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Print versus digital texts: understanding the experimental research and challenging the dichotomies

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This article presents the results of a systematic critical review of interdisciplinary literature concerned with digital text (or e-text) uses in education and proposes recommendations for how e-texts can be implemented for impactful learning. A variety of e-texts can be found in the repertoire of educational resources accessible to students, and in the constantly changing terrain of educational technologies, they are rapidly evolving, presenting new opportunities and affordances for student learning. We highlight some of the ways in which academic studies have examined e-texts as part of teaching and learning practices, placing a particular emphasis on aspects of learning such as recall, comprehension, retention of information and feedback. We also review diverse practices associated with uses of e-text tools such as note-taking, annotation, bookmarking, hypertexts and highlighting. We argue that evidence-based studies into e-texts are overwhelmingly structured around reinforcing the existing dichotomy pitting print-based ('traditional') texts against e-texts. In this article, we query this approach and instead propose to focus on factors such as students' level of awareness of their options in accessing learning materials and whether they are instructed and trained in how to take full advantage of the capabilities of e-texts, both of which have been found to affect learning performance.

Keywords: digital texts; e-texts; electronic books; e-books; comprehension; recall; professional development

Introduction

Recent years have seen a dramatic rise in the adoption of blended learning to enhance learning outcomes, and universities are increasingly using digital technologies to make education more accessible and personalised for increasingly diverse student cohorts (Turner 2015; Wells, Blincoe, and Spence 2015). Current blended learning initiatives developed by universities include online components such as curriculum-based resources, exams, tests and feedback. Due to these changes, there is a growing need for awareness of the affordances of various available technologies and how technology use can optimise learning through its alignment with evidence-based pedagogical practice. The rapidly evolving area of e-texts, while not a new concept in the

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educational technology sphere per se, offers a cost-effective, efficient and accessible resource for students.

With its focus on e-texts used for teaching and learning, this article presents a critical systematic review of interdisciplinary literature into e-text uses and capabilities. There are two aims to the study: firstly, to identify trends in e-texts research, and secondly, to propose practical recommendations on how to use e-texts for impactful teaching and learning. Among the key issues, the article investigates are comprehension and recall; preference and familiarity; navigation and scrolling; feedback; and the various other uses of e-text tools including note-taking, annotation, bookmarking, hypertexts and highlighting. The analysis presented queries regarding the apparent dichotomy pitting e-texts against print-based texts and offers alternative ways to position e-texts as impactful teaching and learning tools.

While the focus of this article is primarily on higher education, we note that pedagogical issues related to technology are not specific to location, age, discipline or educational level (Henderson and Romeo 2015). For this reason, where relevant, examples from secondary schooling are included in the analysis. This review's main inclusion criterion is that the published research focuses on the formal use of e-texts within education and that results are generated in the controlled environments of a classroom. It is important, however, to acknowledge that e-texts are not exclusively e-textbooks (i.e. textbook content converted or created for online use and made available for a variety of digital devices) but rather encompass an array of online readings and text-based resources that students may use together with, or instead of, 'traditional' print-based materials. What makes such a study of e-text usage in education timely is that, although earlier research showed a relatively slow uptake of e-texts since the concept entered the lexicon of university education in the late 1990s (Smith *et al*. 2013), adoption of mobile devices in more recent years has ensured increased access to learning resources (Martin, Mcgill, and Sudweeks 2013), leading to a higher demand for e-texts (Records *et al*. 2015; Warschauer 2015).

Earlier e-text research focused on a variety of topics, ranging from student preferences and the impact of e-text-based learning on retention and comprehension (Van Horne, Russell, and Schuh 2016), to the complexities of e-text design. Factors such as learner perceptions and attitudes (Baek and Monaghan 2013), as well as physical aspects such as eye fatigue and strain (Jeong 2012) which can affect the learning process, have also been explored. A set of studies investigated instructor engagement with e-texts (Abaci, Morrone, and Dennis 2015; Dennis *et al*. 2016), while others (Junco and Clem 2015) explored e-text analysis in the context of predicting student academic outcomes. With few exceptions, the body of research reviewed in this article approached e-texts within the context of a dichotomy where e-texts were pitted against print-based texts, and where e-texts' effectiveness as a learning tool was questioned. While the collection and analysis of evidence of e-texts' effectiveness is important and has the capacity to generate insightful findings, conceptualising of e-texts as something of an opposition to print-based texts may not be useful; it creates unnecessary barriers which may not be reflective of the complex realities of learners.

