SMART Note: Student-Centered Multimedia Active Reading Tools for Tablet Textbooks

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Abstract. Active reading is a fundamental task for the study experience, yet existing tablet textbook platforms fail to provide the wide range of flexibility required for active reading, particularly when multimedia content is included. To address this, we propose SMART Note, a set of active reading tools that provides learners with novel annotation and reorganization methods intended to better support active reading in the tablet environment. In an evaluation study with SMART Note prototypes, users had high success rates with usability inspection tasks and rated novel annotation and reorganization tools more favorably than tools offered by most existing tablet textbook platforms. Our work builds a foundation for future research that explores how SMART Note affects active reading and learning with multimedia tablet textbooks.

Keywords: Active reading, tablet textbooks, educational multimedia, usability.

1 Introduction

With the advent of tablet devices, a new breed of textbook is emerging that combines the physical affordances of traditional textbooks with rich multimedia. Tablet textbooks are now designed to look like browse-able books and often seamlessly integrate interactive, multimedia content and tools to support user interaction and active reading. As tablet textbooks become more prevalent, so too will the inclusion of audio and video in educational textbooks. However, existing tablets and eReaders fail to provide learners with the wide range of flexibility that is required for active reading [4, 17]. Likewise, students may have difficulty migrating from the print textbooks with which they are familiar to interactive digital textbooks, particularly when multimedia is added. In the digital world, learners are accustomed to *reading* text, *watching* video, and *listening* to audio. Yet, they must *study* all three in a tablet-based multimedia textbook. Therefore, the strategies they have been accustomed to using for static, print textbooks may not be sufficient for tablet textbooks.

The physical nature of active reading involves several strategies that generally fall into one of four categories: annotation (highlighting, note taking), reorganization (outlining, summarizing), cross-referencing (working back and forth among documents, annotations, etc.), and browsing (studying artifacts developed during the

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other phases). These strategies are meant to assist an active reader in the necessary cognitive processes for learning, which include describing, critiquing, and building an analysis of a document in order to form an understanding of it. Generally accepted methods for active reading include highlighting, making notes in margins, organizing notes into outlines, making flash cards for future review, and other similar practices. These activities are help learners identify important parts of a text and organize notes in meaningful ways that are conducive for repeated review. However, recent studies suggest certain reading tasks, such as preparing for exams [19], reviewing texts for research or to prepare for class [18], and reading to learn specific information [13] are challenging with eReaders. Likewise, annotating can be cumbersome, as mechanical interaction with the device often interrupts the flow of learning. This raises several important questions about the learning process when it comes to tablet textbooks. For example, what does it mean to study integrated multimedia content–i.e., multiple videos/animations, audio clips, expository text, interactive graphics, and more–in the context of an interactive, digital document designed to look like a browse-able book? Additionally, what types of tools must be developed for users to achieve all of their active reading and learning goals in the multimedia textbook?

To address these concerns, we propose SMART Note, a set of tablet textbook tools that provides learners with novel annotation and reorganization methods intended to better support active reading in the tablet environment. The SMART Note design is based on findings from a prior study that suggests 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. Specifically, this paper makes the following contributions:

- Introduces SMART Note, a novel active reading tool that is based on the learner behaviors specific to a multimedia tablet textbook;
- Assesses usability of SMART Note at two stages of fidelity with 20 users;
- Envisions possible improvements in the learning process when SMART Note is applied to an interactive, multimedia tablet textbook.

Following is a review of related literature and existing tools. We then report on results from an iterative design and usability study that assessed SMART Note at two stages of fidelity. Directions for future research and development are also addressed.

2 Related Work

This work draws on three interrelated fields: 1) active reading, 2) multimedia learning, and 3) current state-of-the-art in tablet textbooks and active reading technologies.

2.1 Active Reading and the Digital Space

Active reading involves reading and studying to understand a document's structure or purpose [1] and reorganizing (e.g., outlining or summarizing) and browsing (e.g., studying annotations and outlines for future recall) [2]. Most research on active reading has focused on the strategies enacted on paper and with narrative text. However, a few studies have indicated that students may have difficulty migrating from print textbooks to interactive digital textbooks, particularly when multimedia is added. Students also exhibit trouble building mental maps of content when it is presented in a nonlinear fashion [19]. Likewise, they have difficulties adjusting to new ways of annotating [14]. Because of this, prior research has indicated that in spite of some novel affordances offered by digital reading devices, learners still generally prefer paper because it easily supports a wide range of active reading requirements [17]. Although significant progress has been made for supporting active reading in the digital space, most systems fall short of providing an active reading experience that fully matches the flexibility learners' desire [16]. At present, college students are moderately traditional in their attitudes toward using tablets and eReaders for textbooks because they believe tools intended to aid in studying are in need of further improvement before they will be fully accepted and widely used [8].

