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Enhancement of digital reading performance by using a novel web-based collaborative reading annotation system with two quality annotation filtering mechanisms ☆

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ABSTRACT

Collaboratively annotating digital texts allows learners to add valued information, share ideas, and create knowledge. However, excessive annotations and poor-quality annotations in a digital text may cause information overload and divert attention from the main content. The increased cognitive load ultimately reduces the effectiveness of collaborative annotations in promoting reading comprehension. Thus, this work develops a web-based collaborative reading annotation system (WCRAS-TQAFM) with two quality annotation filtering mechanisms—high-grade and master annotation filters—to promote the reading performance of learners. Ninety-seven students from three classes of a senior high school in Taiwan were invited to participate in an 80-min reading activity in which individual readers use WCRAS with or without annotation filters. Analytical results indicate that digital reading performance is significantly better in readers who use the high-grade annotation filter compared to those who read all annotations. Moreover, the high-grade annotation filter can enhance the reading comprehension of learners in all considered question types (*i.e.*, recall, main idea, inference, and application). Also, the Cohen's kappa statistics was used for assessing whether the annotation selected by the high-grade annotation filter is in agreement with the annotations selected by a domain expert. The statistic results indicate that the proposed high-grade annotation filter is valid to some degree. Finally, neither of the proposed quality annotation filtering approaches significantly reduces cognitive load.

1. Introduction

Rapid advances in information technology and digital publication have sparked a growing interest of reading texts in electronic online form. According to a survey by Gartner Inc. (2013), the time that individuals spend reading online is almost equal to the time spent reading printed texts. Adolescents are especially much more likely to read online rather than a printed text. Liu (2005) discussed reading behavior in a digital environment, indicating that reading digital texts differs from reading printed texts in many facets, including interactivity, nonlinearity, and immediacy in accessing information. Eden and Eshet-Alkalai (2013) indicated that although digital readers complete short text reading faster than print readers, their comprehension levels were not lower. However, Birkerts (1994) found that adolescents growing up in a digital environment generally fail to read deeply and sustain their attention in digital reading. Carr (2010) also asserted that screen reading and the fragmented nature of hypertext reduce sustained reading, resulting in shallow reading.

To assist readers in annotating digital texts for promoting digital reading performance, collaborative annotation tools, such as Diigo (Estellés et al., 2010), PAMS (Su et al., 2010), and CRAS-RAIDS (Chen and Chen, 2014), allows learners to collaborate efficiently in annotating digital texts in order to add valued information, share ideas by expressing different perspectives on digital texts with annotations, as well as create knowledge by reading digital texts with annotations. A classic collaborative annotation tool generally has functionalities including editing, revising, deleting, browsing, and sharing annotations. An augmented collaborative annotation tool may provide other advanced functionalities, such as on-line discussion for digital texts with annotations (Rau et al., 2004), reading annotation scaffolds and interactive discussion scaffolds for improving reading performance (Chen and Chen, 2014), or a self-regulated learning mechanism for helping learners to generate rich and high-quality annotations

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(Chen et al., 2014a; Chen and Huang, 2014). Many studies (Chen and Chen, 2014; Nokelainen et al., 2005; Ovsiannikov et al., 1999; Rau et al., 2004) demonstrated that collaborative annotation tools can promote reading performance and facilitate collaborative reading. However, several studies argued that adding supplemental information may increase the cognitive load of readers, thus reducing learning performance (Brünken et al., 2004; Plass et al., 2003). Wallen et al. (2005) further indicated that multiple annotations may increase cognitive load more than one annotation. It is therefore possible that too many poor annotations collaboratively generated by learners may cause information overloading and raise cognitive load, thereby diminishing the effects of annotations on promoting digital reading performance.

To enhance collaborative annotation applications in digital reading environments, this work proposes two quality annotation filtering mechanisms: high-grade and master annotation filters. Based on the observable reading behaviors of learners on a digital text with annotations, the quality annotation filters are designed to filter out poor annotations in order to promote the reading performance of learners and reduce their cognitive load. In this work, a digital text for performing collaboratively reading annotation is a HTML document without hyperlinks. This work attempts to determine whether digital reading with and without the support of the proposed quality annotation filters differ in terms of reading comprehension and cognitive load. Also, this work tries to understand whether the correlations among reading comprehension, reading annotation ability, and cognitive load exist while students actively read a digital text with and without the support of different quality annotation filters.

The remainder of this paper is organized as follows. Literature review is presented in Section 2. Section 3 presents the annotation system architecture and Section 4 explains the user evaluation method. Section 5 shows the experimental results. Section 6 gives a discussion for the research findings of the work. Finally, the conclusions and future work are stated in Section 7.

