QuizCram: A Question-Directed Video Studying Interface

1st Author Name
Affiliation
Address
e-mail address
Optional phone number

2nd Author Name
Affiliation
Address
e-mail address
Optional phone number

3rd Author Name
Affiliation
Address
e-mail address
Optional phone number

ABSTRACT
TODO less than 150 words

Author Keywords
Guides; instructions; author's kit; conference publications; keywords should be separated by a semi-colon. Optional section to be included in your final version, but strongly encouraged.

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H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

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INTRODUCTION
Online courses on platforms such as Coursera and EdX focus heavily on viewing video content. However, a phenomenon known as the testing effect shows that actively engaging with the material and quizzing yourself on it is more effective for retention than simply passively watching the content. Platforms such as Coursera have in-video quizzes which attempt to bring the benefits of testing into the video context by asking the user a multiple-choice question at key points in the video about the content that they have just watched.

Our system, Quiz-driven Video Cramming (QuizCram), makes the quiz the focus of the review and doing the following:

Quizzes are shown before and alongside the associated video content, instead of after A timeline of previously answered quizzes, along with associated videos, is shown Quizzes can depend on video segments other than just the immediately preceding one.

However, there are some weaknesses with the standard in-video quiz format, which the system presented in our paper attempts to address:

In-video quizzes are shown only after the viewer has viewed the video: The in-video quiz serves simply as an after-the-fact indication to the user of whether they understood the preceding section or not. It does not actually help the user with the task of deciding whether he needs to watch this section, or identifying the key parts of the video that they should pay attention to while watching.

No call-to-action if the user doesn't know the answer: The user is freely able to skip over the quiz, and if they answer the question incorrectly then they are simply told they are incorrect (with no other feedback), or if they answer incorrectly 3 times the answer is shown and the video advances onwards. This does not encourage the

Limited flexibility in writing questions: In-video quizzes imply that their answer is located

Limited density of questions:

We present a system which attempts to improve on these weakness of in-video quizzes in the following ways:

Show the quiz beforehand: Our interface encourages users to look at the associated question before watching the video, so that it serves as an advance organizer to prime them towards the key concepts they should focus on while watching the video.

Provide helpful feedback

However, because the in-video quiz tests the key concepts in the section, it can also serve as a summary of the video. It is useful to look at it prior to viewing, both to show the user whether or not they need to view the video. Our interface encourages users to look at the in-video quiz before watching the video, so that it serves as an advance organizer to prime them towards the key concepts they should focus on while watching the video.

No call-to-action if the user doesn't know the answer: The user is freely able to skip over the quiz, and if they answer the question incorrectly then they are simply told they are incorrect (with no other feedback), or if they answer incorrectly 3 times the answer is shown and the video advances onwards. Instead, our system more useful feedback in response to an incorrect answer, encourages the user to review the relevant portion of the video, and enforces that users can answer the question on their own before advancing them to the next portion of the video.

Users are not encouraged to review the portions of the video they do not understand: Our own independent analysis of

viewing logs on Coursera shows that among users who finish watching a video, less than a sixth will ever re-open it. To encourage people to review videos, our system keeps track of which video portions users need to review (using a score based on question scores on associated segments, percentage of the segment reviewed, and recency of reviewing), and gives them suggestions of portions to review once they have watched all the video segments.

RELATED WORK
We designed our system features around a set of phenomenon from the education literature, which are also exploited by many other systems.

Testing Effect: Traditional Quizzes and In-video Quizzes
The testing effect finds that repeated testing combined with fast, informative feedback helps students remember material [8]. . Traditional courses already employ testing in the form of exams, but these are infrequent, are not repeated, and . Although in-video quizzes are more frequent, help resolve the delayed feedback issue by putting the quiz immediately after the relevant section of the video. However,

Our system attempts to make this more granular, making testing and quizzing at the video-clip level rather than the .

Pre-Testing Effect
Lindsey E. Richland: The Pretesting Effect: Do Unsuccessful Retrieval Attempts Enhance Learning?