One critical question is whether e-text converted from its print version (Porion *et al*. 2016) is significantly different from text designed either primarily or exclusively for the digital screen (Pegrum 2015). If the latter is the case, as with some e-textbooks which have morphed from merely delivering content to more collaborative, active learning resources, then the overall pedagogy of reading books will need to be reconsidered in the future (Pegrum 2015). Furthermore, there is a clear need for some

key pedagogical considerations to be drawn with regard to e-text usage if e-texts are to be implemented more effectively in the classroom.

The benefits of print-based texts

In the context of the apparent dichotomy of print-based texts versus e-texts, an over-whelming number of studies reviewed suggested that print-based texts contributed more to increased comprehension and recall than e-texts. For example, Singer and Alexander (2016) found that although students could recall the main ideas regardless of the text type, they were better able to recall key points linked to the main idea and other relevant concepts when reading print. Another study (Jeong 2012) showed higher quiz scores indicating better comprehension in print-based texts, while eye fatigue and strain reported by students was greater when reading e-texts. As far as meta-cognitive learning regulation (i.e. higher-order thinking) is concerned, e-text-based learning yielded inferior results compared to print-based text learning (Ackerman and Lauterman 2012; Lauterman and Ackerman 2014), though subsequent research has queried the reliability of this comparison (Norman and Furnes 2016).

Navigation, display and scrolling are identified as possible factors affecting reading comprehension. For instance, a study of learner comprehension concluded that e-texts were inferior to print due to the negative effects associated with screen navigation, display and scrolling (Mangen, Walgermo, and Brønnick 2013). Further, students reading print-based texts performed significantly better on a reading comprehension test than those reading e-texts. While this difference could indeed be due to the modes of navigation within the document, with scrolling used in digital mode, the issue could in fact be more complex: if the text navigation is simple and, therefore, less taxing cognitively – as is arguably the case with print-based texts – the reader may have more free capacity for comprehension. In fact, others (Dundar and Akcayir 2012) indicated that e-texts used more of the reader's mental resources than print-based texts and that this drain made recall more difficult.

It is important to acknowledge the ever-growing diversity of devices students can use to read e-texts: for instance, scrolling is not required when reading the screen of a specially designed e-reader. Instead, a page can be 'turned' at the push of a button which requires the same effort as the physical act of turning the print-based page (Bilton 2010). Some claim that students are more likely to skim a computer-based text, often searching for key terms in an 'F' pattern rather than reading line by line (Nielsen 2006). Skimming, however, may also occur when reading a print-based text (Nel, Dreyer, and Klopper 2004) and may be indicative of students' varying approaches to reading rather than a cause for alarm. Moreover, having a good spatial mental representation of the physical layout of a text supports reading comprehension (Baccino and Pynte 1994; Cataldo and Oakhill 2000; Kintsch 1998; Piolat, Roussey, and Thunin 1997). Further, specially designed e-readers are not lit up from inside in the way smartphones or iPads are and therefore do not strain the eyes, although as students may utilise an array of devices when accessing e-texts, generalising becomes problematic (Bilton 2010).

Decreased concentration caused by eye fatigue can be a barrier to successful e-text-based learning, as screens can strain the eyes and cause headaches (Jabr 2013). A recent study (Lin, Wang, and Kang 2015) found that both memory and ability performance improved after using paper and pencil, and that eye fatigue was greater

when using a tablet. Fortunately, research is already underway to understand the various contributing factors to eye fatigue and develop guidance around optimal text sizes and viewing distances (Kochurova, Portello, and Rosenfield 2015). Meeting these requirements, however, could be inherently difficult on some mobile devices (Kochurova, Portello, and Rosenfield 2015). The difference between the display of a screen versus a print-based text possibly affects other tasks such as proofreading: for example, it may be more difficult to complete proofreading tasks when reading on computer screens (Imai and Omodani 2008), where the difficulty of reading on screen is attributed to being able to see only one page at the time. The more pages shown on screen at a time, the higher the proofreading performance, suggesting that different display options may impact differently on reading cognition.