2. Literature review

2.1. Web-based collaborative annotation tools

Collaboratively annotating digital texts provides benefits in accumulating knowledge and allows readers to share knowledge with the others (Chen and Chen, 2014). Importantly, annotated texts help readers more thoroughly understand content than digital texts without annotations (Porter-O'Donnell, 2004). Collaborative annotation tools are widely used online and linked to online resources, owing to the popularity of online services. Because annotation data and documents are stored in different databases, readers can manage annotations without changing the contents of original documents. Among those tools, Rau et al. (2004) presented web-based annotation tools (WATs), allowing users to annotate HTML documents, build up a knowledge structure, browse instructions provided by a system administrator or instructor, share annotations with the other learners, and instruct other learners. Moreover, WATs also support synchronous discussion with online readers. Nokelainen et al. (2005) proposed a shared document-based annotation tool, capable of supporting learner-centered collaborative reading. Their annotation tool allows readers to insert a document into a document pool, read and annotate the document, and write a brief report by analyzing the document with annotations. Their annotation tool also allows readers to create personal filters in order to restrict visibility of other user annotations. Moreover, Estellés et al. (2010) developed an annotation tool termed as Diigo, which allows signed-up users to bookmark webpages, highlight any part of a bookmarked webpage, annotate directly onto bookmarked webpages, and share webpages with annotations to group members. Su et al. (2010) proposed a personalized annotation management system (PAMS) that manages, shares, and reuses individual and collaborative annotations. In PAMS, an annotation discussion handler is designed for readers to exchange their own annotations with others; related discussion can further be treated as a new annotation. According to their results, students with high learning achievement have a higher willingness to use collaborative annotations for on-line article reading than students with low learning achievement in collaborative learning environments. Also, contributing more annotations implies higher learning achievements in collaborative learning environments. Furthermore, Mendenhall and Johnson (2010) developed a social annotation model learning system (SAM-LS) to support students in improving their critical thinking, critical writing, and literacy-related capabilities. In particular, SAM-LS includes the online annotation tool HyLighter, capable of supporting annotation activities by using different colors to display aggregated views of various groups' annotation. According to their results, HyLighter may help students in several areas, including the ability to enhance the critical thinking skills of students.

Recent studies (Chen et al., 2014a; Chen and Chen, 2014) have proposed augmented collaborative annotation tools to improve students' reading performance of reading digital texts. Chen et al. (2014a) developed a web-based digital reading annotation system (DRAS) with a self-regulated learning (SRL) mechanism to facilitate learners in contributing rich and high-quality annotations in order to enhance students' reading comprehension of reading English-language texts. The annotation functionalities of DRAS include underlining important texts, browsing individual annotations or all shared annotations, voting useful annotations, and highlighting annotated texts as well as showing the most popular annotations. In addition to using a self-monitor table for individuals to set their learning goals and plans, the SRL mechanism counts the number of different type annotations in current learning by using an annotation ranking table, as well as displays success rates by using a self-regulated radar plot. According to their results, grade 7 students who used DRAS with SLR to learn English have better reading comprehension and annotation capabilities than grade 7 students who used DRAS without SLR. Moreover, Chen and Chen (2014) developed a collaborative reading annotation system with an annotation and interactive discussion scaffold (CRAS-RAIDS) for improving the reading performance of students in collaborative digital reading environments. In addition to providing basic annotation functions, their system also contains seven reading annotation scaffolds to assist readers in creating annotations with appropriate semantic tags, as well as six interaction discussion scaffolds to assist readers in creating structured and meaningful interactive discussions in order to increase reading comprehension. Analytical results indicate that students who read digital texts with CRAS-RAIDS support significantly outperformed those who read printed text with paper-based annotation and face-to-face discussion in terms of direct and explicit comprehension, inferential comprehension performance, and the use of reading strategy.

To our knowledge, despite the availability of many collaborative annotation tools with basic or advanced functions to support digital reading, few studies have attempted to solve problems involving a large number of annotations, or poor-quality annotations in a digital reading activity with the support of annotation tools. These problems may lead to information overload, diverge readers' focused attention on important annotations, and increase cognitive load among learners, thus reducing the effects of annotations on promoting reading comprehension performance. Similarly, social media or social annotation systems also have the problem of filtering out inaccurate information by crowdsourcing human contributions (Kittur et al., 2013). Mitra and Gilbert's study (2015) presented CREDBANK, which can systematically integrate machine computation with the judgments of human annotators, to produce credibility annotations of the