QuizCram: A Question-Directed Video Studying Interface

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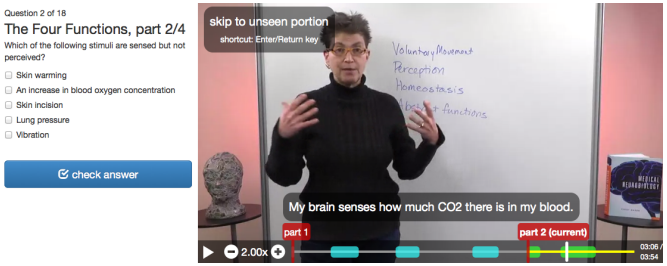

Figure 1: The QuizCram interface, showing the current video. The focus question is on left, and the associated video is on the right. The progressbar highlights the relevant portion of the video, and shows which segments have already been seen

Abstract
QuizCram is a question-focused format for navigating and reviewing lecture videos. QuizCram shows users a question to answer, with an associated video segment. Users navigate through the video segments by answering questions. We encourage users to review questions, by keeping track of their question-answering and video-watching history and scheduling users to review questions they have not fully mastered. We also allow users to review using a timeline of previously answered questions and videos. QuizCram-format courses can be generated automatically from lectures with in-video quizzes, though the format is flexible enough to accommodate multiple questions per video segment. Our user study comparing QuizCram to in-video quizzes finds that users are better able to remember answers to questions that they encountered when using QuizCram.

Author Keywords
video flashcards, lecture reviewing, in-video questions

ACM Classification Keywords
H.5.2. [Information Interfaces and Presentation (e.g. HCI)]: Graphical User Interfaces

Introduction

Lecture videos that have multiple-choice questions inserted at key points in the video (*in-video quizzes*) are widely used in MOOC platforms such as Coursera. In-video quizzes exploit the *testing effect*, which suggests that quizzing improves retention of the viewed material.

During our analysis of viewing logs for the Machine Learning course on Coursera, we observed that users' navigation behavior is heavily influenced by in-video quizzes. There are peaks in viewing and reviewing surrounding in-video quizzes. Users often skip forward within video segments to the in-video quizzes, but rarely skip over in-video quizzes. Some users seek from one in-video quiz immediately to the next. Examples of these seeking behaviors are shown in Figure 2.

Based on these observations, we wished to develop a video viewer that would better support such quiz-centric navigation strategies, and encourage reviewing.

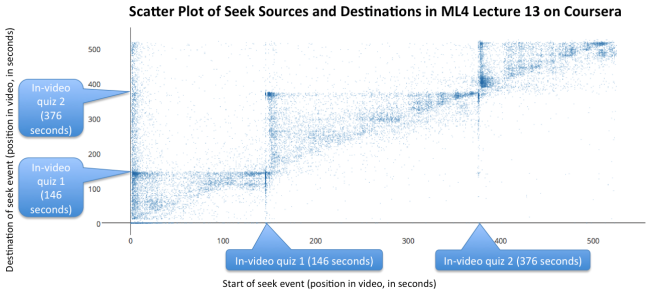

Figure 2: Seeks sources and destinations within a Coursera lecture with in-video quizzes. There are many seeks from the start of the video to the first in-video quiz (x=0, y=146), and between in-video quizzes (x=146, y=376). Backwards seeks tend to go from in-video quizzes (x=146 and x=376) to points in the immediately preceding section.

Our system, Quiz-driven Video Cramming (QuizCram), uses quizzes to help users navigate the course, and helps direct their review process. To do so, we include the following features:

- Our interface shows the question before and while the user watches the video, so that it serves as an advance organizer to prime them towards the key concepts they should focus on
- To encourage people to review videos, our system keeps track of which video portions users need to review, and gives users suggestions of questions and video portions to review
- We enable the more flexible addition of questions into the video, by allowing questions depend on video segments other than just the immediately preceding one. This allows for there to be a higher density of questions in the QuizCram format.

