NoteStruct: Scaffolding Note-taking while Learning from Online Videos

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ABSTRACT

Note-taking activities in physical classrooms are ubiquitous and have been emerging in online learning. To investigate how to better support online learners to take notes while learning with videos, we compared free-form note-taking with a prototype system, NoteStruct, which prompts learners to perform a series of note-taking activities. NoteStruct enables learners to insert annotations on transcripts of video lectures and then engages learners in reinterpreting and synthesizing their notes after watching a video. In a study with a sample of Mechanical Turk workers (N=80), learners took longer and more extensive notes with NoteStruct, although using NoteStruct versus free-form note-taking did not impact short-term learning outcome. These longer notes were also less likely to include verbatim copied video transcripts, but more likely to include elaboration and interpretation. We demonstrate how NoteStruct influences note-taking during online video learning.

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Note-taking, Online learning, Video learning, MOOCs

INTRODUCTION

Note-taking has been a common activity adopted by learners in online learning [11], but it is not necessarily beneficial for learning. While researchers have shown robust benefits of reviewing notes, learners' notes are usually incomplete and limited for later use [5]. The process of recording notes can possibly facilitate learning especially when learners produce outputs that contain ideas beyond the presented information (e.g., elaboration and explanation) [2]. However, note-taking that involves retrieval of large amounts of knowledge and conceptual planning is substantially more demanding than simply learning from a lecture [9]. Being faced with demanding note-taking activities and the learning task at the same time, learners may fail either to comprehend learning materials or to take notes without deep processing.

In traditional classroom, instructors play important roles to support learners' note-taking process. For instance, instructors would provide visual scaffolds of the lecture [10], pre-train students' note-taking skill [6], or provide their own notes to facilitate students' note-taking activity [6]. However, instructors' facilitation can be limited in online learning because it is hard for them to deal with learners' various learning motivation, goals, or background knowledge in a large-scale learning context. Even more, simple instructional intervention (e.g., prompting learners to take notes in their own words instead of transcribing) was shown to be completely ineffective at reducing verbatim content [7]. Thus, we see a potential to support note-taking process in a large-scale learning context by guiding online learners to take notes from online videos.

This research aims to scaffold large-scale learners' note-taking while learning from online lecture videos. We designed NoteStruct, a prototype system that divides a note-taking practice into step-by-step activities. It provides lightweight annotation functions on provided transcripts, engages learners to review and create interpretations for highlighted contents after watching the video, and finally enables learners freely edit their notes. We conducted a controlled experiment with workers on Amazon's Mechanical Turk, who were assigned to learn with two different lecture videos using NoteStruct and a baseline system, which has a text editor beside the video for note-taking. Preliminary findings indicate that learners using NoteStruct generated notes that contained more words and less verbatim content. They also performed better, although not significant, in pre-post- testing and reported significant greater perceived learning gain.

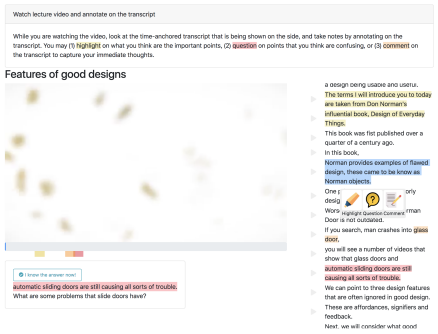

Figure 1: Phase 1: Annotate video transcript with highlights, comments, questions

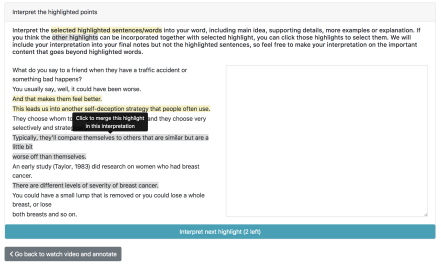

Figure 2: Phase 2: Review and interpret highlighted sentences in addition to verbatim notes

