Active Reading Behaviors in Tablet-based Learning

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Abstract

Active reading is fundamental to learning. However, there is little understanding about whether traditional active reading frameworks sufficiently characterize how learners study multimedia tablet textbooks. This paper explores the nature of active reading in the tablet environment through a qualitative study that engaged 30 students in an active reading experience with two tablet textbook modules. We discovered novel study behaviors learners enact that are key to the active reading experience with tablet textbooks. Results illustrate that existing active reading tools do little to support learners when they struggle to make sense of and subsequently remember content delivered in multiple media formats, are distracted by the mechanics of interactive content, and grapple with the transient nature of audiovisual material. We collected valuable user feedback and uncovered key deficiencies in existing active reading tools that hinder successful multimedia tablet textbook reading experiences. Our work can inform future designs of tools that support active reading in this environment.

Introduction

Successful learners study educational material by engaging in some form of active reading (Adler & van Doren, 1972). During active reading, a learner builds an analysis of the material by applying specific strategies, such as annotating, summarizing, cross-referencing, and revisiting portions of a larger work (Figure 1). Serving as a fundamental meta-cognitive function, active reading allows content to leave strong memory traces and thus, helps learners understand a text for a specific purpose, such as future recall in an educational setting or as part of a job-related task (Adler & van Doren, 1972).

Traditional frameworks for active reading (Adler & van Doren, 1972), responsive reading (Pugh, 1978), and/or work-related reading (Adler, Gujar, Harrison, O'Hara & Sellen, 1998) have primarily focused on reading text in print. However, the development of tablet-based textbooks is in rapid forward motion, moving textbooks to the mobile arena. There, students encounter

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several integrated multimedia formats–i.e., video/animation, audio, expository text, interactive graphics–in a single interactive tablet textbook. Learners are now accustomed to *reading* text, *watching* video, and *listening* to audio. However, the textbook invites careful study, review, and annotation. Thus, how do learners effectively *study* integrated multimedia content in a tablet textbook? This is an important question, considering that with the advent of tablet devices, an increasing amount of educational content will be delivered as audio and video. Several platforms like Inkling[1] and Kno,[2] as well as development tools like Adobe Digital Publishing Suite and Apple's iBooks Author already make multimedia integration possible. Thus, a new breed of textbook is emerging that facilitates multi-touch interaction, robust annotation features, and integrated multimedia content designed as a browse-able book.

This paper examines the nature of active reading while learning with a multimedia tablet textbook. The multimedia tablet textbook can be distinguished from other digital textbooks, such as epubs/eBooks, which are usually interactive PDFs with hyperlinks and basic annotation features. In contrast, a multimedia tablet textbook blends the structure of a traditional book with additional media, such as *audio*, *video*, *animations*, and *interactive graphics*. We use the term "tablet textbook" to refer to this rich, multimedia format. Specifically, we examine strategies learners use or wish to use to engage in careful study of a tablet textbook that involves video-intensive content, animation, and other forms of interactive multimedia. Our goals are to discover how students apply active reading strategies and identify novel directions to support active reading with the most appropriate tools. The following questions guide this work: 1) Do current frameworks of active reading sufficiently addresses the key activities learners use when

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[1] Inkling, www.inkling.com

[2] Kno, http://http://www.kno.com/

studying a multimedia tablet textbook? 2) What active reading strategies and/or behaviors emerge when learners engage with interactive, multimedia content? 3) What types of tools must be developed for users to achieve all of their active reading and learning goals in the multimedia textbook?

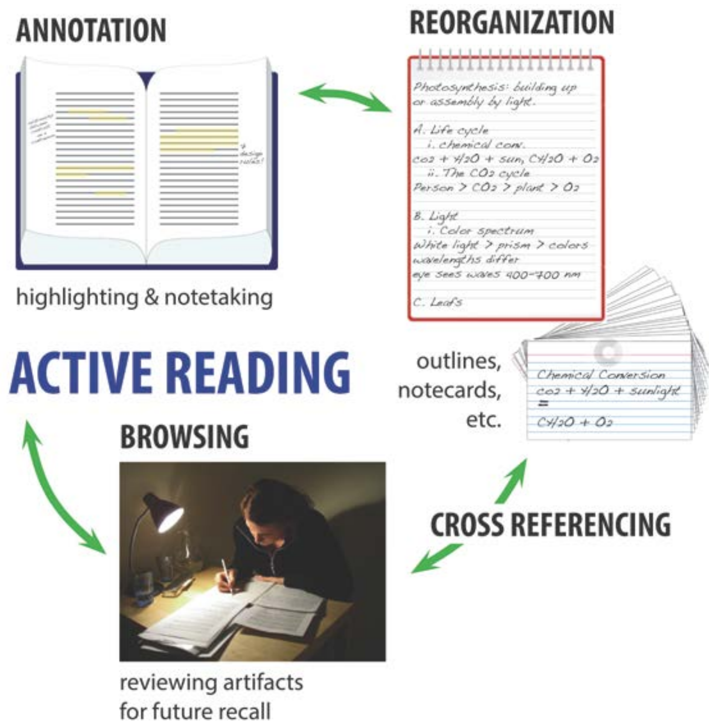

Figure 1. Active reading involves four actions: annotation (highlighting, note taking), reorganization (outlining, summarizing); cross-referencing (working back and forth among documents, annotations, etc.); and browsing (studying artifacts developed during the other phases).

To address these questions, we conducted a qualitative, exploratory study, in which 30 participants engaged with one of two tablet-based learning modules. Our most salient findings center on the fact that learners often struggle to make sense of and remember content delivered in multimedia formats, are distracted by the mechanics of interactive content, and grapple with the transient nature of audiovisual material. Novel traits of active reading emerge that characterize tablet-based learning and indicate directions for better active reading support. This paper makes the following contributions:

- Identifies and characterizes a set of learner behaviors specific to active reading of a multimedia tablet textbook;
- Discovers limitations and potential regarding the usability of existing active reading tools;

- Envisions key requirements grounded in relevant theories of active reading and multimedia learning for novel systems to better support educational active reading of tablet textbooks.

The following review focuses on the constructive nature of reading comprehension, multimedia learning theory, and the active reading framework. We then report on key study behaviors learners enact, which are unique to the interactive, multimedia tablet textbook. We also share user feedback that will inform future novel designs of active reading tools.