The importance of preference and familiarity

Technical factors aside, self-reported preference is another significant factor in the effectiveness of e-texts for learning. Students may be more likely to engage with and perceive as useful technologies with which they are already familiar; alternatively, they may have a strong preference for print-based texts based on prior experiences. A variety of factors are at play here: familiarity with and comfort levels of the medium or platform (Baek and Monaghan 2013; Chen *et al.* 2014; Weisberg 2011), the cultural attitudes of learners (Kretzschmar *et al.* 2013), the subject matter (John 2014), the length of text (Abdullah and Gibb 2008; Baek and Monaghan 2013; Gibson and Gibb 2011; Muir and Hawes 2013) and whether the text needs to be understood thoroughly or merely skimmed and scanned (Buzzetto-More, Sweat-Guy and Elobaid 2007; Dilevko and Gottlieb 2002; Dundar and Akcayir 2012; Jamali, Nicholas, and Rowlands 2009; Spencer 2006).

Students may declare their preference for print-based texts over e-texts, but they can also appreciate using a combination of the two (Dobler 2015; Falc 2013; Mizrachi 2015; Singer and Alexander 2016). While students overall appear to prefer print-books, they are also satisfied with e-texts (Jeong 2012). Reasons for a preference for print-based texts can be the following: students may feel more easily distracted when reading e-texts (Dobler 2015); students perceive e-texts' page-to-page navigation tools as poor and the speed of page loading as slow (Muir and Hawes 2013); and students also encounter various technical difficulties when learning with e-texts, leading to frustration (Falc 2013). Print-based texts are also considered superior for studying large sections of text (Baek and Monaghan 2013). On the contrary, student preferences for e-texts are centred on searchability (Muir and Hawes 2013), as well as cost and accessibility (Mizrachi 2015). Overall, attitudes towards e-texts are affected by their (perceived) usefulness, ease of use, whether they were enjoyable and pleasant to use (Hsiao, Tang, and Lin 2015) and a student's resultant intention to continue using them (Stone and Baker-Eveleth 2013).

Importantly, using a student's preferred platform for learning does not always equate with increased comprehension (Singer and Alexander 2016), while familiarity with a platform may increase reading comprehension (Chen *et al.* 2014). For example, it was found that students who preferred e-texts and predicted better performance with e-texts did not necessarily perform better when using them (Singer and Alexander 2016), suggesting that students may not always be best placed to predict the factors that contribute to their learning outcomes. However, factors such as time pressure, regulation and interruptions while studying are found to skew students' preference

towards print-based texts (Ackerman and Lauterman 2012): when under time pressure, students who reported a moderate preference for print-based texts showed lower test scores using e-texts. Students reported best test scores when using their preferred medium, suggesting that preference affects their metacognitive processes. Interestingly, a study of reading effort on three different platforms (print, tablet and e-reader) showed that all participants preferred reading a print-based text, despite it not requiring more effort to read on a screen (Kretzschmar *et al*. 2013). The authors suggested that this may be due to participants' cultural attitudes towards screen use. In addition to students' preference, familiarity with a platform has also been found to affect reading comprehension (Chen *et al*. 2014): students with a high level of tablet familiarity performed significantly better on deep-level comprehension than those with a low level of familiarity, though no difference was found for the shallow level of comprehension (Chen *et al*. 2014). It was concluded that increasing students' training and familiarity with tablets may lead to better reading comprehension using tablets.

In summary, where learner preference and familiarity are concerned, students tend to be in favour of traditional paper-based texts while the speed of reading, time pressure and an array of other factors can also influence students' uptake and engagement with learning materials via e-texts. However, as the following section demonstrates, there are a number of significant advantages of e-text-based learning which, when better understood, have the capacity to facilitate more impactful learning.

The advantages of e-texts

Several studies find no clear difference between print-based texts and e-texts where learner comprehension is concerned (Green *et al*. 2010; Margolin *et al*. 2013; Norman and Furnes 2016; Porion *et al*. 2016), while a recent study (Norman and Furnes 2016) reveals no difference in metacognitive learning regulation between print and digital texts. Likewise, Chen *et al*. (2014) discovered no noticeable difference in deep-level comprehension of the three learning platforms of paper, tablets and computers. A study of test scores of students assigned a print-based textbook and those assigned an e-book also shows no significant differences (Murray and Pérez 2011), as is also the case with an examination of cognitive learning or grades between students using e-texts and print-based texts (Rockinson-Szapkiw *et al*. 2013).

Comparing test scores of students using either a print text or e-text reveals interesting results: Dennis *et al*. (2015), for instance, found that while students scored significantly higher when using the e-text system, they perceived that the print text met their learning needs better than the e-text. In a more recent study, however, Dennis *et al*. (2016) found that students learning with e-text outperformed their paper text peers on some types of quizzes. At the same time, a comparative study of fully online students and fully face-to-face students found that e-text usage correlated with increased academic performance in the online group but made no difference for the face-to-face students (Biranvand and Khasseh 2014). This was possibly due to the online students relying on digital resources more heavily than face-to-face students.