Advance organizers: Video Transcript Summaries
Amy Pavel: Video Digests: A Browsable, Skimmable Format for Informational Lecture Videos

Visualizing progresss within videos
Robert Mertens: Social navigation in web lectures

Juho Kim: Data-Driven Interaction Techniques for Improving Navigation of Educational Videos

Abir Al-Hajri: Video Navigation with a Personal Viewing History

Spaced repetition: Flashcards
Spaced repetition is a technique designed to help learners retain information by having them review items at regular intervals. 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. Flashcards can also have associated multimedia, such as video clips.

Similar to flashcards, our system also schedules items (questions and associated video clips) for review according to mastery and recency of review. One key difference is that lecture videos build on each other, so this is an additional constraint for scheduling: the user needs to have covered the previous videos. Another key difference is the cost of review: a user memorizing vocabulary using flashcards only needs to spend a few seconds on each flashcard, while answering a question or reviewing a video clip takes an order of magnitude more

time. Hence, the user will make fewer review passes through the video content than they would with vocabulary flashcards.

Integration and assessment of streaming video content and API development into a spaced repetition service

The relevant portion of the video is not indicated by the quiz: the portion being tested is obviously

Density of In-video Quiz Questions
Is there any related work for this?

SYSTEM DESIGN
QuizCram's interface shows users a question to review, with an associated video segment, as shown in Figure 1. 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 is also suitable for having multiple questions associated with a single video segment.

Question-Focused Video Viewing
For each section of the video in the course, we have one or more associated questions. We can get these question-video pairs automatically from existing videos with in-video quizzes, by associating the in-video quiz section with the immediately preceding video segment. For video segments that did not have an associated in-video quiz, we either automatically insert a generic "How well did you understand this video" question, (the format tested in our first study), or write a new question (the format tested in our second study).

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 1. The video does not autoplay, so that the user has time to read the question before they start watching the video. 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 already know the answer, reading the question before they watch the video serves as an advance organizer which summarizes the key points they should pay attention to when watching the video.

Unlike in-video quizzes, which users are freely able to skip over, in QuizCram the user must correctly answer the question before they can move on to the next question and associated video segment. This is designed to ensure that users learn the material before advancing onwards, as opposed to simply passively watching the videos without testing themselves.
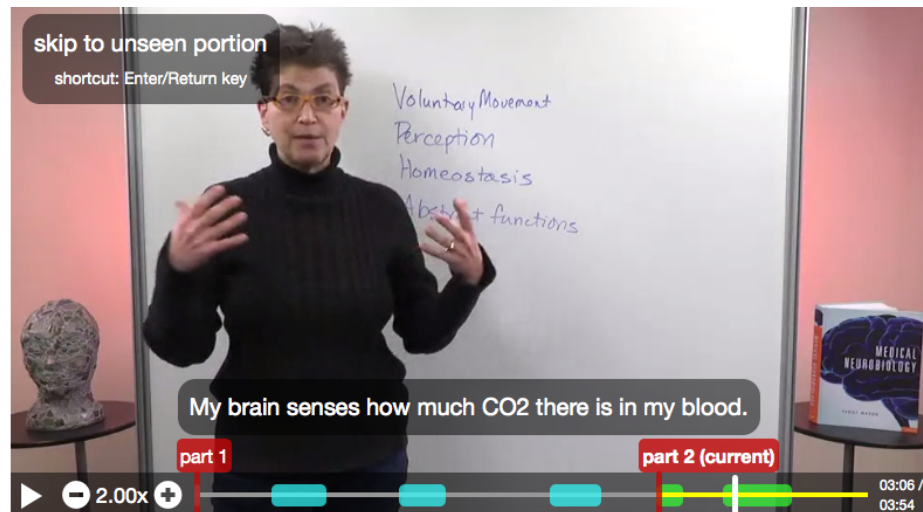
Figure 1. The QuizCram interface, showing the current video. The focus question is on left, and the associated video is on the right. The progressbar highlights the relevant portion of the video in yellow. Already-watched segments of previous sections is in blue, already-watched segments of the current part are in green. Because we are currently watching a section we have already viewed, an option to skip to the unseen portion is shown.