Review of Background

This work draws from three interrelated fields: 1) the constructive nature of reading comprehension, 2) multimedia learning theory, and 3) active reading and the digital space.

Constructivism & reading comprehension

Cognitive-based views of reading emphasize the interactive nature of reading (Rumelhart & Ortony, 1977) and the constructive nature of comprehension (Spiro, 1980). Expert readers possess a set of adaptable strategies to make sense of text and monitor understanding (Rumelhart, 1980). Strategies are conscious, instantiated, and flexible plans readers apply to texts and tasks (Pressley, Johnson, Symons, McGoldrick, & Kurita, 1989). Strategies emphasize readers' deliberate plans to use reasoning and critical thinking as they construct and reconstruct evolving meanings from the text, modify strategies to fit different kinds of texts, and reflect on what they are doing while they are reading (Baker & Brown, 1984). This cognitive view assumes an active reader who constructs meaning through the integration of existing and new knowledge and the flexible use of strategies to foster, monitor, regulate, and maintain comprehension (Dole, Duffy Roehler & Pearson, 1991). A number of scholars have also characterized the cognitive and behavioral strategies learners engage during educational reading. Reading instruction must include comprehension fostering and monitoring activities to help young learners develop active reading strategies (Dewitz, Carr, & Pat-berg, 1987). Prior knowledge also has a significant effect on reading comprehension (Anderson, 1978; Spiro, 1980). In short, reading comprehension involves both high cognitive and behavioral activity if meaningful learning is to occur.

Multimedia learning

The cognitive theory of multimedia learning (Mayer, 2009) asserts that words and pictures together create optimal learning conditions (Levie, 1982). Well-designed multimedia messages therefore foster deeper understanding because they are learner-centered rather than technology centered (Cuban, 1986). Furthermore, cognitive load theory asserts that working memory is limited with respect to the amount of information it can hold and the number of related operations it can perform (Kalyuga, Chandler & Sweller, 1999). Thus, researchers have explored the cognitive constraints related to multimedia learning to provide guidance for multimedia instructional designers (Mayer, 2009). The cognitive theory of multimedia learning, however, does not address active reading. Rather, it is focused on multimedia instructional messages presented in isolated video presentations and/or verbal and pictorial formats. Multimedia learning theory provides a foundation for exploring active reading in the tablet textbook environment (Clark & Mayer, 2011). But more research is necessary to determine how multimedia textbook developers can implement established principles of multimedia learning in this new environment to better facilitate active reading.

Active reading & the digital space

Active learning is an umbrella that includes active reading and several other instructional models, including learning by teaching, class discussion, and collaborative learning groups, to name a few (Bonwell & Eison, 1991). In contrast, most research on *active reading* has focused on strategies enacted on paper and with narrative text. Several studies indicate students struggle to migrate from print to interactive digital textbooks, particularly when multimedia elements are added. Recent studies suggest that certain academic reading tasks–such as preparing for exams, tests, or class (Thayer, Lee, Hwang, Sales, Sen & Dalal, 2011); reviewing texts for research purposes (Tashman & Edwards, 2011); and reading to learn specific topics or information (Lorch, 1993)–are challenging with eReaders. Students have also exhibited trouble building cognitive maps of content when it is presented digitally and/or nonlinearly (Thayer, Lee, Hwang, Sales, Sen & Dalal, 2011). Likewise, learners struggle with orientation when only one page can be viewed at a time (Doering, Pereira & Kuechler, 2012), have difficulties adjusting to new ways of annotating (Marshall, 1997), and struggle to manage multiple related documents on one device (Chen, Guimbretiere & Sellen, 2012). In spite of some novel affordances offered by digital reading devices, learners and workers still generally prefer paper because it easily supports a wide range of active reading requirements (O'Hara, Taylor, Newman & Sellen, 2002). Additionally, issues related to academic reading processes are underexplored in studies of tablet devices, partly because students' goals and techniques for reading academic texts have not been sufficiently considered (Thayer, Lee, Hwang, Sales, Sen & Dalal, 2011).

Study Design

Rationale

A qualitative study was designed to facilitate observation of leaners during an active reading experience involving an interactive, multimedia tablet textbook. The protocol was intended to instantiate a typical study session to determine what, if any, active reading behaviors

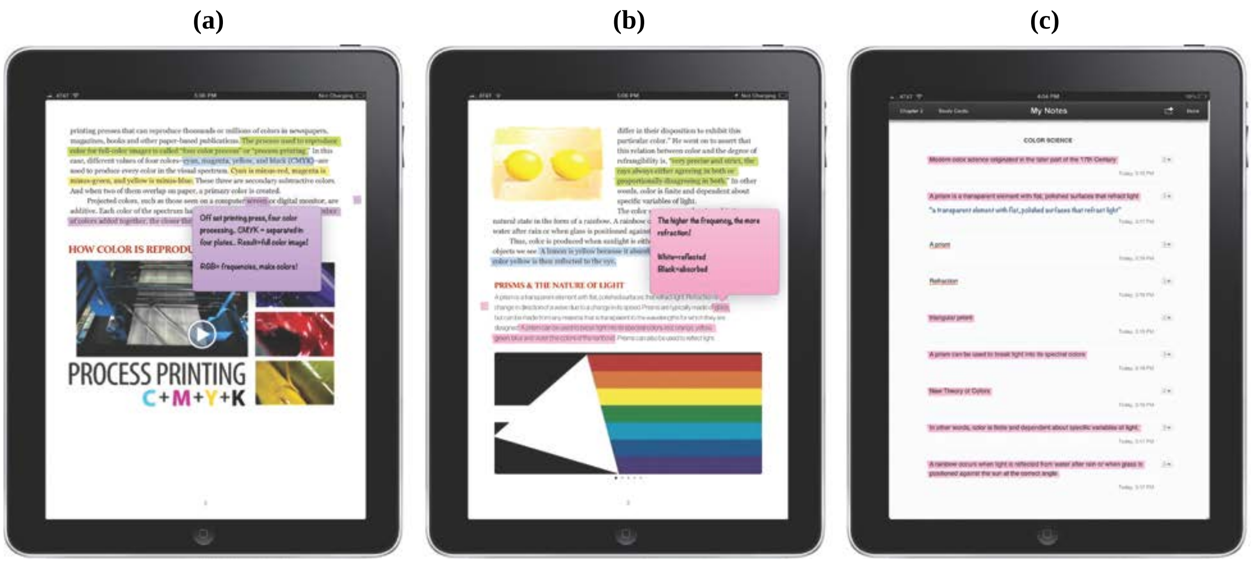

Figure 2. Tablet textbook modules included (a) videos/animations and interactive graphics, (b) built-in tools for highlighting and annotation, and (c) a concatenated list of a learners' highlighted text and annotations for future review.

learners attempt in the tablet textbook environment, as well as how effectively those efforts are supported.