Studies with a focus on reading speed and comprehension also failed to establish any differences between print-based and e-text-based learning. For instance, the study by Sackstein, Spark, and Jenkins (2015) concluded that students read faster on iPads than in print despite no significant difference in comprehension levels across the platforms. In contrast, Dyson and Haselgrove (2001) found that the recall of information did not depend on reading speed, and that comprehension decreased as

reading speed increased. The highest level of comprehension when reading at a high speed was achieved when lines were of medium length rather than short. With regard to readers' scrolling, a pattern with longer pauses between movements correlated with better comprehension. The distinction between different types of readers – those favouring speed over accuracy and vice versa – tend to produce different scrolling and reading patterns.

With regard to the scrolling patterns, while no significant differences were found between print and e-text mode in reading comprehension and recall accuracy, when examining digital reading comprehension it was found that the e-text reading technique known as adaptive shortcuts is used by e-text readers (Niccoli 2015). This technique involves using scrolling, scanning and hyperlinks, and may impede cognitive processing, though this has been not empirically proven. A study which examined eye movement comprising direction and duration of movement, as well type of movement (fixations or regressions) whilst reading from a computer display, tablet or e-reader and on paper, revealed no significant differences between reading from an electronic screen and reading the printed book (Zambarbieri and Carniglia 2012). This may present evidence against studies arguing that students are likely to skim e-texts and not read line by line as they would do with a book. If eye movement does not change between e-texts and printed texts, then students are presumably reading the material in the same way and their comprehension and recall, therefore, will also not differ.

Instructor use of e-texts' teaching and learning affordances has been a focus of a number of recent studies (Abaci, Morrone, and Dennis 2015; Dennis *et al*. 2016; Junco and Clem 2015). Receiving instructor feedback via e-text annotation functions appeared to give students a slight advantage when performing on open-end quizzes, while no difference in test results were registered between e-text and paper-based learning cohorts when measuring their performance via multiple-choice quizzes (Dennis *et al*. 2016). The authors concluded that such an e-text affordance as feedback provision via the annotation function could in fact lead to higher-level learning. Other studies found that instructors can further benefit from e-text features such as engagement analytics as a way of predicting student outcomes (Abaci, Morrone, and Dennis 2015; Junco and Clem 2015).

Regardless of the purposes and outcomes of the studies considered so far, one point is particularly clear: whether intentionally or not, the body of e-text research tends to frame this topic as a dichotomy and draw a clear line between e-texts and print-based texts as two separate aspects of learning that do not overlap. The complexities of learner experiences instead suggest a blurry division rather than a strict demarcation. As a way to transcend this dichotomy, we propose a number of recommendations on how to maximise the impact of e-text usage for learning.

Recommendations for impactful e-text learning

The analysis of interdisciplinary literature presented in this article suggests that while there may not be drastic differences between e-texts and print texts with regard to student comprehension and recall, students' perceptions of e-texts, their familiarity, personal preference and even bias towards print-based texts may play a bigger role in how successfully students engage with e-texts compared to many other factors perceived as important. Studies that discussed students' frustration with e-texts and those reporting on students' satisfaction with e-texts despite their overall preference for print-based texts support this view. In light of these findings, training and personal

development emerge as key aspects of any future e-text learning initiative: both students and teaching staff may need to be trained in the use of e-texts to optimise their learning outcomes. The considerations to keep in mind here are threefold. Firstly, one size does not fit all with e-texts, and students therefore need to be taught how to use a variety of available technological features and to develop strategies that suit their personal reading experiences of e-texts. Secondly, e-reader communities or spaces are useful to encourage students to share their expertise and e-reader strategies. Finally, technical assistance and professional development is important to the successful integration of e-text technology; teachers may need time for collaboration and resource development, including access to authoring tools for customised e-books (Dalton 2014).

Other studies across various education levels support this urgent need for better training of students and staff to maximise the positive effects of technologies on learning (Abdekhodaee, Chase, and Ross 2017; Larson 2012; Røkenes and Krumsvik 2016), including those associated specifically with e-text (Baek and Monaghan 2013; Chen *et al*. 2014; Mulholland and Bates 2014). Some have also identified a need for educators to incorporate the teaching of digital literacy skills into their classrooms (John 2014), claiming that students, even when they appear to be digitally literate, often lack the necessary skills to manage online content. Rather, they use different strategies and practices when reading e-texts instead of print-based texts.

