QuizCram: A Quiz-Driven Lecture Viewing Interface

1st Author Name
Affiliation
City, Country
e-mail address

2nd Author Name
Affiliation
City, Country
e-mail address

3rd Author Name
Affiliation
City, Country
e-mail address

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 also allow users to review using a timeline of previously answered questions and videos. To encourage users to review questions, QuizCram keeps track of their question-answering and video-watching history and recommends users to review questions they have not fully mastered. 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 found that users practice answering and reviewing questions more when using QuizCram, and are better able to remember answers to questions they encountered.

Author Keywords

video flashcards; lecture viewing; in-video quizzes

ACM Classification Keywords

H.5.2. User Interfaces: Graphical user interfaces (GUI)

INTRODUCTION

Lectures on platforms such as Coursera use *in-video quizzes* to test learners on material while they watch videos. Although online courses also have problem sets and exams, many learners only watch lectures [1] [4]. For these students, in-video quizzes are an important opportunity to test themselves on the material, which is critical for long-term retention [9].

While analyzing viewing logs of the Machine Learning course on Coursera, we observed that in-video quizzes play an important role in video navigation. Specifically, we observed that users often seek backward from in-video quizzes to review the preceding section, and forwards to in-video quizzes to look at the upcoming question. We also observed that users rarely review lecture videos. Based on these observations, we wished to develop a video viewer that would better support quiz-centric navigation strategies and encourage reviewing.

Figure 1. The Quizcram interface shows questions on the left, and corresponding video segments on the right. The scrollable timeline displays the past videos and associated questions, to help users review parts they had trouble with.

Our system, Quiz-driven Video Cramming (QuizCram), uses quizzes to help users navigate the course and guide their review process. It includes the following features:

- QuizCram shows questions while users watch the video, to serve as a preview of the video content, and to guide their focus towards key concepts.
- 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 facilitate adding questions to videos by allowing questions to depend on multiple video segments rather than just the immediately preceding one. This enables the presentation of a greater density of questions in the QuizCram format.

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

- Users remember answers to in-video questions significantly better when using the QuizCram interface
- Users practice answering and reviewing questions more often when using QuizCram
- We can improve the recall of particular facts from the video by adding extra questions in QuizCram.

Event type	Seek chains going forward		Seek chains going backward	
	% of all seek chains	# seek chains, normalized by the length of the seek target (seconds). Ratio to baseline in parentheses	% of all seek chains	# seek chains, normalized by the length of the seek target (seconds). Ratio to baseline in parentheses
All seek chains	56%	16.40 (baseline)	44%	12.86 (baseline)
Seek chains going to in-video quizzes (and their surroundings)				
Seeks to quiz (+/- 0.5 sec)	0.35%	67.43 (4.1x)	0.20%	38.21 (3.0x)
Seeks to 10 seconds preceding quiz	3.35%	62.17 (3.8x)	1.82%	34.58 (2.7x)
Seeks to 10 seconds following quiz	1.15%	21.89 (1.3x)	0.70%	13.33 (1.0x)
Seek chains coming from in-video quizzes (and their surroundings)				
Seeks from quiz (+/- 0.5 sec)	0.36%	67.17 (4.1x)	3.79%	713.4 (55x)
Seeks from 10 seconds preceding quiz	0.65%	12.30 (0.8x)	0.96%	17.99 (1.4x)
Seeks from 10 seconds following quiz	1.89%	35.95 (2.2x)	1.63%	30.76 (2.4x)

Figure 2. Sources and destinations of seek chains in the Machine Learning course on Coursera, which uses in-video quizzes. Users tend to seek backward from in-video quizzes (55x higher than baseline back-seek rate), and forward to in-video quizzes and the 10 seconds immediately preceding them (4x higher than baseline forward-seek rate)

Event type	value
Forward seek chains	
Total # of forward seek chains	1169873 (55.6% of seeks)
Average length of a forward seek chain, in seconds	129 seconds
Average # of times each second of video was seeked forwards over	2153 (baseline forward seek rate)
# forward seek chains crossing quizzes (109 quizzes total)	98613 (4.69% of seeks)
# forward seek chains crossing each quiz	**905 (0.42x baseline)**
Back seek chains	
Total # of back seek chains	933463 (44.4% of seeks)
Average length of a back seek chain, in seconds	54 seconds
Average # of times each second of video was seeked back over	719 (baseline back seek rate)
# back seek chains crossing quizzes (109 quizzes total)	47184 (2.24% of seeks)
# back seek chains crossing each quiz	**432 (0.6x baseline)**