Setting & stimuli

Participants were exposed to one of two tablet textbook modules. One focused on color theory and included content adopted from a desktop multimedia textbook used in 100-level graphic design courses. The second focused on photosynthesis and replicated content in a 100-level Biology text. Figure 2 illustrates the design and structure of the modules. This was not a comparative study. Rather, two modules were used to ensure diverse educational content with the understanding that subject matter could affect perceptions of the experience. Modules included text (approximately 2,500 words), videos and animations (five, two-minute segments per module), and interactive graphics (two per module). Built-in tools, such as highlighting text, saving portions of highlighted text on a separate page, and bookmarking important content were supported. Users could also stop, rewind, fast-forward, and replay audiovisual content and insert

Table 1. Participants attended a 90-minute study session during which they met one-on-one with the researcher.

Description of Activity	Time
Introduction: Overview, consent, training	**10 m**
Study Session: Participants were asked to study the module as they would for a class reading assignment.	**20-30 m**
Break: Mitigated fatigue and established separation between "study session" and "review session"	**10 m**
Review Session: Participants were asked to review module and notes as if preparing for a quiz.	**15-25m**
Quiz over studied material: Five-question, short answer quiz included open-ended questions to mitigate possibility participants could guess correct answers.	**15-20 m**
Semi-Structured Interview (audio recorded): Interviews included pre-established and follow up questions to elicit feedback about the experience.	**10 m**

annotations near videos. iBooks Author was used to develop the modules, the design of which mirrors most tablet textbook platforms currently on the market. iBooks Author offers all the necessary functionality for simulating typical active reading behaviors offered by other tablet textbook platforms, such as highlighting text, making personalized notes, and reorganizing annotations for future review. McGraw-Hill, Pearson Education, and Houghton Mifflin Harcourt–the world's leading textbook publishers–all have created iBooks Author titles.

Participants

Thirty undergraduate students (aged 18-20; 12 male, 18 female) at a mid-sized Midwestern University were recruited from a 100-level mass media course. Participants were given extra credit in exchange for participation. Most reported limited experience with digital textbooks. None had extensive experience with interactive, multimedia tablet texts. Only seven owned a tablet device; and nine said they had read a textbook on a tablet before.

Procedure

Participants were randomly divided into two groups of 15, and each group was assigned one of two tablet-based modules (color theory or photosynthesis). Table 1 details procedures meant to instantiate a typical study session. Sessions included time to initially study the material, a break, and time to review. An introduction and follow-up questions rounded out the research.

This study was not intended to assess learning, but to uncover problems that may emerge when learners attempt to engage in active reading with a multimedia tablet textbook. Therefore, no longitudinal retention data was collected. Quizzes were administered to strengthen the study design based on two assumptions. First, because sessions were not tied to performance in a specific course, it was possible participants might not have studied as carefully as if they were being graded. By instructing students to prepare for a quiz, we could better simulate an actual study session. Second, by gauging how thoroughly participants studied material, we could better assess the specific nature of their active reading behaviors. Interview questions revolved around participants' perceptions of usability related to the overall experience, as well as individual active reading features.

Data Analysis & conversion

Three types of data were collected: 1) observational notes taken by the primary researcher, 2) participants' paper notes and frame grabs from tablet annotations and notes, and 3) responses to semi-structured interviews. Qualitative data analysis software was used to code all three types of data.

Observational notes

The observer noted participants' interactions with the device, such as the number of times he/she paused a video to take notes or re-watched a video. Likewise, notes taken outside the device–such as sketching notes while a video played–were also cited. Observational notes generated 72 units across 30 participants. A unit was defined as a specific active reading activity, strategy or behavior observed by the researcher. Each unit of analysis was assigned a code to represent a summative, salient, and/or essence-capturing attribute (Saldana, 2009). Four key themes emerged from observational notes, which are discussed in the forthcoming section. Behaviors observed for at least one-fourth of participants were considered pervasive.

Semi-structured interviews

Interviews generated 1,962 units across 30 participants. Transcript analysis included the development of a coding schema designed to illuminate learner behaviors, active reading strategies, and opinions about the active reading experience in the multimedia tablet environment. Each unit of analysis was again assigned a summative code to capture the essence of the feedback (Saldana, 2009). A “unit” was defined as any simple sentence or coherent fragment. Collections of codes of similar content were developed so that data could be grouped together. The coding schema revolved around observed active reading behaviors and participant comments regarding experience and ease of use, perceptions of the quality of content, how interactivity and multimedia content affected the learning process, additional strategies used to annotate and take notes (e.g., use of paper), and study habits. Data was tallied to form a summative picture of the most common and/or significant themes that emerged. Table 2 (in the results section) shows the complete coding schema and illustrates the number of participants who made one or more statements related to an individual code.

Participants’ annotations

Paper notes and frame grabs were analyzed using a standard artifact analysis method to provide a qualitative interpretation of the general properties of notes (Given, 2008). Artifacts were analyzed for general content and organization. Similar artifact observations were grouped together and counted. A total of 16 pages of written notes and 231 pages of in-text frame grabs were collected. Finally, responses to quiz questions were evaluated for accuracy. Answers were

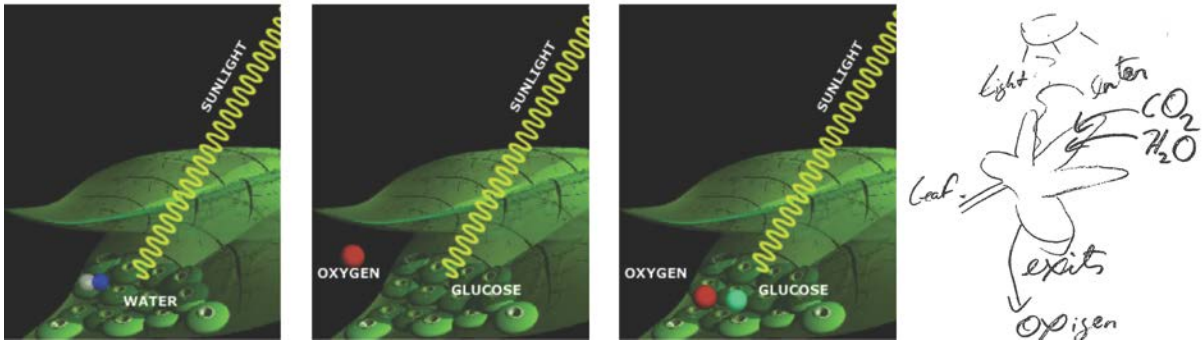

Figure 3. Sketching video frames–Participants often combined several frames of an animation into a single sketch.

coded as *correct*, *incorrect*, or *partially correct* (a portion of the correct answer, but still lacks completeness).

