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Interactivity Unleashed: Integrating Embedded Questions in Videos to Increase Student Interaction with Content in Asynchronous Engineering Courses

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Introduction

Video is a versatile and widely used medium in online higher education. However, the format's primarily passive nature is a common concern for both instructors and designers. Incorporating interactive elements, such as embedded questions and interactions, offers a way to transform video content from a one-way content delivery mechanism into a more dynamic, learner-centered tool that fosters active engagement, deeper comprehension, and improved performance.

This study explores student interaction with embedded video quizzes in an asynchronous online engineering course, *Purchasing Applications in Distribution*. By analyzing participation rates, completion patterns, and response behaviors, this research offers insight into how embedded video interactions and strategic course design choices can be leveraged to increase student interaction with video content.

While this study provides a detailed analysis of student interaction patterns with embedded video quizzes, it does not include direct measures of student learning outcomes, such as final grades or exam performance. Therefore, the findings should be understood as descriptive of behavioral engagement rather than indicative of learning gains.

Literature Review

Video is a staple of online higher education, offering a range of affordances that make it a versatile instructional tool. It is well-suited for exposition, demonstrations, guided processes, and the clarification of complex concepts through narration paired with dynamic imagery [1]. Additionally, the medium supports self-paced learning [1], can aid in the management of cognitive load [2], may enhance instructor presence [3], and has been shown to foster positive study habits among students [2]. Scagnoli, Choo, and Tian highlight a strong correlation between satisfaction with video learning and positive learning experiences [4], highlighting video's importance in contemporary online instruction.

Despite the many benefits of videos, ensuring sustained student focus during viewing remains a significant challenge [5],[6]. Videos rely on students to self-direct their focus on the concepts being presented, potentially leading to issues like reduced comprehension or retention and early dropout [7]. Research indicates that videos are most effective when integrated into interactive environments [1]. Without interactive elements, video learning can be essentially a passive experience [6], which can limit its educational impact [1], [8].

To address these challenges, incorporating interactive elements into instructional video is increasingly seen as a valuable strategy for optimizing its instructional potential. Even simple interactive features, such as giving students control over video playback, have been shown to improve learning outcomes [8]. Advancements in video technology now enable more sophisticated interactivity features such as embedded quiz questions, polls, enforced pauses, and branching scenarios. These features can foster deeper learning by encouraging students to actively process and apply new knowledge as they watch [10], [11], [8], [12], leading to deeper understanding and retention of material [1], [9].

Embedded Quizzes

Embedded quizzes are interactive questions integrated directly within the video user interface, which pause playback and require learners to respond before the video continues. This design can be used to prompt learners to process and apply information in real time and encourage viewers to stay focused. Research shows that embedded quizzes increase student attention and reduce mind-wandering [4], [13], [14], [5], [16], foster active learning through content interaction [5], [15], and encourage positive study behaviors. Additionally, embedded quizzes provide accountability through knowledge checks [17] and provide timely feedback during the learning process [6], [14].

Embedded interactions demonstrate potential to improve learning outcomes. Stronger student-content interactions have been shown to enhance learning [11], and several studies have found that embedded quiz questions can positively affect test scores [18],[19]. Notably, even the mere presence of embedded questions can trigger an indirect testing effect, further supporting retention and understanding [4].

In addition to these benefits, embedded questions address the issue of video dropout. Several studies report that students watching videos with embedded questions remain engaged for longer, view a larger percentage of the video before leaving, and replay the video more [14], [20].

Embedded questions are well-received by students [14],[21] who find them to enhance their learning experience [22]. Students report advantages such as improved comprehension, increased agency, attention, engagement, and immediate feedback [4], [18]. Many students find embedded quizzes helpful in studying [4].

By prompting learners to interact with material rather than passively consume it, embedded quizzes represent a promising approach to making video content more dynamic and instructionally effective.

Research Questions

This research investigates student behavior in response to embedded quizzes within course videos in an online asynchronous undergraduate engineering course. The research was guided by the following research questions:

- What is the level of student interaction with embedded interactions in the course, as evidenced by quiz participation, time spent, and scores?
- How do course design and policy decisions impact student interaction with embedded video quizzes?

- How consistent is student participation across different quizzes throughout the course?
- What trends can be observed in student performance on quizzes over time?
- Are there specific areas of the course material where students face more challenges, as indicated by quiz scores and completion rates?

These objectives align with the data available and will allow a detailed observational analysis that seeks to identify how embedded video interactions and related course design and policy decisions may influence student behaviors in an online asynchronous course. This could inform the design and implementation of interactive video content to optimize the instructional value of videos in online education.