2.2 Multimedia Learning Theory

The Cognitive Theory of Multimedia Learning [15] is a foundation for exploring active reading of interactive, multimedia textbooks. The theory asserts that the presentation of information in both words and pictures facilitates optimal learning conditions. Well-designed multimedia messages therefore foster deeper understanding when they rely on the brain's dual coding ability, processing words and visuals through two different channels of the brain and maximizing understanding. In this regard, multimedia messages are learner-centered rather than technology centered. There is consensus among scholars that technology-centered approaches to learning generally fail to lead to lasting improvements in education [7]. Deficiencies in active reading support among existing tablet textbook environments, therefore, necessitate further research to determine how multimedia textbook developers can implement established principles of multimedia learning to better facilitate active reading. Furthermore, research has shown that processing educational video increases cognitive load because it is difficult for students to synthesize visual and auditory streams of information and extract the semantics of the message [10]. Therefore, a key concern in using video as an instructional device is creating conditions for learners' cognitive systems that help address the processing demands needed to organize and integrate knowledge from dynamic media like video [11]. Ultimately, novel active reading tools must provide learners with better annotation and organizational support.

2.3 Tablet Textbooks and Active Reading Technologies

Tablets have gained traction in education as a number of publishers, namely Pearson and McGraw Hill, have taken the lead in the tablet textbook market. Both companies are partnered with digital publisher Inkling to test-drive new interactive textbooks at several universities [6] and re-imagine the traditional textbook to provide students with a tablet-based multimedia experience. Inkling books boast a number of active reading features, including the ability to highlight text, take notes and explore clickable keywords (annotation); add bookmarks and mark notes others have posted in a social learning network (reorganization); and browse collections of highlighted text, notes, and glossary terms (browsing). New systems that simulate paper and support novel ways of annotating text have also surfaced. Multi-Slate [4] is composed of several interconnected "slates" to provide learners with flexibility required for active reading. Similarly, PapierCraft [12] simulates paper with tablet PCs. Usability research suggests that these and similar systems that combine the affordances of paper and computers may be promising alternatives for overcoming some challenges students encounter with educational content on tablet devices.

3 SMART Note: Student-Centered Active Reading Tools

SMART Note is envisioned as a suite of multimedia annotation tools for tablet textbooks that integrate traditional narrative text with interactive, multimedia content. SMART Note includes features meant to improve two main aspects of the active reading experience. First, SMART Note allows learners to enact several different annotation strategies on multimedia content, while minimizing interaction with the device. Cumbersome interaction mechanics often distract users from content and take attention away from the flow of learning. Second, SMART Note offers more concrete reference points for mentally mapping a collection of annotations back to their original media sources. When content is presented in multiple media formats, it may become difficult to remember from where individual pieces of information originated.

3.1 SMART Note Rationale and Key Requirements

We conducted an exploratory field study to elucidate the nature of active reading in the tablet textbook [9]. Results suggest that this environment represents a heightened level of complexity for learners. Specifically, we identified key active reading behaviors learners enact in the multimedia tablet textbook environment, as well as breakdowns in their ability to access and study annotations effectively:

Sketching Video Frames. Participants often sketched on paper while watching videos to replicate the visual frames in their notes. Some combined several frames of an animation into a single sketch. Participants who did this said it helped them capture information delivered in transient and consequently elusive moving images and audio.

Annotating Connections among Notes and Media. Learners often created diagrams to indicate the media format in which individual pieces of information were originally

delivered (i.e., *v*=video). They also drew additional marks to indicate when concepts in their notes were in some way connected. Many said they did this because important contextual connections are lost when annotations are viewed as a list. They also said that when annotations over audiovisuals are combined with annotations from text-based content, it is difficult to mentally map information to its original source.

Fixating on Animation Mechanics. Learners often tried to describe what they remembered seeing in the visual sequences of a video, but failed to render complete or accurate explanations. In these cases, learners seemed to remember the general mechanics of the videos but had less firm a grasp on the descriptive content.