Forcing users to answer the question may lead to frustration if the user is unable to determine the correct answer even after watching the video. Hence, whenever the user answers the question incorrectly, we provide them with immediate, informative feedback by showing the answers and providing an explanation, as opposed to the model used by Coursera where it states that the answer is incorrect, and only shows the explanation and correct answer after 3 tries. We made this design choice based on literature that finds that specific feedback that explains the correct answer to learners is more helpful and motivates them more than simply stating that their answer is incorrect [10].

Of course, immediately showing the answer in response to an incorrect answer leads to the risk that learners may choose to immediately reveal the answer without attempting to answer the question themselves. To discourage such behavior, even though we show the user the answer and explanation in response to an incorrect response, we do not advance them automatically. Rather, we shuffle the answer options and require them to view an additional 10% of the video, which is roughly 20 seconds, before attempting to answer it again, as shown in Figure 2. We do not enforce the 10% viewing requirement if the user has already watched over 75% of the video. This viewing task encourages users to view unseen portions of the video, incentivizes users to answer questions correctly, and ensures they aren't simply storing the answers in short-term memory and reproducing them. Requiring users to view the video and then retesting them after an incorrect response creates an additional retrieval opportunity, which should improve retention of the material [8].

While shuffling the answers and requiring video watching in response to an incorrect response discourages users from simply submitting the incorrect response and memorizing the answers, it does not entirely eliminate the risk. We can further discourage memorization of answers by having multiple questions for each video segment, which we alternate between. For example, in a algebra context we could simply ask the question again with different variable values whenever the user responds incorrectly. However, we did not use this option in our user studies since it would require us to write additional questions.

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 question's mastery score is based on the following 3 factors:

- *Past performance on question*: This element of the score encourages users to review questions they answered incorrectly. Each time a user tries answering the question, we give them a score between 0 to 1 based on the percent of checkboxes they correctly checked (the questions used in our study were all multiple-check questions). We then do a weighted-mean of all historic scores, with each newer score assigned 2 times more weight than the previous score (so more recent performance is weighted more heavily). For those video segments that have no associated question, we obtain this score by asking users to rate "How well did you understand this video?". If the user has never answered the question before, this has a default score of 0.

- *Fraction of associated video segment watched*: This element of the score encourages users to view video segments they have not seen. For each section of video, we keep track of whether the user has ever watched it. This score is the number of seconds watched in the question's video segment, divided by the total length of that video segment.

- *Recency of review*: This element of the score encourages spaced repetition for the questions. It also ensures that users are not shown the same questions repeatedly, which

Figure 2. In response to an incorrect response, the user is asked to view an additional 10% of the video, the answer options are shuffled, and the user needs to re-answer the question correctly before moving on.

would make users bored. It is equal to 1 / number of questions elapsed since this question was last seen by the user. If the question has never been seen, this has a default score of 0.

The mastery score is a weighted sum of these factors, where question correctness is 4/7 of the score, fraction of the video watched is 2/7 of the score, and recency of review is 1/7 of the score. We assign question correctness the highest priority because users should all be able to answer the questions correctly, but some users may choose to not watch portions of video they consider irrelevant or already know.

Sorting by the mastery score alone does not enforce that users have met the prerequisites for understanding the video and answering the question, before we show them the video and question. Unlike flashcards, lecture videos are meant to be watched in order and build on each other, so each video segment has a set of prerequisite videos which need to be watched before students can understand them. In our implementation, we enforce prerequisites by requiring that the user has correctly answered the questions for preceding video segments, before we show them the next video segment and associated question.

Sorting questions by mastery score and enforcing the prerequisites effectively results in users first being shown questions that work them through the videos in the order the course covers them, then asking them to review the questions they got low scores for and videos did not finish watching.

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. We also show the historic correctness of the user's answers to that question, and percentage of the video they have watched, to help users identify questions they had trouble with and videos they did not fully watch.

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 Parts of Video Relevant to Question
Standard in-video quiz viewers show the entire video at once. However, QuizCram shows only the part of the video relevant to answering the question, specifically, the start of the video up until the point where the question would be located (in an in-video context). We additionally highlight in yellow the section of the progressbar where question answer is located. This is designed to focus the user's attention to the portion of the video that will help them answer the question.

