (2013) recommends more research that focuses on children reading e-books for pleasure, and takes into account the opinions and preferences of children.

Students (and teachers) need sufficient time in learning to take advantage of digital textbooks and their educational affordances (Chou, 2016). Educators and publishers need to communicate to students the benefits of using e-textbooks (e.g., low prices, accessibility, weight, etc.), what features e-textbooks offer (e.g., highlighting capabilities, portability), and how e-textbooks can be better for the environment (e.g., use less paper) (Millar & Schrier, 2015). In particular, teachers need to be trained properly to utilize all features/tools of the e-textbook, and also be able to model the tools for the students (Chapman et al., 2016; Clinton-Lisell, Kelly, & Clark, 2020; van Horne et al., 2016).
Last but least, the adoption of digital textbooks should be driven by educational value instead of other criteria such as a potential textbook price reduction (Murray & Pérez, 2011).

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