Ultimately, the tensions between learning with and engaging with a multimedia tablet textbook must be minimized for learners to have efficient and satisfying active reading experiences. SMART Note is designed to help learners to achieve their goals while mitigating challenges faced when interactivity and multimedia are integral parts of studying. The following requirements have, thus, driven the SMART Note design:

R1. Develop new annotation tools that better support active reading strategies applied to audiovisuals.

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

R3. Improve the organization of annotations so learners are more easily able to recall the original source format of an individual note, filter notes by type, and make conceptual connections among notes combined in a study guide.

R4. Allow learners to enact their active reading goals without taking them out of the flow of learning, which involves careful attention for effective comprehension.

3.2 Primary Features

SMART Note presents learners with four main ways to annotate video (Figure 1), three of which are new and allow learners to annotate audiovisuals in different ways with a simple button tap. Annotation features are designed to mitigate distractions often caused by the mechanics of interaction and keep learners in the flow of learning. A study guide tool is also included and serves as a visual outline of the most salient portions of a text and a logical organization of a learner's annotations.

Annotation. Included in the SMART Note interface are three new audiovisual annotation features: *Segment Capture*, the ability to capture and annotate short segments from a longer video; *Transcript Annotation,* the ability to highlight and annotate a transcript that corresponds with the audio track; and *Key Term Capture,* the ability to capture key term definitions as they are revealed in a longer video. Like other systems, SMART Note also allows learners to annotate points along a timeline that corresponds with a video. The new tools allow learners to be more granular with their annotations and more easily access portions of a longer video for future review.

Segment Capture directly ties to results from the preliminary study that indicate annotating a single point along a video timeline doesn't provide users with context for an individual note. By allowing users to capture and annotate shorter segments, they are able to easily and quickly access portions of a longer video and avoid grapping

with interface mechanics. *Transcript Annotation* allows learners to see a dynamic text version of audio accompanying a video or animation. The transcript can be highlighted, saved for future review, and used to navigate to the corresponding point in the video. The transcript annotation feature directly ties to results from the preliminary study that suggest that audiovisual content is often transient and elusive. Transcript annotation provides learners with a concrete artifact that is easier to access and review later when preparing for exams or assignments. *Key Term Capture* allows learners to activate a *popup view* that alerts them when keywords and phrases are mentioned in a video. Learners may choose to capture a key term and definition, which are then saved separately with other annotations. The key term capture feature also provides learners with a concrete artifact for sometimes transient audiovisuals.

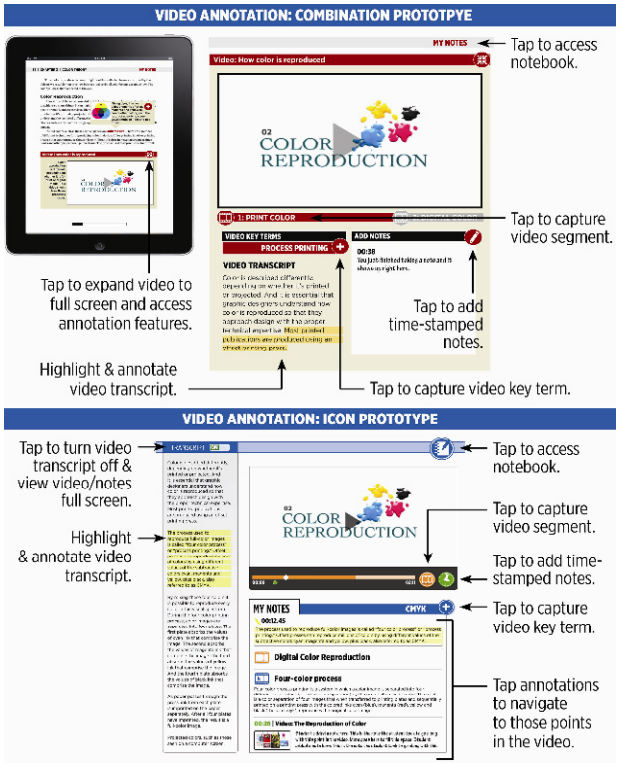

Fig. 1. SMART Note allows users to annotate video in four key ways: segment capture, key term capture, transcript annotation, and time-stamp annotation

Reorganization. SMART Note also includes a notebook and Concept Map Study Guide (Figure 2) where learners can access and review annotations in one place. Other systems often present annotations in a long list with little to no reference to their originating sources. SMART Note provides additional contextual cues and allows users to choose from two different presentation views. *List View* is organized by different kinds of annotations in the order they wee made, and learners can view

all annotations at once or filter them by type. Labels or icons also indicate the type of media format in which the original content was delivered. *Map View* presents learners with an interactive concept map or flow chart that illustrate connections among main concepts in the chapter. The concept map is organized topically so learners can see a complete framework for the material they read and so their annotations can be mapped back to key topics covered in the chapter. The Concept Map Study Guide feature ties results from the prior study that indicated it is difficult to make connections among content in the tablet textbook.