Figure 3. Portions of the video that are skipped over by seeks in the Machine Learning course on Coursera. Users do not tend to seek forward across in-video quizzes.
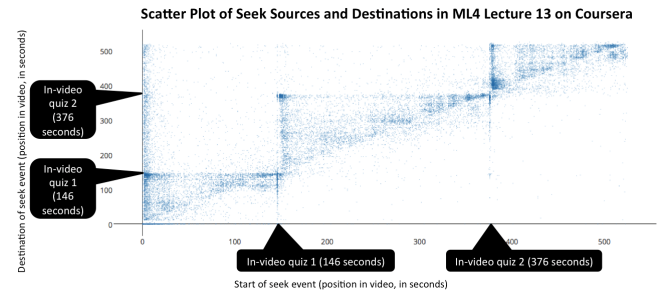

Figure 4. Seeks sources and destinations in a lecture with 2 in-video quizzes. Each point at (x,y) represents a seek from time x to y. There are many seeks to in-video quizzes from the start of the video, the previous section, and between quizzes.

MOTIVATION: COURSERA'S IN-VIDEO QUIZZES

This work was motivated by seeking activity around in-video quizzes we observed while analyzing Coursera's viewing logs for the Machine Learning course. We observed that there are large peaks in seeking activity around in-video quizzes, which is likely due to users previewing the questions and trying to find answers to them.

There are many backwards seeks starting from in-video quizzes. As shown in Figure 2, 8.6% of all backwards seeks (or 3.8% of total seeks) start from in-video quizzes – which is 55x more seeking per in-video quiz than we'd expect from a second of video in the course. This peak in backwards-seeking from in-video quizzes is likely due to users trying to find answers in the preceding section.

We also observe that there are forward seeks that end up at or immediately preceding the quiz. As shown in Figure 2, 6.6% of all forwards seeks (or 3.7% of total seeks) end up either at the in-video quiz or within 10 seconds preceding it. These forward seeks are likely reflect users attempting to view the in-video quiz – as Coursera's interface does not provide an option to go to in-video quizzes, users must seek to directly before the in-video quiz in order to view it.

Most seeks (93%) do not cross in-video quiz boundaries – users do not tend to skip forward or backward across in-video quizzes. As shown in Figure 3, users are 0.4x less likely to skip forwards across an in-video quiz, than across a second of video. Figure 4 visualizes seek sources and destinations in a single lecture video with 2 in-video quizzes: there are many forward seeks to quizzes, and backward seeks from quizzes.

Users also rarely review lecture videos: only 11% of users who finished watching a lecture will ever open it again.

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

Further details and methodology for this logs analysis work can be found in the supplement.

RELATED WORK

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

Testing and Pre-Testing Effects

The *testing effect* shows that repeated testing combined with fast, informative feedback helps students remember material [9]. QuizCram's emphasis on answering and reviewing questions is designed to exploit this effect.

The *pre-testing effect* shows that asking users to try answering a question before they actually study the material enhances long-term retention [8]. QuizCram exploits the pre-testing effect by allowing users to preview the question before watching the associated video.

Spaced repetition

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. There have been a number of algorithms and models designed for optimizing learners' retention of the material via spaced repetition [7]. However, they tend to be designed for flashcard-like content, such as isolated facts or vocabulary, rather than lecture videos.

A key difference between flashcard-like content and lecture videos is that lecture videos have an order, and a given video may depend on the user having viewed a previous video to understand it. Additionally, there is an difference in the cost of testing and reviews – with flashcards, both testing and review-

ing can be done in seconds. With videos, in contrast, the cost of reviewing a video is much greater than the cost of testing – we can test a user's knowledge for a video segment with a question that takes seconds to answer, but viewing a complete video takes several minutes. These additional constraints are reflected in QuizCram's modified scheduling algorithm that takes into account the order of videos, as well as its increased emphasis on testing via questions.

Advance Organizers

Advance organizers are information presented prior to learning, that help the learner process the material that is about to be presented [10]. QuizCram's questions can be thought of as an advance organizer for the video segment – the question provides an overview of the content that is to be covered in the video.

Interfaces for Navigating Lecture Videos

Video Digests is a system that uses textual summaries of video clips to help users navigate through the video [6]. LectureScape uses other users' aggregated viewing logs to help identify points of interest in the video [3]. Panopticon uses a visual display of all video segments to help users find segments of interest [5]. Rather than relying on external annotations, QuizCram instead uses questions extracted from existing in-video quiz content to help users navigate videos.