Research Design and Methodology

This study employs a primarily quantitative, retrospective, and observational research design to investigate student interactions with embedded quizzes in an asynchronous online engineering course. Our analysis utilizes descriptive statistics to observe and interpret patterns in student participation, quiz completion rates, and student performance across 27 lecture videos containing 93 embedded interactions.

Data were extracted from the PlayPosit gradebook and individual quiz analytics, providing detailed information on quiz scores, points earned, time spent, and student responses to each question. Data from all enrolled students and quizzes was included, ensuring a comprehensive dataset by downloading the information in CSV format, compiling it, and removing duplicate records to ensure accuracy and consistency. Descriptive analysis was conducted using Excel to generate metrics such as mean scores, median scores, standard deviations, minimum and maximum scores, and time spent on quizzes.

This study does not include direct measures of learning outcomes, such as final grades or assessments beyond the embedded video quizzes. It focuses on student interaction patterns, and given the course-specific context and small sample size, the findings should be interpreted as exploratory.

Our university's Institutional Review Board (IRB) approved the research protocol for this study, ensuring that all data collection, analysis, and reporting processes met ethical and legal standards, with a strong emphasis on protecting student privacy. Identifiable data were anonymized by replacing personal identifiers with unique numerical identifiers.

Course Context and Design Rationale

Background

This paper examines a pilot initiative to integrate interactive video interactions into an online asynchronous engineering undergraduate course, “Purchasing Applications in Distribution.” This senior-level course is part of the BS in Industrial Distribution program within the College of Engineering. The course content explores various aspects of purchasing within the distribution industry and integrates theoretical concepts with mathematical applications relevant to distribution purchasing strategies, strategic planning, supplier relations, and cost analysis.

The online version of this course was collaboratively developed by the course instructor and instructional designers from the College of Engineering's remote learning department. The analysis and planning phase began in the fall of 2019; lectures were recorded during the spring of 2020 face-to-face sessions using lecture capture technology, then edited and adapted for the online course, which launched in the summer of 2020.

One of the main challenges in transitioning to an asynchronous format was preserving the dynamic interactivity that supported student learning and reflected the instructor's distinctive teaching style. In the face-to-face delivery of this course, the instructor regularly used graded clicker questions and paused at frequent intervals during the lecture to implement various questioning techniques to engage students and monitor their comprehension. Recognizing the importance of this course component, the design team looked for ways to replicate this experience for asynchronous learners. To achieve this, the instructional design team selected PlayPosit. This interactive video tool can be used to enhance any video with interactive features such as multiple-choice questions, open-ended questions, polls, discussion prompts, and links to enrichment content like websites and PDF files. As students watch an assigned interactive video, the video will pause at the points where an interaction is embedded, and a question or prompt will pop up within the video player, requiring a response from the viewer before continuing. PlayPosit integrates with most learning management systems, including Canvas and Blackboard, enabling a seamless quiz score transfer into the gradebook.

Development Process

Developing interactions was a collaborative effort. The instructor designed some of the questions and interactions while preparing the lecture, and instructional designers identified additional opportunities during video analysis and editing. Each interaction was carefully reviewed to ensure it contributed meaningfully to the learning experience and was aligned with course, module, and lecture objectives.

In this course, each video lesson included a set of embedded, graded interactions. These sets were grouped and recorded as a single quiz grade in the LMS. From this point forward, the term quiz refers to the complete set of embedded interactions associated with a single video lesson. A total of 27 quizzes were used in the course.

Although PlayPosit supports nine interaction types, we strategically decided to exclude those that would require manual grading, and instead focus on creating well-written, self-grading interactions that could provide immediate feedback to students. With this goal in mind, the team carefully selected interaction types such as multiple-choice questions, links, enforced pauses, polls, and fill-in-the-blank questions to maximize learning impact while minimizing instructor workload.

Grading Policy

The instructor emphasized the expectation of video viewing and quiz participation by designating video quiz scores as 10% of the final course grade. For gradebook consistency, all interactions within a given video were grouped into a single quiz entry, ensuring clear grading alignment and transfer from PlayPosit to Blackboard. In keeping with this class's established classroom policy, any participation attempt was rewarded with partial credit, with full credit available for correct answers. Students were allowed unlimited retries for any quiz.

Video Segmentation Strategy

Course design involved dividing longer lectures into shorter, more manageable segments at natural topical breakpoints. This strategy reduces video dropout rates [8], [24] and supports better information processing for learners [9], [25]. However, even after segmenting videos, some videos were longer than recommended, due to the complexity of the content or other factors. Therefore, to further enhance the learning experience, we purposefully integrated in-video interactions to further organize and chunk content. This approach was based on research supporting in-video interactions as an effective alternative to traditional video segmentation [17], [19].