For questions generated from in-video quizzes, we highlight the segment of the video that immediately preceded the in-video quiz to indicate that it is where the answer is found, as shown in Figure 1. However, because we can highlight any
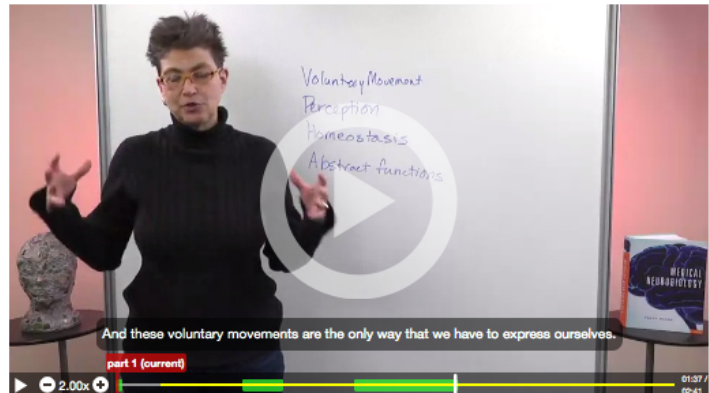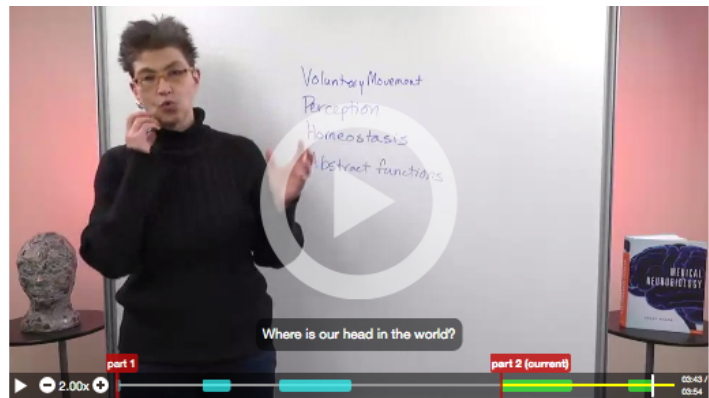
Figure 3. The scrollable timeline, shown immediately below the current question, displays the past set of questions the user has answered. We list the correctness score and video progress scores to help users locate the questions they had difficulty with, and videos they have not yet fully watched.
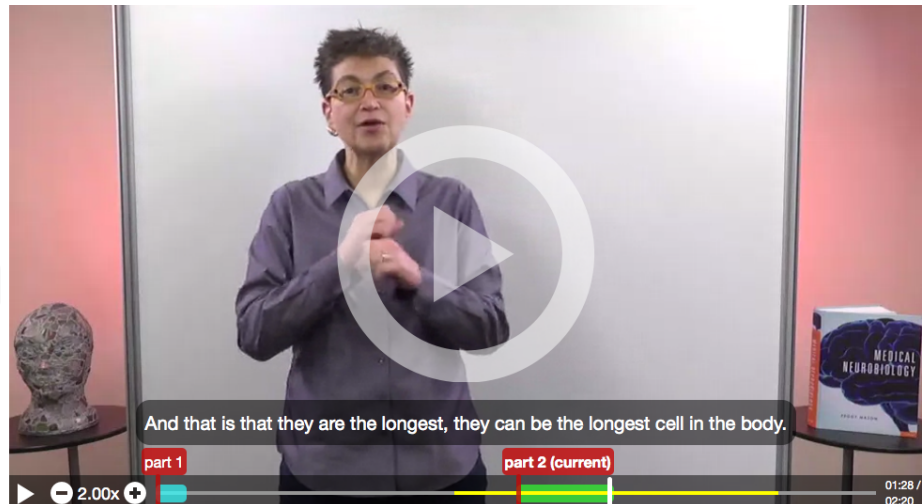