SYSTEM DESIGN PROCESS

Based on our observations that users tend to engage with in-video quizzes but rarely ever revisit MOOC lecture content (see supplement), as well as the importance of testing and review for retention, our goal was to build a system that would test users' knowledge of lecture materials and encourage them to review materials using spaced repetition.

Our initial design was to treat video segments as flashcards, and schedule them using a spaced repetition algorithm. We associated each segment with the corresponding in-video quiz, so we could test users's knowledge of each segment. However, scheduling videos with a simple spaced-repetition algorithm would often result in the user being asked to review older material before they got through all of the video segments, which informal trials and interviews indicated that users were annoyed by. Hence, we focused more on enabling users to freely review videos on their own, and would only start scheduling older videos for review based on spaced repetition, once they had made an initial pass through the videos.

QUIZCRAM INTERFACE FEATURES

QuizCram's interface displays a question and associated video segment, as shown in Figure 5. It also shows a timeline of previous questions below the current question, as shown in Figure 1. Once the user has made an initial pass through the questions, we suggest questions that they should review, based on past performance. We use the video progress bar to indicate the section of the video that is relevant to the current question, and portions 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.
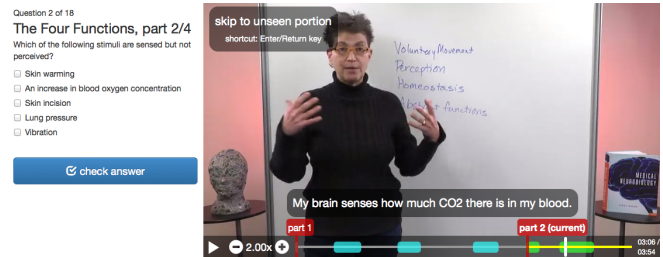

Figure 5. The QuizCram interface, showing the focus question on the left, and the associated video on the right. The progressbar highlights the relevant portion of the video in yellow. Segments that have already been watched are highlighted in blue (segments from previous parts) and green (segments from current part).

Question-Directed Video Viewing

Each section of the video in the course is displayed with an associated question, as shown in Figure 5. The question is designed to help users decide whether they should watch the video. If the user knows the answer, they can answer the question and move to the next section. For users who do not know the answer, reading the question summarizes the key points they will see in the video.

Timeline of Previous Questions and Videos

The *timeline* feature is designed to encourage review by making it easy to refer back to 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, as shown in Figure 1. The timeline displays the question, 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 watching previous videos.

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 finer granularity, as questions refer to a specific subsection of the video, while the title refers only to the entire video contents.

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 questions from areas where their mastery scores are low. The mastery score is a weighted sum 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 at the top of the video timeline.
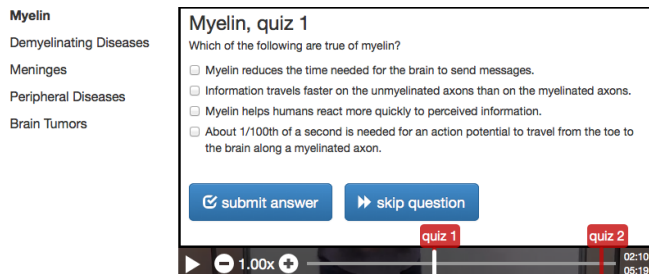
Figure 6. The in-video quiz format that served as our baseline. Locations of quizzes are indicated in red on the progressbar.

Exam	QuizCram	In-Video	Statistically significant?
Original in-video questions	85.4%	81.3%	Yes (t=2.24, p=0.039)
Original unit exam	65.1%	63.4%	No (t=0.44, p=0.669)
Extra multiple-checkbox questions	85.5%	76.0%	Yes (t=2.44, p=0.026)
Extra free-response questions	67.6%	49.0%	Yes (t=3.95, p=0.001)

Figure 7. Average exam scores for each condition

Event	QuizCram	In-Video	Statistically significant?
Original in-video questions answered	22.3	13.5	Yes (t=3.22, p=0.008)
Original in-video questions answered correctly	13.8 (62%)	5.3 (40%)	Yes (t=4.62, p=0.0007)
Original in-video questions re-answered (after at least 1 minute)	9	0.17	Yes (t=5.00, p=0.0004)
Extra questions answered	18.3		
Extra questions answered correctly	14.4 (79%)		
Extra questions re-answered (after at least 1 minute)	8		
Number of seek events	7.2	11.9	No (t=-0.82, p=0.43)

Figure 8. Average number of events per user in each condition

Directing Attention to Unseen Parts of Videos

To help users review videos, QuizCram keeps track of which parts have been watched. It highlights on the progress bar the portions that have already been seen. If the user is viewing a section they have already watched, they can skip to the unseen portion by clicking a button.