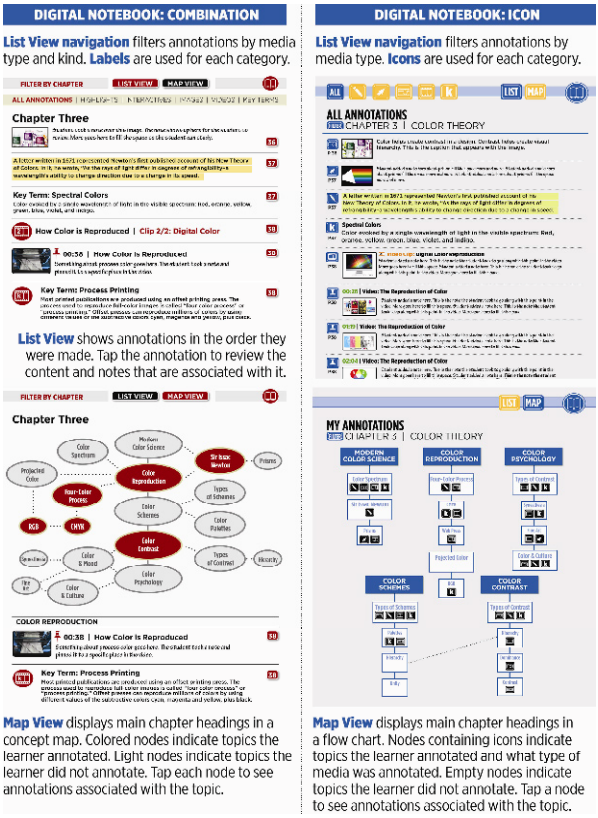

Fig. 2. The *Combination Prototype* (left) makes use of icons and text-based labels for annotation category filters and concept map labels. The *Icon Prototype* (right) makes use of icons for annotation category filters and flow chart labels.

4 Evaluation Study

A task-based study explored usability and user experience on SMART Note at two levels of fidelity. Following is a detailed explanation of the procedures and results.

4.1 Participants, Procedure and Stimuli

Participants. Twenty undergraduate or graduate students (aged 18-26; 10 male, 10 female) at a mid-sized Midwestern University were recruited to participate in the usability study via an all-campus email. The only inclusion criterion was that they own or have extensive experience with a tablet device, such as an iPad or Android tablet.

Procedure. Participants first completed informed consent and brief demographic and reading habits questionnaires. For both rounds of testing, each participant engaged in a 16-task session (complete task table: http://tinyurl.com/ko3t2n7) with each of two versions of SMART Note prototypes. Participants were not given any training about the interface prior to the usability inspection. The nature of tasks was twofold: 1) Seven articulation tasks required participants to explore parts of the prototype and explain how they believed it would function. 2) Nine interaction tasks required participants to complete a number of specific annotation strategies, exposing them to all of the key features in the SMART Note design.

The order in which alternative designs was presented was counterbalanced across participants to minimize learning effect. During task-based inspections, participants rated the perceived difficulty of each task and the researcher completed a success rating for each task. Participants also completed the Systems Usability Scale (SUS) [3] for each prototype. Follow-up questions about usability and preferences regarding the prototypes rounded out the research.

Stimuli. Each stage of testing exposed participants to two fully interactive SMART Note prototypes. Each was designed with content from a chapter on color theory currently used in 100-level graphic design courses. The prototype contained the body of the chapter, with three pages of narrative text and visuals, and the digital notebook, which included six pages of annotations in list view and a concept map study guide that organized notes by key headings and subheadings from the chapter.

There were two main differences between the prototypes, the first semiotic and the second structural. The *Combination Prototype* included both icons and word-based labels for buttons used to operate key annotation and study guide features, while the *Icon Prototype* included only icons for those controls. Additionally, the Concept Map structure in the *Combination Prototype* was a web-like diagram in which nodes represented main topics and key terms in the chapter with lines connecting related concepts. Nodes were also color coded to indicate which topics had been annotated by the learner and which had not. Alternatively, the Concept Map structure for the *Icon Prototype* displayed main chapter headings in the form of a linear, hierarchical flow chart. In each node, icons were used to indicate which sections had been annotated by the learner and which had not. Furthermore, icons were used to provide the learner with visual cues about what kinds of media had been annotated.