Figure 4. We highlight portions of the video that are relevant to the current question. This gives additional flexibility in question writing and placement: if the question depends on a portion of the video from a previous part, as in this example, we can highlight that section in the video progressbar to indicate that it is relevant to the current question
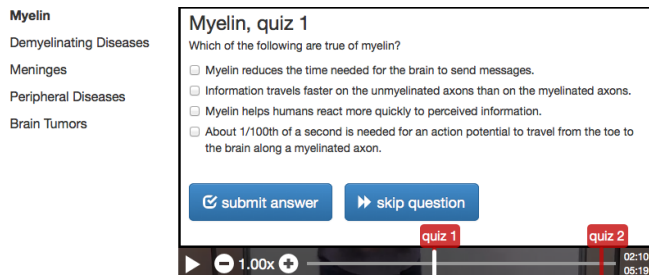
Figure 5. The in-video quiz format that served as our baseline. Left side lists videos, right side is a video viewer that shows the in-video quiz when reached. Locations of quizzes are indicated in red on the progressbar.

preceding portion of the video to indicate that it is relevant to the current question, this also allows us to have more flexibility in question writing and placement: we can place questions where they would fit most naturally, rather than immediately following the section where the answer is covered, as shown in Figure 5. This also enables us to have multiple questions that cover a single segment of video, without confusing users about where the answers to the questions are located.

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 [7] [4], though our system adds the novel feature of allowing users to skip to the next unseen portion.

EVALUATION
We conducted a pair of within-subject user studies that compared students' learning behavior using the QuizCram interface, compared to an in-video quiz format that imitates Coursera. The course materials – videos, in-video quizzes, and unit exams — were Units 1 and 2 of an existing Neurobiology course on Coursera.

The first study tested the QuizCram format which results from a direct, algorithmic transformation from the original materials from Coursera. In the second study, we started with the results of this direct transformation, but then also inserted additional questions to see what the effects of doubling the question-to-video-content ratio would be with the QuizCram format.

The questions we aimed to answer with these studies were:

- Do students prefer QuizCram or the in-video quiz format?

- Do students remember the questions presented along with videos better when using QuizCram?

User Study 1

Our first study was an within-subjects study that compared the automatically-generated QuizCram format to an in-video quiz interface that imitates Coursera. We wished to answer the questions:

- Do users remember the questions better

Study Design

User Study 2
Our second study was an within-subjects study that compared the QuizCram format with double the number of original questions (resulting from inserting additional questions into the video), to an in-video quiz interface with the original questions from Coursera. We wished to answer the questions:

- **Q1:** Do users using QuizCram better remember answers to the original in-video questions?

- **Q2:** Do users using QuizCram perform better on the unit quiz?

- **Q3:** Can we improve recall of particular facts from the video by inserting additional questions with QuizCram?

- **Q4:** Do users enjoy using QuizCram?

- **Q5:** How do users use QuizCram?

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 and job boards. 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 specifically 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 2.5-hour online study.

Materials
We doubled the number of questions shown in the QuizCram condition by adding additional questions in the same style and format as the original multiple-checkbox in-video questions. We chose our questions carefully such that the answers were clearly stated in the video, but they would not ask the same facts that were tested on the unit exam or original in-video questions.

We also wrote a set of free-response questions, one corresponding to each of our extra multiple-checkbox questions. For example, the question "Which of the following are true of astrocytes?" followed by 3 true options and 2 false options would be transformed into the free-response question "List 3 facts about astrocytes". We used these free-response questions to test whether users had actually learned the material tested by our new questions well enough to recall it, as

opposed to simply learning to recognize the answers when presented in multiple-checkbox format.

Procedure

The study was conducted online over 2 days, with a 90-minute study section on the first day, and a 30-minute test section 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 on their contents in 24 hours. We did not tell them about the content of the exams.

On the first day, users used one tool to watch the first half of Unit 1 (5 videos of length 23 minutes total). They were told after 40 minutes to fill out a survey about the tool. Then, they used the other tool to watch the second half of Unit 1 (5 videos of length 25 minutes total), and filled out the survey after 40 minutes of watching.