We used a within-subjects study to compare QuizCram to the in-video quiz format. We found:

- Answers to in-video questions are remembered significantly better when users are using QuizCram, compared in-video quizzes
- Users are satisfied with QuizCram, and find the interface features for answering questions and reviewing videos to be helpful.

Related Work

We designed QuizCram's features based on the following findings from the education literature:

Testing and Pre-Testing Effects
The testing effect finds that repeated testing combined with fast, informative feedback helps students remember material [8]. QuizCram's question-directed studying approach is designed to exploit the testing effect.

The Pre-Testing Effect finds that asking users to try answering a question before they actually study the material enhances long-term retention [7]. QuizCram exploits the pre-testing effect by allowing users to preview the question before watching the associated video.

Advance Organizers: Video Transcript Summaries
Advance organizers are information presented prior to learning, that help the learner process the material that is about to be presented [10]. Video Digests is a system that creates such summaries about videos, and uses them as an advance organizer and navigational guide for video lectures [6]. QuizCram similarly breaks videos into segments associated with an advance organizer, but we use a question to summarize the clip.

Spaced repetition: Flashcards
Spaced repetition is a technique designed to help learners retain information by having them review items at regular intervals [2]. A class of applications that exploit this are flashcards, where information is split into independent chunks that are scheduled for review based on factors such as mastery and recency of review. Similar to flashcards, our system also schedules items for review according to mastery and recency of review.

System Design

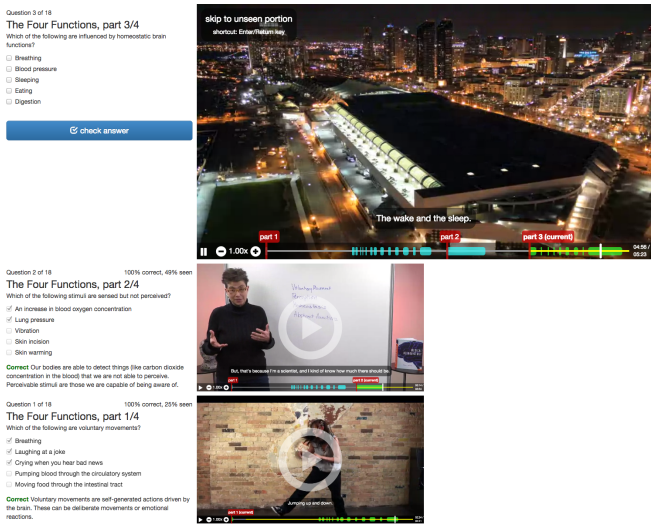

Figure 3: The scrollable timeline, shown immediately below the current question, displays the past videos and associated questions, to help users find parts they had trouble with.

QuizCram's interface shows users a question to review, with an associated video segment, as shown in Figure 3. It also shows a scrollable timeline of previously answered questions and associated video segments below the current question. Questions are first scheduled in order, then once the user has made an initial pass, questions are selected for review algorithmically, based on historic correctness of responses, percentage of associated video that has been watched, and the recency of review. We also use the video progressbar to indicate the section of the video that is relevant to the current question, and portions of the video that the user has previously seen.

An existing course with in-video quizzes, such as MOOCs

on Coursera, can be automatically transformed into the QuizCram format. This results in each video segment having one associated question. However, unlike in-video quizzes, the QuizCram format can also have multiple questions associated with a single video segment.

Question-Focused Video Viewing
Each section of the video in the course has one or more associated questions. Whenever the user advances to a new section, we show the question and video concurrently, with the question to the left of the video, as shown in Figure 3. If the user already knows the answer, they can answer the question and move on to the next section. Even if the user does not know the answer, reading the question before watching the video serves as an advance organizer which summarizes the key points they should pay attention to when watching the video.

Scheduling Questions and Video Sections for Review
We want users to spend their study time focusing on material that they have not yet mastered. Hence, we assign each question a *mastery score*, which represents how well the user currently knows the material, and show users the questions for which they have low mastery score. The mastery score is a based on the user's past performance on the question, the fraction of the associated video segment they have watched, and the recency of review.