EVALUATION

Our study used a within-subjects design to compare users' studying behavior with QuizCram against an in-video quiz interface that mimcs the format used on Coursera, as shown in Figure 6. We used the videos, in-video quizzes, and unit exam from the Neurobiology course on Coursera. We wished to answer the questions:

- Does QuizCram help users better remember answers to the original in-video questions?
- Does QuizCram help users score higher on exams?
- Can we improve recall of particular facts from the video by adding extra questions with QuizCram?
- Do users find QuizCram helpful for studying videos?

Participants

We recruited 18 students by posting on university mailing lists. 12 were female, 6 male. Their average age was 21.7 (σ=4.91, min=18, max=37). All had native-level English proficiency. None had prior exposure to neuroscience. They received $60 for participating.

Materials

The videos, in-video quizzes, and unit exams were from Unit 1 of the Neurobiology course on Coursera. There were 9 questions and 5 videos in each 25-minute section. We generated the initial QuizCram materials directly from the course.

To see whether we could improve the recall of particular facts by adding questions, we added extra questions to the QuizCram condition to double the total number of questions. The extra questions were in the same multiple-checkbox format as the original questions. We made sure that they did not depend on the same facts as the unit exam or in-video questions.

We also wrote a set of free-response questions, with one corresponding to each of the extra 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 (rather than recognizing it).

Procedure

The study was conducted online over 2 days. On day 1, users studied the first section with one tool for 40 minutes. Then, they studied the second section with the other tool for 40 minutes, and took surveys. The order of tools was randomized. On day 2, users took the following exams:

1. Extra free-response questions
2. Original in-video questions from Coursera
3. Original unit exam from Coursera
4. Extra multiple-checkbox questions

Parts 2-4 were automatically graded. Free-response questions were graded blindly according to the formula:

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

RESULTS

Exam Results

Exam results are shown in Figure 7. QuizCram users performed significantly better on the original in-video questions, which had been shown in both conditions. They also performed better at both types of extra questions. Thus, QuizCram improves retention of the original in-video questions, and we can use added questions to improve retention of particular facts from the video.

Survey Results

When asked to rate satisfaction with the tool on a scale of 1 to 7, the average was 5.28 for QuizCram, and 5.17 for in-video quizzes. 61% said would prefer QuizCram if they wanted to remember material long-term or were preparing for an exam. These improvements were not significant.

Survey feedback showed that users liked QuizCram's question-based timeline of videos, and thought it was helpful for reviewing. However, some users disliked the visual complexity of the interface, and thought that the prominent display of questions distracted them from watching the video.

Analysis of Viewing Logs

To compare how users interacted with the two systems, we collected usage logs from each tool, as shown in Figure 8. We found that users answered each question more times when using QuizCram. Users also reviewed previously-answered questions more often when using QuizCram. This increase in practice and reviewing helps explain the increased exam scores on the original in-video questions.

Users seeked less on average when using QuizCram, which may be because they did not have to seek to and from in-video quizzes. However, this difference was not statistically significant.

CONCLUSION

We have presented QuizCram, a system that guides users' video viewing using questions. QuizCram aims to:

1. Encourage users to answer and review questions while they watch videos
2. Enable users to easily follow question-driven video navigation strategies (which we currently observe some users already using on Coursera)

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 guides 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 questions for users to review. Courses in the QuizCram format can be generated automatically from existing videos with in-video quizzes, though it also has the flexibility to accommodate additional questions.

Our user study found that QuizCram increases focus on questions – when the in-video questions were tested again a day later, users using QuizCram remembered them better than if they were presented as in-video quizzes. Users practiced answering and reviewing questions more often when using QuizCram.

We designed QuizCram to address the needs of users who wish to complete the MOOC and master the entire material. Hence, the system tests users' knowledge of video segments, and schedules reviews to ensure that users remember the material. That said, learning the complete course material is not the objective of many learners – many users are only interested in a subset of the material, and do not complete the rest of the course [4] [1]. Although addressing the needs of users interested in only a subset of the material was not an objective of QuizCram, it is potential future work.

Current online courses rely on external problem sets and exams to test understanding of content in more depth than the in-video quizzes. However, many MOOC participants interact primarily with videos and do not take exams or do problem sets. [1] [4]. Thus, moving more of the course content out of problem sets and making the video more interactive and question-oriented provides a way to benefit these viewers without removing them from the scaffolding of videos. We believe that QuizCram is a logical step from in-video quizzes towards more interactive, question-driven study experiences.

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