Results

The sections that follow report on the active reading behaviors observed during study sessions, through artifact analysis, and based on salient feedback from interviews.

Observed behaviors & artifact analysis

Four key behaviors were identified as a result of our analysis of observational data and artifacts generated during study sessions.

Sketching video frames

Participants frequently made sketches on paper while watching videos and animations (n=12) in an attempt to replicate the visual frames in their notes. Moreover, participants often tried to combine several frames of an animation into a single sketch. According to one participant [P22], “Sketching helps me work through the information on my own. I think it helps me remember the information better; but actually making the sketch helps too. It helps me understand it as I sketch it.” Another participant [P8] noted that, “I like the videos. It’s good to have the visual and the action to help me study and remember. But the more complicated videos,

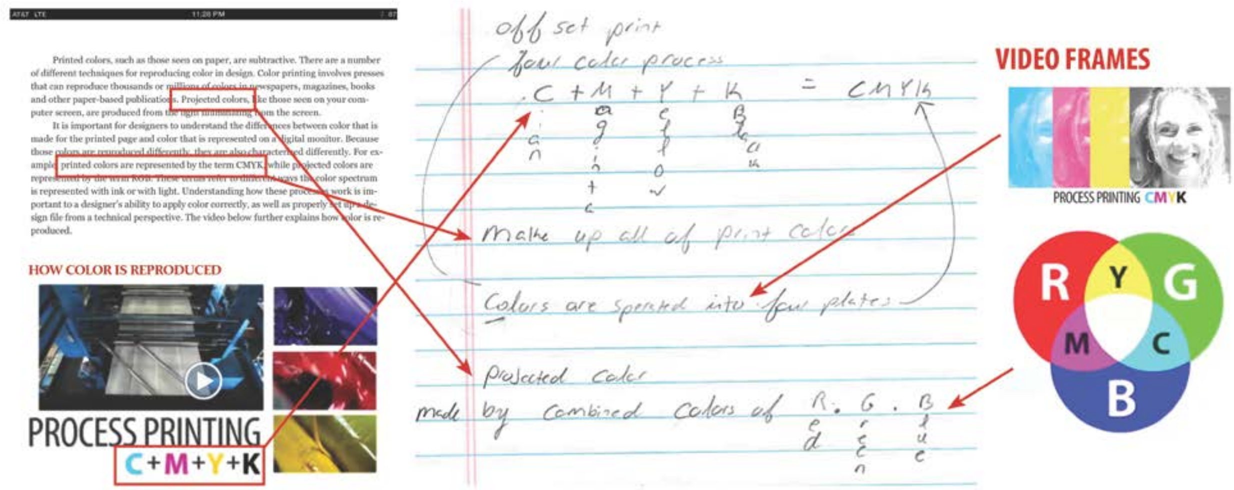

Figure 4. Annotating connections among notes and media formats–Participants created personally meaningful outlines that included lines and other symbols to connect concepts and notes to media formats.

processes, are hard to wrap my mind around because they are moving so fast. Sketching helps slow it down in my head.” Figure 3 illustrates how one participant tried to capture in a single sketch the substance of a 90-second animation explaining the chemical conversion during photosynthesis. Eleven other participants engaged in similar sketching strategies, integrating these sketches with the rest of their notes.

Annotating connections among notes & media

About one-third of participants (n=11) took notes on paper to avoid using the tablet keyboard. Eight abandoned the tablet annotation tools altogether in favor of paper. Participants who took notes on paper often tried to diagram and/or outline information in more personally meaningful ways than the system allowed (Figure 4). For example, several participants drew additional annotation marks to indicate when concepts in their notes were in some way connected, such as arrows, lines, circles, etc. One participant [P3] said, “I need to…sort of show myself how things go together in my notes. This is really important. These little lines and circles are meaningless to someone else. But to me, they have meaning and help me remember [and] understand.” Similarly, those who took notes on paper often marked their notes to indicate from where a particular concept was taken. For example, several participants (n=10) marked notes that were drawn from videos with a “v”, notes drawn from text with a “t”, and so on. One participant [P1] explained, “If I can recall where I first saw it, it’s easier for me to remember more of the information later. Since there are so many different formats here, it’s good to keep track of where everything came from.” When preparing for the quiz, most of participants who did this (n=8) only reviewed sketches.

Fixating on animation mechanics

Quiz results indicate that when answering questions drawn from videos and animations, participants often tried to describe what they remembered seeing in the visual sequences. However, they often fell short of rendering complete or accurate responses. For example, regarding the quiz instructions, “Explain the process of photosynthesis,” one participant [P17] rendered the following:

> *Photosynthesis is the process of sunlight reaching a plant to convert water and carbon dioxide into glucose and oxygen. The sunlight enters the plant and scatters the carbon dioxide and water to separate into the other two produced afterwards. Photosynthesis gives the plant energy to complete tasks by creating sugars.*

Figure 3 shows key frames of a video describing photosynthesis. Although the participant’s response is off to a good start, it begins to wander off as there was clearly trouble remembering all of the steps in the process. One participant [P29] indicated that prior to taking the color theory quiz, she felt confident. However, when trying to recall the printing process, she struggled to remember details well enough to feel confident with her answer. “When I was watching, I felt I understood the concept,” she said. “But then, when I had to describe it myself, I remembered what I saw, but not really exactly what I heard. It was hard to explain.” In these cases, learners seemed to remember the general mechanics of the videos but had less firm a grasp on the descriptive content. Three of the five quiz questions referenced content delivered in the form of a video animation, which generated 90 answers across 30 participants. This tendency to describe animation mechanics (or visual sequences) as opposed to supply an accurate answer to the question was present in nearly half of the responses (n=43).