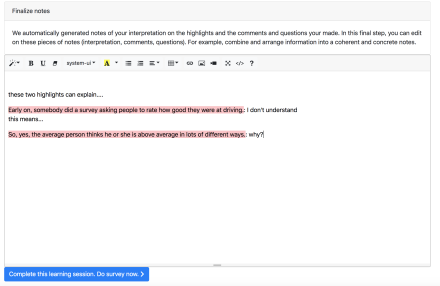

Figure 3: Phase 3: Finalize notes from previous phases with a free-form editor

RELATED WORK

Note-taking and Learning Online

Researchers have investigated the benefits and challenges of note-taking in two aspects: external storage and encoding [5]. Benefit of reviewing notes (external storage) is widely accepted, but learners often take incomplete notes that are limited for later use [5]. Encoding means the process of note-taking can support learning, as it may induce elaborative processing such as generating self-explanations [2], and encourage building connections with prior knowledge [8]. Unfortunately, many studies have shown detrimental effects of taking notes while learning, as note-taking costs attentional resources that are needed for processing rapid and dense lecture presentation [5].

Digital note-taking seems to be an efficient way to facilitate note-taking by providing affordances (e.g., typing or copy-paste functions) to speed up the recording process. Yet, research has demonstrated that digital note-taking may not benefit learners as longhand note-taking can do because digital note-takers tend to transcribe lectures verbatim instead of processing information in their own words [1, 7]. Altogether, the challenges of note-taking motivate us to explore designs to scaffold note-taking processes and prevent the drawbacks of digital note-taking at the same time.

Online note-taking tools

Matthew et al. designed ViDex that enables textbook-style highlighting on a video filmstrip and transcript [4]. Follow-up assessment on ViDex suggested that allowing learners to highlight, append tags and take notes can facilitate active viewing such as more active exploration of video content [3]. LiveNote was designed to support collaborative note-taking process in class by allowing groups of learners to take notes together with instructors' slides in the background as a reference. We intend to extend these works by designing step-by-step note-taking activities to support better note-taking and learning process online.

NOTESTRUCT SYSTEM

We design NoteStruct to scaffold note-taking while learning from online video. NoteStruct divides note-taking process into three phases in order to reduce interference of note-taking in video watching while preventing learners from mindless transcribing lecture into notes without deeper processing.

First, learners are able to annotate the transcript while watching the video, as shown in Figure 1. NoteStruct offers three types of annotation tools on video transcripts: highlighting, commenting, and questioning. Highlighting can help learners recognize and select key points for later use. Commenting allows learners to write down thoughts or ideas, while questioning allows learners to register their confusion about the content. When learners type a comment or question, the system automatically

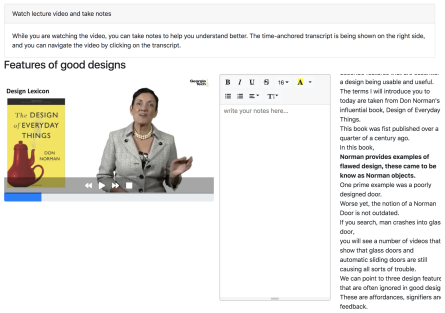

Figure 4: The baseline interface has a simple text input area beside standard video player for free-form note-taking. It also displays interactive video transcripts for navigation. We prompted learners to take notes and engage in constructive learning activities: "You are encouraged to write down not only important points but also comments and questions you have. When you take notes, try to make your own interpretation instead of copying and pasting the content from transcript".

Gender	Female = 37 Male = 40
Education level	Less than high school: 1% High school degree: 26% Some college: 26% Bachelor degree: 38% Master degree: 8% PhD: 1%
Familiarity in video learning	M = 5.34 SD = 1.48

Table 1: Summary of participants' demographic information. Familiarity in video learning was measured with a question: How familiar are you with learning through videos online? 1: Not familiar with it, 7: Very familiar with it

pauses the video, to allow extra time for reflection. If learners add questions, we prompt them to find out answers in later video sections.