Once the user has seen all the questions in the unit, QuizCram encourages them to review questions and sections for which they have low mastery scores, by showing them in the video timeline.

Timeline of Previous Questions and Videos
Although QuizCram focuses the user's attention towards the current question and associated video segment, we also wish to make it easy to refer back to the previously answered questions and video segments. Whenever a question is correctly answered, we insert the next question and associated video segment at the top of the interface, and push the existing questions down. This results in a scrollable visual history of the previously answered questions and videos which we call the *timeline*, shown in Figure 3. The timeline displays the question and its answer and a miniaturized version of the video which can be clicked to enlarge it to full size and play it. The miniaturized video displays the frame the user left off at, so it serves both as a visual summary, and also allows users to easily resume viewing progress of previous videos.

The timeline gives users the option to use a more traditional, self-directed reviewing strategy, in contrast to the flashcard-style reviewing that our question scheduling algorithm encourages. By organizing the list of previous video segments according to the associated question that users answered, this allows users to scan video segments with a more salient summary than just the title. Question-based video navigation also allows users to search at a higher granularity, as questions refer to a specific subsection of the video, while the title refers only to the entire video contents. Furthermore, re-reading the previously answered questions helps trigger the users' memory of the associated clip, giving learners another retrieval opportunity to solidify their memory of the video contents.

Directing Attention to Unseen Parts of Videos
In addition, because QuizCram encourages reviewing videos, we wish to make it easy for users to keep track of what parts they have already watched. Hence, we highlight on the progressbar the already-seen parts in green (if it is from the current part of the video), or blue

(if it is from a previous part of the video). If the user is viewing a section that has already been watched, we show a button at the top-left of the video that allows them to skip to the unseen portion. Similar techniques for visualizing the user's video viewing history have been presented in the literature [5] [3], though our system adds the novel feature of allowing users to skip to the next unseen portion.

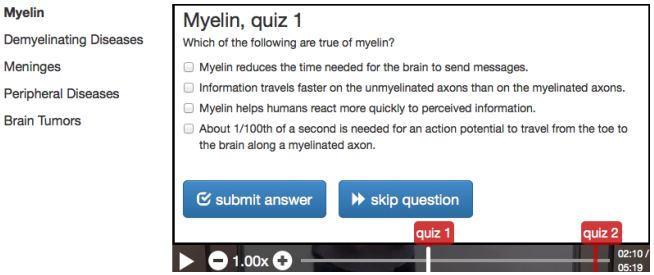

Figure 4: The in-video quiz format that served as our baseline. Left side lists videos, right side is a video viewer that shows the in-video quiz when reached. Locations of quizzes are indicated in red on the progressbar.

Evaluation

Our user study was an within-subjects study that compared users' studying behavior with QuizCram to an in-video quiz interface that imitates the format used on Coursera, as shown in Figure 4. We took the videos, in-video quizzes, and unit exam from an existing Neurobiology course on Coursera. The QuizCram condition was generated from the original in-video quizzes, but also included additional questions that we inserted. We wished to answer the questions:

- Do users using QuizCram better remember answers to the original in-video questions?
- Do users using QuizCram perform better on the unit quiz?
- Can we improve recall of particular facts from the video by inserting additional questions with QuizCram?
- Do users find QuizCram helpful for studying videos?

Study Design

The study was a within-subjects design, where each learner used QuizCram and an in-video quiz viewer interface to study a set of videos. They were asked to provide qualitative feedback immediately after viewing, and were tested on the material they studied a day later.

Participants

We recruited 18 students by posting on university mailing lists. 12 were female, 6 male, their average age was 21.7 (stddev=4.91, min=18, max=37), and all had native-level English proficiency. We asked that they have no experience with neuroscience, to ensure that they did not know the material beforehand. 9 participants reported having previous experience with MOOCs, and of these 6 had experience with Coursera. Participants received $60 for participating in the 2-hour online study.