Tension between operation & learning

More than two-thirds (n=22) frequently paused, rewound, and re-watched videos while taking notes so as not to miss audiovisual content that would continue to play when they were looking away from the screen (Figure 5). Many participants also re-watched videos or portions of videos more than once (some as many as five times). Some rewound and re-watched content they missed while looking away; others did not, potentially missing important information. By way of example, during a five-minute interaction with a 40-second video, one participant paused the video nine times to take notes, re-watched a portion of it four times, and re-watched the entire video three times.

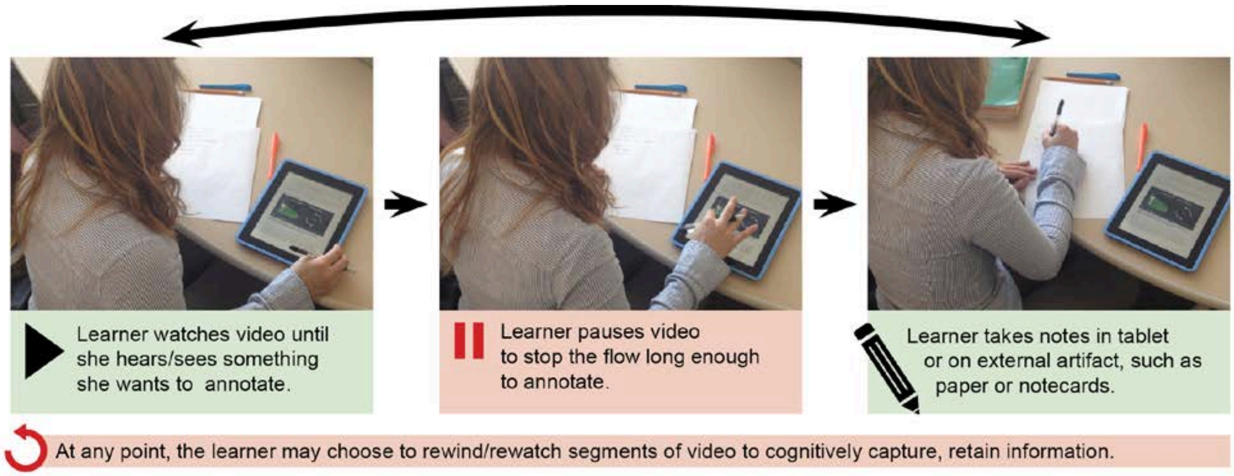

Figure 5. Struggling with the tension between the operation of audiovisual content and the learning process – To effectively annotate video, learners must either: 1) write notes while trying to follow along, requiring them to split their attention between listening, watching and writing; or 2) stop the flow by pausing the video long enough to write notes.

Interview findings

Overall, participants found the tablet textbook enjoyable and easy to use and navigate. More than half said the it was more efficient, convenient, and/or organized than print textbooks. Some said they found the tablet textbook to be more engaging than previous experiences with printed textbooks. Likewise, most participants reported tablet content was easy to understand and study. On the other hand, nearly half reported being confused or frustrated by some aspect of the interface at least once, with most complaints made in reference to a lack of familiarity with touch screen gestures for annotation. Nearly all were frustrated by the limited ability to annotate videos and animations. Yet, most (n=27) reported that in the future they would prefer tablet textbooks, citing convenience, interactivity and multimedia as attractive features for learning. To clearly categorize participants' feedback, additional responses can be matched with the four most common active reading strategies: annotating, cross-referencing, reorganizing, and browsing.

Table 2. The coding schema was designed to illuminate learner behaviors, active reading strategies, and opinions about the active reading experience during the qualitative study. Collections of codes of similar content were developed so data could be grouped together. This table offers a summative picture of the most common and/or significant themes that emerged as well as the number of participants who made one or more statements related to an individual code.

Feedback gathered during participant interviews	Percent Occurrence (by participants)	N=P
Operating the Tablet Textbook: General Interface Mechanics		
Tablet was easy to use, navigate	**90%**	**27**
Tablet was more engaging than printed textbooks	**33%**	**10**
Tablet is more efficient, convenient, organized than a print textbook	**57%**	**17**
Tablet experience was enjoyable	**73%**	**22**
Tablet interface was confusing at times	**43%**	**13**
Tablet experience was not enjoyable	**7%**	**2**
Some parts were enjoyable; others were not	**20%**	**6**
Active Reading Mechanics Ease of Use: Annotating, Reorganizing, & Browsing		
The mechanics of operating the active reading tools were distracting	**33%**	**10**
It took a few minutes to get used to the active reading features	**43%**	**13**
Had to pause and/or rewind video frequently	**40%**	**12**
Annotation of text was easier on the tablet than on printed textbooks	**53%**	**16**
Annotation of text is easier in printed textbooks than on the tablet	**3%**	**1**
Color coding highlights helps organize information	**17%**	**5**
Seeing annotations all in one place makes them easier to study	**57%**	**17**
Tablet note taking tools are difficult to use, ineffective	**32%**	**7**
Lack of video annotation tools was not a problem	**10%**	**3**
Lack of video annotation tools was frustrating	**90%**	**27**
Paper is better than tablet for annotation/note taking	**43%**	**13**
Moving video and/or audio is difficult to annotate/take notes		
Content recall & Cognitive Processing		
Video, animations & graphics help me remember/recall information better than text	**73%**	**22**
Video commanded concentration, focus, attention, interest; aided recall	**80%**	**24**
Video is more engaging, informative than text, still images	**43%**	**13**
Had to re-watch video for it to sink in	**63%**	**19**
Re-watching video is an effective way to study	**10%**	**3**
Re-watching video is not an effective way to study	**90%**	**27**
Static text and/or still images are easier to follow than video	**27%**	**8**
Tablet content was easy to study	**83%**	**25**
Tablet was difficult to study	**17%**	**5**
It was difficult to make connections among annotations in the tablet environment	**50%**	**15**
Putting content "into my own words" aids in understanding and/or recall	**47%**	**14**
Reorganizing content in another format aids in understanding and/or recall	**17%**	**5**
Writing on paper aids recall	**40%**	**12**
Videos did not command concentration, focus, attention, interest	**20%**	**6**
Overall Quality of Tablet Textbook Content		
Content is interesting, easy to understand	**83%**	**25**
Content was not interesting, easy to understand	**17%**	**5**

Annotating & highlighting

Feedback regarding annotation was mixed, depending on whether participants referred to highlighting and note taking over text-based content or audiovisual content.