On the second day, users filled out a set of exams in the order listed below:

1. Extra free-response questions (as described in the Materials section), both halves

2. Original in-video questions from Coursera, both halves

3. Original unit exam from Coursera, both halves

4. Extra multiple-checkbox questions (as described in the Materials section), both halves

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 general form "List N examples of X" or "State N facts about X", were graded by first marking each example provided by students as correct or incorrect. Examples and facts did not need to be the same ones provided in the video – so long as they were appropriate to the question and correct, they were marked as correct. Then, we scored each response via the formula:

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

Thus, if a question requests 2 examples, giving 1 correct example gets a score of 1/2, giving 2 correct examples and 1 incorrect example gets a score of 2/3, etc. The overall score for the free-response exam was the mean of these scores.

We chose this design of having users watch both sets of videos before taking any exams, as opposed to having them take an exam after they finished studying each section, because this way the user does not know that the exam includes the in-video questions, so this does not influence their study behavior. In previous versions of this study we had observed that if users know they will be tested on in-video questions, either by taking the exam or if we told them, they will explicitly study them and will have near-perfect scores on those parts of the exam, but not the rest of the exam. We instead chose our current study design so that we can observe the tool's effect on in-video question retention in natural study contexts where the user knows nothing about the exam.

Test Results

Users were better able to answer the original in-video questions when using QuizCram. They averaged 85.4% correctness with QuizCram, compared to 81.3% correctness with the in-video quiz format. A t-test showed this difference was statistically significant (t=2.24, p=0.0391). The average scores between the two halves were similar – 84.5% average for part 1, 82.2% average for part 2, with no significant difference (t=0.55, p=0.589). Thus, even though the users encountered the original in-video questions in both conditions, the QuizCram format caused them to remember the answers better.

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). The average scores between the two halves were similar – 59.4% average for part 1, 57.1% average for part 2, with no significant difference (t=0.35, p=0.731).

Although the users who used QuizCram had never seen the free-response questions before, the questions asked similar material to the extra multiple-checkbox questions we had inserted for the QuizCram format, except in free-response format.

Users performed slightly better . The second part of the unit exam appeared to be easier than the first half – the mean was 59% for the first half, vs 69% for the second half – however, this difference was not statistically significant ().

Thus, even though the users encountered the original in-video questions in both conditions, the QuizCram format caused them to remember the answers better.

DISCUSSION

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Figures	Below	Below

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- Briefly define or explain all technical terms that may be unfamiliar to readers.

- Explain all acronyms the first time they are used in your text—e.g., "Digital Signal Processing (DSP)".

- Explain local references (e.g., not everyone knows all city names in a particular country).

- Explain "insider" comments. Ensure that your whole audience understands any reference whose meaning you do not describe (e.g., do not assume that everyone has used a Macintosh or a particular application).

- Explain colloquial language and puns. Understanding phrases like "red herring" may require a local knowledge of English. Humor and irony are difficult to translate.

- Use unambiguous forms for culturally localized concepts, such as times, dates, currencies and numbers (e.g., "1-5-97" or "5/1/97" may mean 5 January or 1 May, and "seven o'clock" may mean 7:00 am or 19:00). For currencies, indicate equivalences—e.g., "Participants were paid 10,000 lire, or roughly $5."

- Be careful with the use of gender-specific pronouns (he, she) and other gendered words (chairman, manpower, man-months). Use inclusive language that is gender-neutral (e.g., she or he, they, s/he, chair, staff, staff-hours, person-years). See [9] for further advice and examples regarding gender and other personal attributes.

- If possible, use the full (extended) alphabetic character set for names of persons, institutions, and places (e.g., Grønbæk, Lafreniére, Sánchez, Universität, Weißenbach, Züllighoven, Århus, etc.). These characters are already included in most versions of Times, Helvetica, and Arial fonts.

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CONCLUSION

It is important that you write for the SIGCHI audience. Please read previous years' Proceedings to understand the writing style and conventions that successful authors have used. It is particularly important that you state clearly what you have done, not merely what you plan to do, and explain how your work is different from previously published work, i.e., what is the unique contribution that your work makes to the field? Please consider what the reader will learn from your submission, and how they will find your work useful. If you write with these questions in mind, your work is more likely to be successful, both in being accepted into the Conference, and in influencing the work of our field.

REFERENCES FORMAT

References must be the same font size as other body text.

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