Second, learners were walked through every highlight they made and asked to elaborate their thoughts, which can be talking about the key concept from their perspective, providing supporting details, giving more explanation or examples (see Figure 2). Learners are guided to interpret one highlighted sentence at a time in order to allocate their attention on minimum key points when interpreting, but they can also merge multiple highlights in an interpretation.

In the final phase (see Figure 3), learners review all initial notes generated in phase 1 and 2 in a free-form text editor, including their comments and questions with the anchored transcript sentences and their interpretations. Learners have the option to add anything else they like, or edit and remove parts from the notes. They were prompted to combine and arrange information into coherent notes.

EVALUATION

We conducted a within-subjects experiment on Amazon Mechanical Turk to see if NoteStruct helps learning and note-taking. The study compare NoteStruct against a baseline system (see Figure 4).

80 participants were recruited for an approximately 40-minute long online study. 3 data were dropped due to technical problems. Compensation was $4 for each HIT. Workers' demographic information are summarized in Table 1.

Participants were first guided to visit the NoteStruct website where they received an overview of the study procedure. The procedure included three phases: (1) a pre-survey that included demographic items and pre-test questions for two videos, (2) two learning sessions, in which they watched two different, consecutive videos (4 minutes long each). One video was paired with the baseline system, the other with NoteStruct. The pairing and presentation orders of video and note-taking tool were counterbalanced. (3) Post-surveys after each learning session, which included post-test questions ,and open-ended questions to understand their learning experience.

We measured learners' short-term learning outcome, perceived learning gain, and also evaluated learners' notes by number of words, degree of verbatim. Short-term learning outcome was measured as the change in accuracy between the post-test items and the pre-test items, and then converted the results within the same video to z-scores. Perceived learning gain was calculated as the difference between two questions: (1)"After going through the learning process, how much do you think you have learned from the lecture? 1: Not at all, 7: Fully learned from the lecture", (2)"Before watching the video, how much background knowledge related to the topic of the video did you have? 1: Not at all, 7: Expert knowledge". Degree of verbatim in notes was defined as percentage of copied one-, two-, and three-grams from video transcripts in the notes.

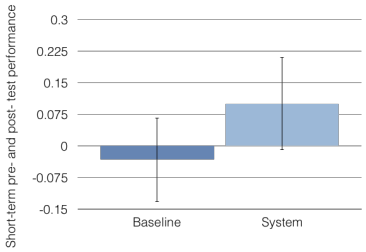

Figure 5: Short-term learning outcome by pre- and post- test. Error bars indicate standard errors of the mean in this and all subsequent figures.

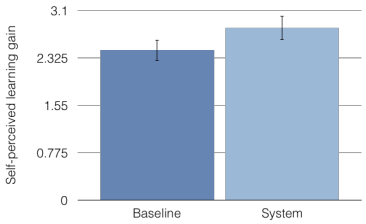

Figure 6: Self-perceived learning gain.

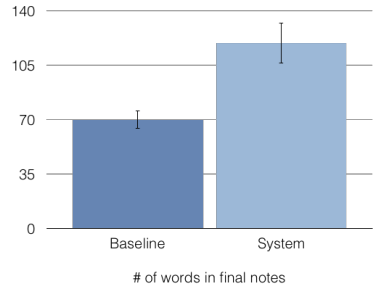

Figure 7: Number of words in notes.

Analysis and Results

Participants reported higher perceived learning gain ($F(1,76)=4.05$, $p=0.048$) using NoteStruct (Figure 6). There was a numerical trend of higher short-term learning outcome for NoteStruct (Figure 5) but no significant difference. This and all subsequent analyses was revealed by mixed-model analysis with learning tool as a within-subjects fixed effect and video type as a random effect.