Annotation of text-based content was characterized as easier on the tablet than in printed textbooks for about half of the participants (n=16). Similarly, about half reported that the ability to see all annotations in one place makes it easier to study (n=17). At the same time, about a third (n=7) said the tablet note taking tools are difficult to use. *Annotation of audiovisual content* did not fare well among most participants, who said existing tools were insufficient. Most participants said viewing video, animations, and visualizations helped them recall information better than reading text. But most also said re-watching video over and over again, pausing/rewinding the video frequently to take notes, and/or trying to take notes while the video is playing without stopping/rewinding are not efficient or effective ways to study. Figure 6 shows a complete summary of participant feedback regarding annotation of video.

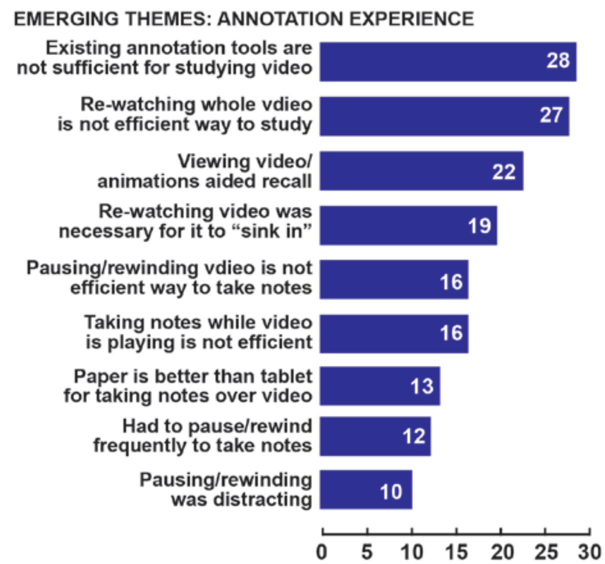

Figure 6. Annotation of video and animation

Cross-referencing & operating system mechanics

Half of the participants (n=15) reported that it was difficult to make connections among annotations, notes, and/or pages or segments of content. They cited four main challenges explained below and visualized in Figure 7.

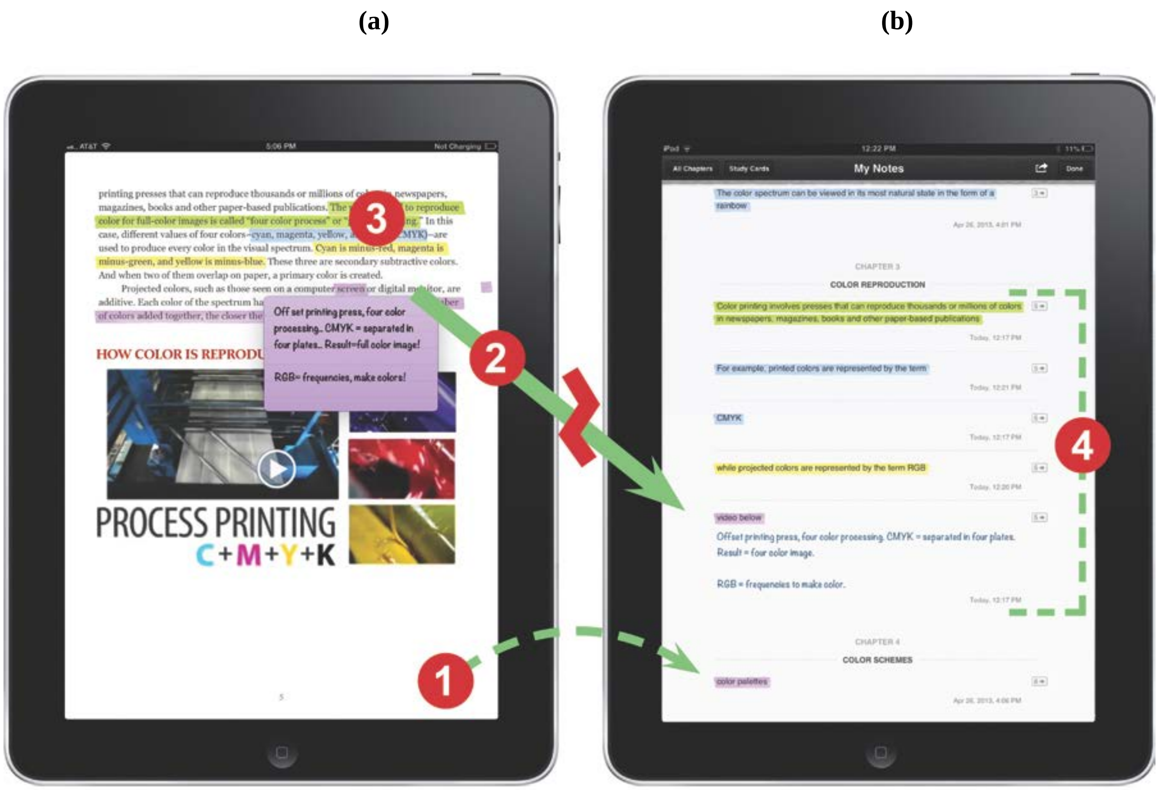

Figure 7. Four main breakdowns challenged learners' active reading process.

1. The ability to see only one page at a time makes it hard to quickly "flip back and forth" among multiple pages (n=15). As a result, learners struggle to efficiently cross-reference annotations (made both on paper and within the tablet textbook environment) with the original source material in the body of the text. This complaint is consistent with prior research (O'Hara, Taylor, Newman & Sellen, 2002) that suggests that traditional books provide an important visceral affordance by allowing learners to quickly scan through a number of pages and maintain a sense of orientation with their progress through a chapter and pages of content in relation to one another.
2. Important contextual connections are lost when annotations are viewed as a list, organized in the order they were made and separate body of the chapter (n=12). For example, highlighting a single word or sentence fragment is common practice among

learners studying a traditional print text. However, in the tablet environment, highlights typically appear isolated in the digital notebook (illustrated in Figure 7b), completely separate from the originating page. As a result, individual highlights are rendered useless, as it is often difficult for learners to remember the specific significance of a highlighted word or phrase when it is taken out of context. A learner can tap a button to return to the page on which the highlight appears. However, this action subsequently takes them away from the notebook and out of the flow of that particular review experience. This can be both disorienting and cumbersome.