In the first round of testing, wireframes included narrative text on color theory with black boxes as placeholders for visual and/or multimedia content. After the first round of testing, prototypes were revised and the level of fidelity was also improved. In the second round of testing, actual images, graphics, and videos were included.

4.2 Results

Overall response to SMART Note prototypes across all participants was positive. All seven of the SMART Note annotation features explored in the usability inspections received favorable ratings from users (Figure 3). On average, participants found SMART Note annotation features easy to learn (average responses ranged from 4.0 to 4.9 out of 5 for all prototypes) and easy to use (average responses ranged from 3.8 to 4.2 out of 5 for all prototypes). Most participants also reported they would use SMART Note frequently if it were available (average responses ranged from 4.1 to 4.3 out of 5 for all prototypes). Figure 4 displays average responses to the Systems Usability Scale.

Evaluation Stage One. For both the *Combination Prototype* and the *Icon Prototype* wireframes, participants had no problems with interaction tasks. A few articulation tasks were more challenging.

Combination Prototype–Wireframe. Three articulation tasks proved problematic in this prototype, all of which related to users' inability to immediately understand the meaning of interaction icons. Users had the most trouble making sense of the video segment capture button (40% success rate). In most cases, users weren't even able to make a guess at what the button meant or would do. Participants also struggled to understand what would happen if they tapped the icon used to navigate to the Concept Map Study Guide (50% success rate). In this version, most mistook it for a menu button. Participants were equally confused by the icon used to represent key term capture (50% success rate), noting that the grabbing hand looked more like a punching fist. Figure 5 illustrates the problematic icons.

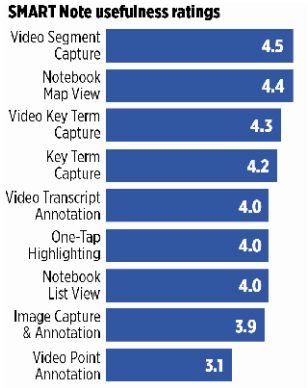

Fig. 4. Participants rated the usefulness of each SMART Note annotation feature. (5-Very Useful; 1-Very Unuseful).

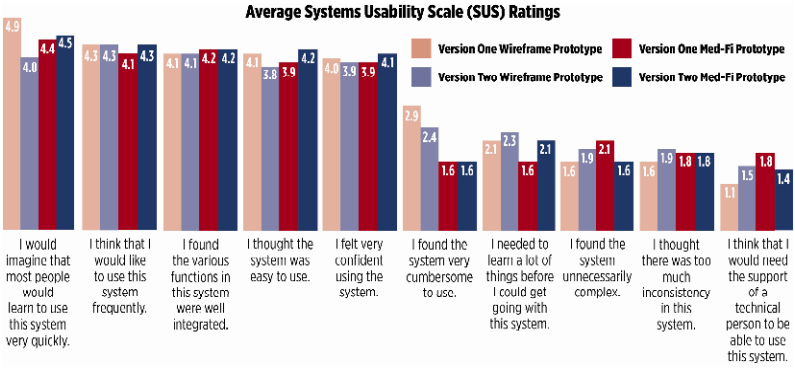

Fig. 4. Systems Usability Scale ratings

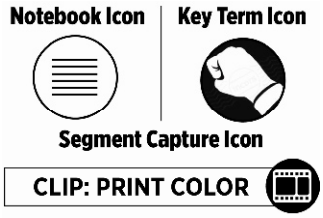

Fig. 5. Problematic notebook, key term and segment capture icons

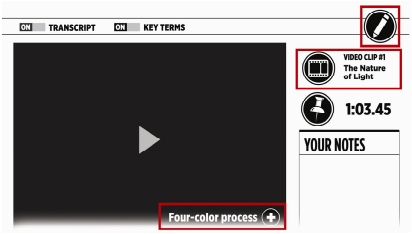

Fig. 6. Problematic video annotation design

Icon Prototype–Wireframe. Three articulation tasks were challenging. Although users more easily understood the meaning of key term capture button in this version (60% success rate), when used with video, it was more difficult for users to correctly identify (30% success rate). If they noticed it at all, most users thought the "+" sign and key term placed on top of the video was a label for the video as opposed to a key term mentioned in the audio that accompanies the video. The video segment capture feature was also elusive in this prototype (30% success rate), with most users not realizing that it was a button and some indicating they thought it would pull up a new video if tapped. Finally, the Concept Map Study Guide navigation button (a pencil) was again confusing (30% failure rate), with most users reporting they thought it was for note taking. Figure 6 illustrates the problem issues with this prototype.