Participants generated significantly more words ($F(1,76)=14.77$, $p<0.001$) when using NoteStruct ($M=119.21$, $SD=115.25$) than baseline interface ($M=69.82$, $SD=51.89$) (Figure 7). At the same time, they generated less copied one- ($F(1,76)=10.23$, $p<0.005$) and two- ($F(1,76)=3.97$, $p=0.05$) grams in NoteStruct condition, but no significant difference in three-grams ($F(1,76)=2.35$, $p=0.13$) between two conditions. Results are illustrated in Figure 8, 9, 10. Noted that participants generated much shorter notes in baseline condition, the low copied three-gram fraction of baseline condition is more likely to be a result of abbreviation (e.g., simply noting down concept without explanation) instead of elaboration.

Our preliminary result showed that design of NoteStruct led learners to write significantly more words than a free-form note-taking system, and a greater proportion of these words tend to be elaborations and interpretations, rather than verbatim copy-pasted text. We didn't see significant effects on short-term learning outcome, which might suggest process of taking notes with NoteStruct has no impact. On the other hand, 4-minute videos could be too short for testing learning performance. Studies conducted with longer videos or over longer time periods might be needed to detect the cumulative effects of taking elaborative notes or reviewing more complete notes.

Note-taking experience in NoteStruct: Overall, they were positive about the guidance NoteStruct provided: "I really liked the step by step note generation. I feel that it helped me create cohesive notes." Participants appreciated the convenience of annotating a transcript while watching the video. They valued the second phase that allowed them to extend their notes: "I like that it had everything that was said and could be highlighted and elaborated upon". They also appreciated the flexibility of the final free-form editing function: "I found it useful that it listed all the information and it was easy to organize the notes." However, a few reported that note-taking with NoteStruct was time-consuming: "the second part of interpreting the highlights a little tedious and long.", and that NoteStruct diverged from their typical note-taking habits.

Learning experience in NoteStruct: Participants reflected that by prompting them to review the content several times, NoteStruct might benefit their learning: "...and going through the content multiple times at each stage helped cement my understanding of the topic." They also reported benefits in reflecting when taking notes: "...I enjoyed being able to rearrange my thoughts after the lecture by reviewing each highlight."

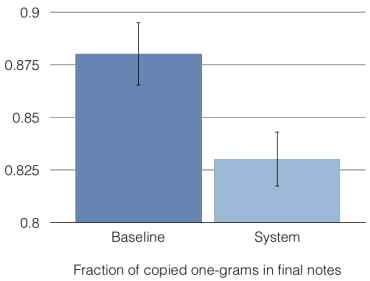

Figure 8: Fraction of copied one-grams in notes.

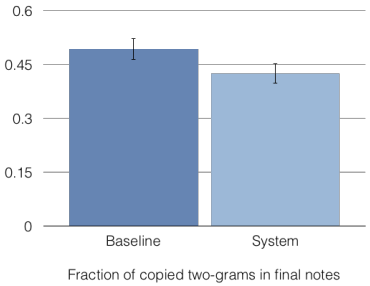

Figure 9: Fraction of copied two-grams in notes.

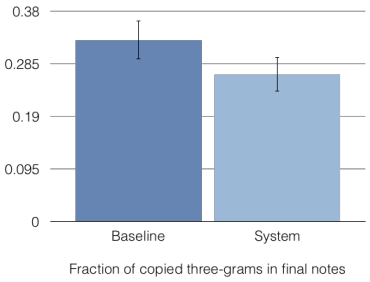

Figure 10: Fraction of copied three-grams in notes.

FUTURE WORK

We will take an iterative design approach to revise the design of NoteStruct for better promoting learning. A possible idea is to explore benefits of sharing peers' notes. The notes from NoteStruct (highlights, comments, questions, interpretations) provide a format that is easier to share at scale. Learners might benefit in seeing others interpretations or in what peers find important, such as commonly highlighted content they might otherwise overlook (e.g., a participant in our study expressed: "the only difficulties I had was making sure I highlighted the important points.").

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