Materials

The course materials – videos, in-video quizzes, and unit exams — were the first and second halves of Unit 1 of an existing Neurobiology course on Coursera. There were 9 questions for each 25-minute segment. We generated the initial QuizCram materials directly from the course. Because we wished to observe the effects of increasing the question-to-video ratio in the original videos, we wrote additional questions for the QuizCram condition to double the total number of questions. We wrote questions in the

same multiple-checkbox format as the original questions, and made sure that they did not ask the same facts that were tested on the unit exam or in-video questions.

We also wrote a set of free-response questions, one corresponding to each of the extra multiple-checkbox questions. We used these free-response questions to test whether users had learned the material tested by in-video questions well enough to recall it.

Procedure
The study was conducted online over 2 days, with a 90-minute study session on the first day, and a 30-minute test session on the second day. Before users started the study, we informed them that they would be given 2 sets of videos, they should study them for 40 minutes apiece, and they would be given an exam the next day. We did not tell them about the content of the exams.

On the first day, users studied the first unit (5 videos, 23 minutes total) with the first tool for 40 minutes. Then, they used the other tool to study the second unit (5 videos, 25 minutes total) with the second tool for 40 minutes, and filled out a survey.

On the second day, users took the following exams:

1. Extra free-response questions (as described in the Materials section)
2. Original in-video questions from Coursera
3. Original unit exam from Coursera
4. Extra multiple-checkbox questions (as described in the Materials section)

Parts 2-4 of the exam were automatically graded, giving each question a score equal to the fraction of checkboxes correctly checked. The free-response questions, which were of the form "List N examples of X" or "List N facts about X", were scored as:

$$\frac{\#correct\ examples\ given}{Maximum(\#examples\ requested,\ \#examples\ given)}$$

Exam Results
Users were better able to answer the original in-video questions when using QuizCram. They averaged 85.4% with QuizCram, compared to 81.3% with the in-video quiz format. This difference was statistically significant (t=2.24, p=0.0391).

Unit exam scores were similar when using QuizCram compared to the in-video condition. Average scores on the portion of questions covered by QuizCram was 65.1%, while scores for the questions from the portion viewed using the in-video interface was 63.4%. This difference was not significant (t=0.44, p=0.669).

Users were better able to answer the extra questions we inserted in the QuizCram condition when viewing the section with QuizCram. They averaged 85.5% with QuizCram, compared to 76.0% with the in-video interface. This difference was statistically significant (t=2.44, p=0.0260).

Users were also better able to answer the free-response questions when using QuizCram. They averaged 67.6% correctness with QuizCram, compared to 49.0% correctness with the in-video quiz format. A t-test showed this difference was statistically significant (t=3.95, p=0.0010).

Survey Results
When asked to rate their overall satisfaction with the tool a scale of 1 to 7, the average was 5.28 for QuizCram, and 5.17 for the in-video quiz format.

61% indicated they would prefer using QuizCram if they wanted to remember material long-term or were preparing for an exam.

Discussion

The design goal behind QuizCram is to increase users' focus on questions, utilizing questions as a means to navigate and review the video material. Our user study focused on a short-term study task, modeling an exam-cramming scenario. In reality, however, we want to remember the contents of entire courses rather than single units, and need to study it across the period of months rather than hours. We believe the QuizCram format is well-suited for such use cases.

When reviewing lectures with traditional interfaces, the user needs to keep track of what they remember and what they need to review. This may be an easy task if they are reviewing only an hour of video. However, when studying entire courses over the course of a month, a user can easily lose track of what their study progress was. Instead, QuizCram keeps track of users' historic performance on questions and video progress, and makes suggestions for questions and associated segments of video to review. Thus, it relieves the user of the mental burden of needing to keep track of their study progress and determine what they need to review.

Another interesting finding was that with QuizCram, we were able to increase the number of questions associated with a video segment without adversely effecting the user experience or exam performance. In fact, we find that users remember the material covered by these additional questions well enough to answer them in free-response format. This paves a way for further increasing the amount of testing that occurs within video content.