3. Typing is more cumbersome than writing. Thus, taking notes on paper is easier than doing so with the tablet keyboard (n=12). Participants voiced that it was much easier and faster to write notes on paper than it was to use the tablet keyboard.
4. When notes taken over audiovisuals are combined with notes from text-based content, it is difficult to mentally map content to its original source (n=11). For example, when a learner adds a personalized note to the text, the note is generally “attached” to specific content, such as a paragraph of text or a whole video. However, when the learner reviews a collection of notes in the notebook, each annotation appears by itself, with no specific reference to the content it was originally attached to. Thus, in order to review often-important contextual information, the learner must tap a button to return to the originating page, leaving the notebook entirely. Additionally, existing tablet textbook formats, like Inkling and iBooks Author, only allow the learner to attach notes to a video, but not to individual points within that video. Thus, although a learner may have multiple notes associated with a single video, there is no way to discern what part of a video each individual note references during a review session. These issues can be both disorienting

and confusing when learners are trying to remember the significance of an individual audiovisual annotation.

Interactivity while browsing

At present, two methods for studying annotations are supported in most tablet-based texts. The first is scanning previously read pages in search of annotations. The second is scanning the automatically generated list of annotations made by the learner during the initial read-through. Several participants reported that reorganizing content in this type of outline aids understanding or recall. However upon completing the quiz, a third of the participants said that scanning pages for annotations and/or reading over a collection of annotations was less effective than they thought for helping remember what they read. Although most participants were able to answer the quiz questions with some degree of accuracy, most said more interactivity during the studying process would be more effective. In fact, participants were largely in favor of any feature that allowed them to interact with the device, noting that interactivity was engaging and aided in recall. Most likened interactivity to the same type of cognitive processing that occurs when writing notes, putting material "in my own words," and outlining a significant section of content.

Discussion

Research questions revisited

RQ1: *Do current frameworks of active reading sufficiently address the key activities learners use when studying a multimedia tablet textbook?* We assert that the current notions of active reading do not sufficiently addresses all of the key activities learners use when studying a tablet textbook. This was especially manifest when text, audio, video, and other multimedia content on a single topic are combined in one learning module. Differences in the ways users engage with them (i.e., read, watch, listen, touch) can be as distracting as they are engaging. Thus, although annotating, reorganizing, cross-referencing, and browsing are still relevant, their application is more complex in the tablet textbook. Thus, an effective tablet textbook must go beyond traditional active reading tools and be re-imagined to better support learners' complete active learning needs.

RQ2: *What active reading strategies and/or behaviors emerge when learners engage with interactive, multimedia content?* Our results identified key behaviors learners may enact when studying a tablet textbook. These strategies represented one of two themes: 1) adapting familiar active reading strategies to audiovisuals (*sketching video frames* or *integrating concepts embedded in multimedia with notes drawn from other sources*); or 2) toiling with the mechanics of audiovisual content (*recalling animation mechanics rather than accurate content* or *struggling with the tension between the operation of audiovisual content and the learning process*). Furthermore, interview results confirm some specific challenges learners face when balancing the learning process with tablet interaction. This tension between learning with and engaging with a tablet textbook must be minimized for learners to have efficient and satisfying active reading experiences. The sections that follow illuminate the most important themes related to the balance between learning and interaction mechanics. Additionally, we return to the cognitive theory of multimedia learning to inspire novel designs that may better support active reading.

Challenging "content-format mapping"

Content-format mapping of multimedia can be defined as a learner's attempt to make sense of and subsequently remember content delivered in different media formats. Even the simplest forms of multimedia learning represent “a demanding process that requires selecting relevant words and images, organizing them into coherent verbal and pictorial presentations, and integrating the verbal and pictorial presentations with each other and with prior knowledge” (Mayer, 2009, p. 75). Thus, it stands to reason that the interactive tablet textbook represents a heightened level of complexity by integrating content delivered in several media formats and designed as a browse-able book.

One way participants attempted to cope with this complexity was to mark their notes in an effort to trace ideas, concepts, and key segments of information back to the media format in which it was first encountered. Some users also made markings in their notes to indicate that concepts from different segments of a chapter relate to one another. This strategy represents a form of mental mapping, as learners articulated a need to mentally connect information to the media format in which it was delivered.

The fact that learners struggle remember content delivered in this integrated multimedia book-like format suggests that existing tablet textbooks may create an increased demand on cognitive load during the textbook reading and studying process. Although participants may have expressed that the tablet textbook *was easy to navigate and operate* in a general sense, this sentiment doesn’t necessarily translate to *easy to study* (or easy to recall) when it comes to employing active reading and learning strategies. Moreover, the breakdowns illustrated in Figure 7 further reflect challenges participants faced in making connections among annotations and notes, both across all content and among information presented in different media formats. Ultimately, this may make it difficult to migrate from print texts to their multimedia tablet counterparts. Of course, content-format mapping is not a new concept, nor is it unique to active reading. However, the behaviors – both physical and cognitive – that learners use to develop mental maps of the tablet textbook are not only different, but potentially more complex than those developed for print textbooks and singular audiovisual presentations.

Transient & elusive audiovisual content

Two key behaviors observed while participants were engaged in active reading – *sketching video frames* and *integrating concepts in multimedia with notes drawn from other sources* – demonstrate that learners struggle with the transient nature of audiovisual content. For example, moving animations – while highly visual and explanatory in nature – are also comprised of sequential images and audio, which are gone from view as quickly as they first appeared. Because of this, any attempt to *carefully study* audiovisual content is thwarted by its very nature. Not only is it difficult for students to maintain focus, the transient nature of audiovisual content is such that the focus of the content is constantly changing. This finding is consistent with scenarios outlined in the cognitive theory of multimedia learning, which notes that "in viewing a fast-paced narrated animation that explains the steps in a process, some learners may not fully comprehend one step in the process before the next one is presented, and thus, they may not have time to see the causal relation between on step and the next" (Mayer, 2009, p. 175). What is significant about the observed active reading behaviors is that when placed in a study session involving a tablet textbook, participants tried to counteract the dynamic nature of moving pictures and audio by freezing it in the form of a single image to be used for future review. This suggests an interesting dichotomy regarding whether still images or videos/animations are more effective. While the dynamism of a video may be more engaging to *consume*, the static nature of the still image may be easier to *study*. Thus, rather than favoring one over another, perhaps an effective active reading system would allow users to capitalize on the values of both. It is worth noting that this type of approach would broaden the application of multimedia learning principles by exploring how they can be used to inform novel designs that support active reading.