The explicit teaching of technology skills to primary and sometimes secondary students is seen as a necessity for developing 21st century skills in children, whereas students who have reached university level are all too often – and inaccurately (Bennett, Maton, and Kervin 2008; Selwyn 2009; Thompson 2013) – seen as 'digital natives' or millennials, presumably already having had the opportunity to develop the technology skills that would enable them to utilise e-texts. These students, however, may need further education in how best to utilise new technologies such as e-texts. Similarly, teachers need sound knowledge of how new technology operates if they are to stay abreast of changes in pedagogy and the practice needed to implement e-texts into classroom teaching (Brueck and Lenhart 2015). Staff must be provided with information, direction and skills to utilise e-books. In addition, there is also a need to develop e-texts that are user-friendly (Myrberg and Wiberg 2015).

Professional learning should also assist teachers to develop language facilitation skills with e-texts, as traditional strategies for reading instruction may not necessarily be transferable from print to e-text. This need for training and professional development is present across all education levels: for instance, Warschauer (2015), citing the example of a secondary teacher who aims to close the gap for his students in reaching higher education by developing the skills to exploit e-texts, claims that the increased use of e-texts and mobile devices has similar benefits to both K-12 and university students. Others (Abaci, Morrone, and Dennis 2015) reach similar conclusions with regard to instructor upskilling, calling for best-practice-based professional development opportunities for instructors to enhance their use of e-texts for teaching.

Interestingly, other factors which may be of importance to attitudes towards e-texts, such as age or gender, are rarely explored in depth (exceptions include Baek and Monaghan 2013; McGowan, Stephens, and West 2009; Woody, Daniel, and Baker 2010). For example, a finding that younger students are less satisfied with e-texts compared with their older peers (Baek and Monaghan 2013) may be due to the older

students having had more exposure and experience with technology, and therefore being more familiar with e-texts. For this reason, younger students may particularly benefit from training sessions within their faculties in order to learn strategies for the effective use of the available features of e-texts.

Conclusion

This article presented findings of a systematic synthesis of interdisciplinary experimental literature, exploring studies concerned with e-text use for teaching and learning purposes. It found that most studies tended to juxtapose e-texts with paper-based texts in their research design, hence creating and perpetuating a 'print versus digital' dichotomy. While we acknowledge that various affordances of e-texts, such as mark-ups and annotation tools, can be utilised when learning with print-based texts as well as e-texts, ultimately these features cannot be separated from their contexts. These contexts can be defined by either digital or print format, their effectiveness or the pedagogical rationale adopted by educators.

To step away from this dichotomous representation of e-texts in education, we argue in favour of study designs that consider e-texts in the contexts of student achievement and learning processes, without making comparisons to print texts. Another alternative approach to studying e-texts could be instructor-centric, that is, exploring instructor choices for pedagogical uses of e-texts and how those choices align with instructor teaching philosophy and/or attitudes to educational technology.

Overall, the use of e-texts is increasing in higher education with both content and formatting evolving as academic publishers add more innovative functions, including speech outlining tools, quizzes, video libraries and sharing via social media platforms. The area of scholarship exploring benefits and challenges of e-text versus print texts indicates that there are complexities in our understanding of the platform, students' preferences and how they engage with material for learning. Students may respond to different learning strategies that do not take reading comprehension into account when interacting with digital devices compared to print. At the same time, however, the way in which students perceive of their learning, the platform and the device is important to their uptake and engagement.

Importantly, this article identifies the issue that, despite the widespread use of e-texts, students' comprehension and recall may be similar when reading print and e-texts, although there are factors that may impede digital text comprehension and recall. These factors concern reading large sections of text where distractions regarding hypertext as well as the complexities of skimming and scanning techniques apply. Furthermore, research indicates that, overall, students prefer to read print texts. For this reason, higher education institutions clearly need to train both their staff and students in how to approach digital texts in order to achieve the best learning outcomes. This training should encompass areas of knowledge such as general familiarity with the devices, allowing for personal preferences between e-text and printed text, teaching students and staff about the modes of navigation and how to take full advantage of the additional features e-text provides. It is important to keep in mind, however, that any disparity in learning outcomes between e-text and printed texts is likely to be minimised as young people become more familiar with reading on screen and as the relevant technology (computer screens and print quality) continues to develop.

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