Current online courses have external problem sets and quizzes outside of the ones in videos, because they cannot test the content in sufficient depth using in-video quizzes. However, if we consider the engagement patterns of users with MOOCs, the majority of users are interacting only with the videos and never doing the problem sets or quizzes [1]. Thus, moving more of the course content out of external quizzes and making the video more interactive and question-oriented provides a way to benefit these viewers' learning by testing their knowledge, without removing them from the scaffolding of videos. By gradually moving along this trajectory of making videos more question-focused and recommending review material to users, online courses of the future could entirely eliminate their need for external problem sets and quizzes, and transform into video and question-based intelligent tutoring systems.

Conclusion

We have presented QuizCram, a system that uses questions to direct users' video viewing. QuizCram breaks the video into segments associated with questions, and always shows a focus question alongside the video. The focus question serves as an advance organizer that directs the user's attention towards the key points in the video. QuizCram also encourages reviewing based on questions: it displays a timeline of questions previously answered and their associated videos. It keeps track of users' progress through questions and videos, and suggests users to review questions that they have not fully mastered. Courses in the QuizCram format can be automatically

generated from existing video content with in-video quizzes, though it also has the flexibility to accommodate additional questions.

Our user study finds that QuizCram indeed does increase focus on questions – when the questions presented during viewing were tested again a day later, users using QuizCram performed better at answering the questions than users who encountered the questions as in-video quizzes. We also found that increasing the amount of questions presented with QuizCram results in users remembering the material tested by the additional questions better, even when answering based on recall not recognition.

Users' qualitative feedback indicates that they felt questions were an important part of the system. Users were divided in preferences between the QuizCram format and the standard in-video quiz format currently predominant in MOOCs. Some users liked the question-directed viewing format and thought it was more engaging, though others thought that displaying the questions were distracting. We believe the QuizCram format is a logical step from the in-video quiz format towards more interactive, question-focused intelligent video viewing platforms.

References

[1] Anderson, A., Huttenlocher, D., Kleinberg, J., and Leskovec, J. Engaging with massive online courses. In *Proceedings of the 23rd international conference on World wide web*, International World Wide Web Conferences Steering Committee (2014), 687–698.

[2] Karpicke, J. D., and Bauernschmidt, A. Spaced retrieval: absolute spacing enhances learning regardless of relative spacing. *Journal of Experimental Psychology: Learning, Memory, and Cognition 37*, 5 (2011), 1250.

[3] Kim, J., Guo, P. J., Cai, C. J., Li, S.-W. D., Gajos, K. Z., and Miller, R. C. Data-driven interaction techniques for improving navigation of educational videos. In *Proceedings of the 27th annual ACM symposium on User interface software and technology*, ACM (2014).

[4] Lawson, T. J., Bodle, J. H., Houlette, M. A., and Haubner, R. R. Guiding questions enhance student learning from educational videos. *Teaching of Psychology 33*, 1 (2006), 31–33.

[5] Mertens, R., Farzan, R., and Brusilovsky, P. Social navigation in web lectures. In *Proceedings of the seventeenth conference on Hypertext and hypermedia*, ACM (2006), 41–44.

[6] Pavel, A., Reed, C., Hartmann, B., and Agrawala, M. Video digests: A browsable, skimmable format for informational lecture videos. In *Proceedings of the 27th annual ACM symposium on User interface software and technology*, ACM (2014).

[7] Richland, L. E., Kornell, N., and Kao, L. S. The pretesting effect: Do unsuccessful retrieval attempts enhance learning? *Journal of Experimental Psychology: Applied 15*, 3 (2009), 243.

[8] Roediger III, H. L., and Butler, A. C. The critical role of retrieval practice in long-term retention. *Trends in cognitive sciences 15*, 1 (2011), 20–27.

[9] Shute, V. J. Focus on formative feedback. *Review of educational research 78*, 1 (2008), 153–189.

[10] Stone, C. L. A meta-analysis of advance organizer studies. *The Journal of Experimental Educational* (1983), 194–199.