Distracting mechanical interaction

Complex mechanical interaction makes watching and annotating audiovisual content potentially distracting and cumbersome. Unlike a printed book in which page turning and writing with a highlighter or pen represents the bulk of the interactivity, the tablet textbook requires more. Active readers in this environment also must enact a complex set of system mechanics necessary for annotating and otherwise interacting with the textbook. Although a few proposed systems allow users to annotate online video by inserting notes onto a timeline, none addresses the stress between the amount of attention learners must devote to mechanical interaction and whether the content is actually "sinking in." In short, all that time spent pausing, rewinding, and re-watching pulls learners away from focusing on the information. This tension was reflected in both the observed behavior *struggling with the tension between the operation of audiovisual content and the learning process* and the most common frustrations participants expressed during interviews. These deficiencies either force learners to develop new strategies to work around the system's limitations or leave them frustrated as they fall short of their complete active reading goals.

Implications for active reading tools

Rethinking annotation & highlighting

Annotating video is physically and cognitively different from annotating text. Thus, we recommend a few key requirements for future active reading tools based both on the findings from this preliminary study and relevant principles of the cognitive theory of multimedia learning, which to date has been limited to individual animation + audio presentations.

Annotation systems should be flexible, allowing learners to choose from a number of ways to annotate and review. For example, learners could be provided with a mechanism for annotating a text-based transcript accompanying a video. This could provide a more concrete reference for studying annotations and accessing video segments that correspond to points in the transcript. This concept could be viewed as contradictory to the redundancy principle of multimedia learning, which states that people learn better from graphics and aural narration, rather than graphics, narration and text (Mayer, 2009). However, Kalyuga, Chandler & Sweller (1999) found the redundancy principle applies only when text and audio are presented concurrently. Thus, a transcript that is accessible to a learner after the video has been watched at least once could provide learners with a more concrete reference for studying integrated multimedia content. Additionally, the system could allow learners to extract short segments of a longer video that they can access and reuse during a subsequent study session. With more options for video annotation, learners have more opportunities to assert personal preferences on the active reading experience. This concept is consistent with the segmenting principle of multimedia learning, which states, "people learn better when a multimedia message is presented in learner-paced segments rather than a continuous unit" (Mayer, 2009, p. 175).

Improving core study tools

Cross-referencing, reorganizing, and browsing represent the bedrock of active reading. Yet, existing tablet textbook platforms–such as iBooks Author, Inkling, and Kno, to name a few–typically reorganize notes into a long list. These designs exist in spite of the fact that according to multimedia learning theory, meaningful multimedia learning depends on building connections between mental representations of corresponding words and pictures (Mayer, 2009). Our results suggest that the current design paradigm for concatenating a learner's annotations and notes in a multimedia tablet textbook may not sufficiently help learners study those annotations later. In the list format, it is often difficult for learners to make sense of their notes as study aids. Furthermore, the list structure contradicts the very fabric of active reading, which requires that learners be able to make connections among various types of annotations, as well as review and organize notes in a personally meaningful format. Thus, outlining tools should be more robust. For example, learners should be able to see annotations in a format that visually illustrates how concepts pulled from various places or media types are related. This feature could help users isolate important information while keeping contextual cues intact, allowing learners to more quickly make sense of their notes and review them for future recall.

Key Requirements

In summary, based on the findings of this study, we identify the following key requirements for improving the active reading experience in the tablet textbook environment:

R1: Develop new annotation tools that better support active reading goals as applied to audiovisual content. For example, learners may be able to extract smaller segments of a video, a video frame grab, or a key term in the video for future review.

R2: Provide more concrete ways to access important information presented in the often transient and elusive audio format.

R3: Improve the organization of annotations so learners more easily able to recall the original source format (i.e., audio, video, text, etc.) of an individual note; make conceptual connections among notes that have been combined into a study guide; and filter notes in multiple ways, i.e., by type and/or by topic.

R4: Provide tools that allow learners to achieve their active reading goals (i.e., annotation, saving portions of the text for future review, etc.) without taking them out of the flow of learning, which involves careful attention for effective consumption and comprehension of the educational material.

These requirements are important considerations for designers of active reading tools to better bridge the gap between current paper and pen technologies and emerging digital textbook environments.

Limitations

Subject matter alone could affect a student's perceptions of the tablet textbook experience. Likewise, some content may be more suitable for studying active reading behaviors than others. We tried to address these concerns in a few key ways. First, we provided two different modules of vastly different subject matter to ensure some degree of content diversity. Second, we included several segments of audiovisual content in each module to trigger a variety of active reading behaviors. Third, we emulated, as closely as possible, both the design of a typical tablet textbook and the typical active reading study session. Together, these aspects of the research design allowed us to collect valuable insights to better understand active reading in this environment.

Conclusion

Active reading is fundamental to learning. However, our understanding of active reading is currently tethered to traditional print and paper and pen activities. In spite of some novel affordances offered by digital reading devices, students and teachers alike remain reticent about widespread adoption of electronic textbooks. A primary concern is that they do not sufficiently support students' goals and techniques for consuming educational content as effectively as their paper counterparts. Our research uncovered empirical evidence that current tablet textbooks could hinder learners' active reading experiences, as well as force them to enact potentially cumbersome or inefficient strategies to achieve their active reading goals. Specifically, this paper characterized some of the challenges learners face as they grapple with the mechanics of operating the tablet, struggle to effectively annotate sequences of information delivered in audiovisual content, and labor to cognitively make connections between annotations and the source content/media format from which they originated. All of these challenges present potentially detrimental distractions from learning.

Overall, this exploratory, qualitative study sheds new light on the nature of active reading with tablet textbooks by uncovering evidence of both usability and cognitive processing problems. Ultimately, these findings elucidate directions that are crucial to our understanding of next-generation active reading tools and tablet textbook design. Our future work includes design and development of a set of novel annotation and study support tools called SMART Note. We will then compare SMART Note to annotation and study support tools in existing tablet textbook platforms. Specifically, we will explore and compare usability, user experience, student learning outcomes, and levels of efficiency during annotation and study tasks. Additionally, future work will revisit the active reading framework with an eye toward further evolving our understanding of what it means to actively read and study educational material in the digital space.

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