Evaluation Stage Two. Prototypes were revised to address problems, and the level of fidelity was improved. Success rates for interaction and articulation tasks improved.

Combination Prototype–High-Fidelity. In the redesigned prototype, the segment bar is labeled with the name of the corresponding video segment and the button associated with each segment highlights as the video plays. This redesign improved participants' understanding of this feature (90% success rate). Figure 7 illustrates the redesigned buttons and video annotation features. No other interaction or articulation tasks proved problematic, with success ratings for all other tasks at 60% or more.

Icon Prototype–High-Fidelity. Video key terms were changed to look less like labels and more like independent elements. The new design improved users' understanding (70% success rating). The video segment capture design was modified to provide users with more visual feedback related to its function, which improved participants' understanding (80% success rate). Finally, the Concept Map Study Guide button was changed to look like an actual notebook. This improved users' understanding (70% success rate), and most users preferred this approach. Figure 8 illustrates redesigned buttons and video annotation. No other interaction or articulation tasks were problematic, with success ratings for other tasks at 70% or more.

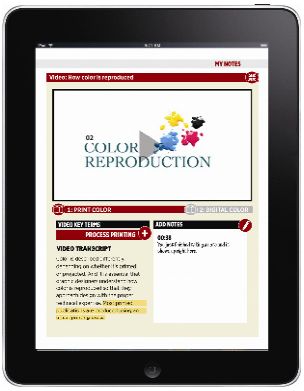

Fig. 7. Combination *Prototype–High-Fidelity*: Redesigned video annotation screen

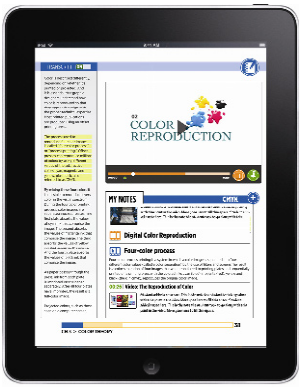

Fig. 8. Icon *Prototype–High-Fidelity*: Redesigned video annotation screen

5 Discussion and Directions for Future Work

The generally high success ratings across all prototypes suggest that the SMART Note conceptual and interaction designs provide a sound user experience. However, it is important to highlight what we learned at each stage of evaluation that will inform our future work. For both wireframe prototypes tested in the first stage, users struggled most with articulation tasks that involved describing the meaning and function related to certain icons. Specifically, the most problematic icons–video segment capture, key term capture, and Concept Map Study Guide navigation–were very difficult for users to grasp. Although it is not surprising that users would struggle explaining features they are not familiar with, this did raise the question of just how much visual feedback and/or on-screen labeling users need to fully understand the meaning and function of such features. For example, users clearly needed more feedback to understand not only what the segment capture button does, but also how it works in concert with the video as it plays. Thus, redesigns of both prototypes for the second stage of testing allowed us to experiment with two different degrees of visual feedback. The *Combination Prototype–High-Fidelity* used highlighting labels and the *Icon Prototype–High-Fidelity* used a highlighting video timeline to provide visual feedback indicating which segment was currently playing. In both cases, learners were more immediately able to articulate what was happening and see the relationship between the highlighted segment and the video capture button. Similar visual and textual affordances were added to the key term capture button to give learners a few more clues as to their meaning and function, which also improved performance on related tasks.

In addition, participants' positive feedback regarding the perceived usefulness of each SMART Note annotation feature was also promising. Specifically, it is worth noting that participants rated SMART Note's three novel audiovisual annotation

features–video segment capture, video key term capture, and video transcript annotation–to be more useful than video point annotation, a feature currently offered by most video annotation platforms. Likewise, the Concept Map Study Guide *map view* feature was rated higher in terms of perceived usefulness than *list view*, also currently offered by most tablet textbook platforms. Collectively, these results indicate that SMART Note shows promise as a means for improving active reading and learning with interactive, multimedia tablet textbooks. Future work will include an experimental study that compares SMART Note annotation and study guide features to annotation and notebook features commonly offered by existing tablet textbook platforms. Ultimately, the goal is to provide students with better study tools to help them more easily migrate from the printed textbooks they are familiar with to the emerging multimedia books increasingly available on their tablets.

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