Summary

By leveraging interactive video tools like PlayPosit to embed interactive elements directly within lecture videos, the course design for *Purchasing Applications in Distribution* attempts to address a common issue faced in transitioning from face-to-face to an asynchronous online format: how to replicate and transform in-class interactions for the asynchronous online setting. This strategic use of technology maintained the instructor's engaging teaching style, facilitated organization of the content, and created opportunities for learner engagement with content. Importantly, the grading policy was structured to reinforce the course design, leverage the interaction tool, and encourage student interaction by rewarding students for both effort and accuracy.

Transitioning into the results, the impact of these thoughtful design choices becomes evident. The high levels of quiz participation and completion rates observed across the course suggest that video interactions, supported by a strategic grading policy, are effective in encouraging student interaction with video content. The following section dives deeper into how students interacted with embedded video interactions and explores the potential implications of these findings for course design.

Findings and Observations

This section explores the data collected from the implementation of the interactive video tool PlayPosit in the *Purchasing Applications in Distribution* course. We detail student participation rates and quiz completion and score statistics to observe how students interacted with the embedded quizzes. We investigate performance variations across different quizzes to pinpoint areas where interactions were most and least effective. This analysis aims to shed light on student interactions and behaviors in response to the course's interactive elements in order to inform and enhance the design of similar asynchronous learning environments in the future.

Scope and Scale of Implementation

The course comprised 34 lecture videos, with about 80% containing at least one interaction. In total, 93 embedded interactions were integrated across 27 instruction videos, with an average of 3.4 interactions per video (Fig. 1). Videos ranged in length from 6 minutes to 32 minutes, with an average length of 18.5 minutes (Fig. 2). On average, interactions were placed every 5.4 minutes—more frequently than the 8.7-minute interval described by Cummins, Beresford, and Rice as acceptable to students [14].

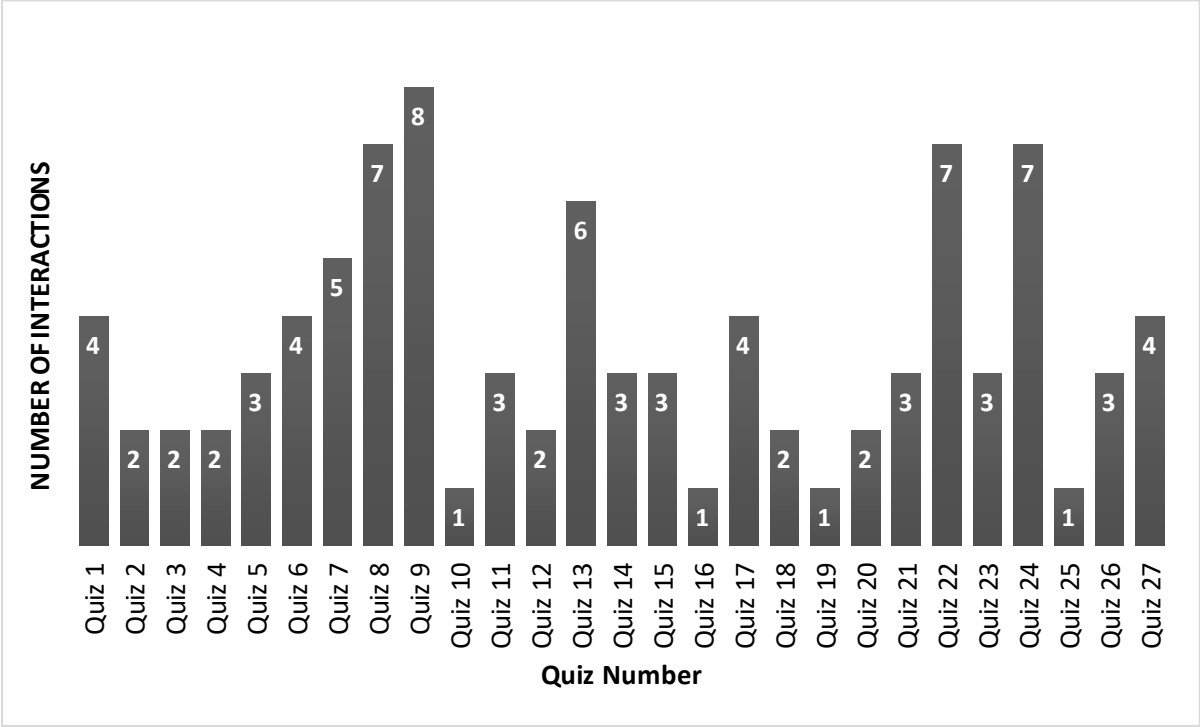

Figure 1. Number of interactions in each video

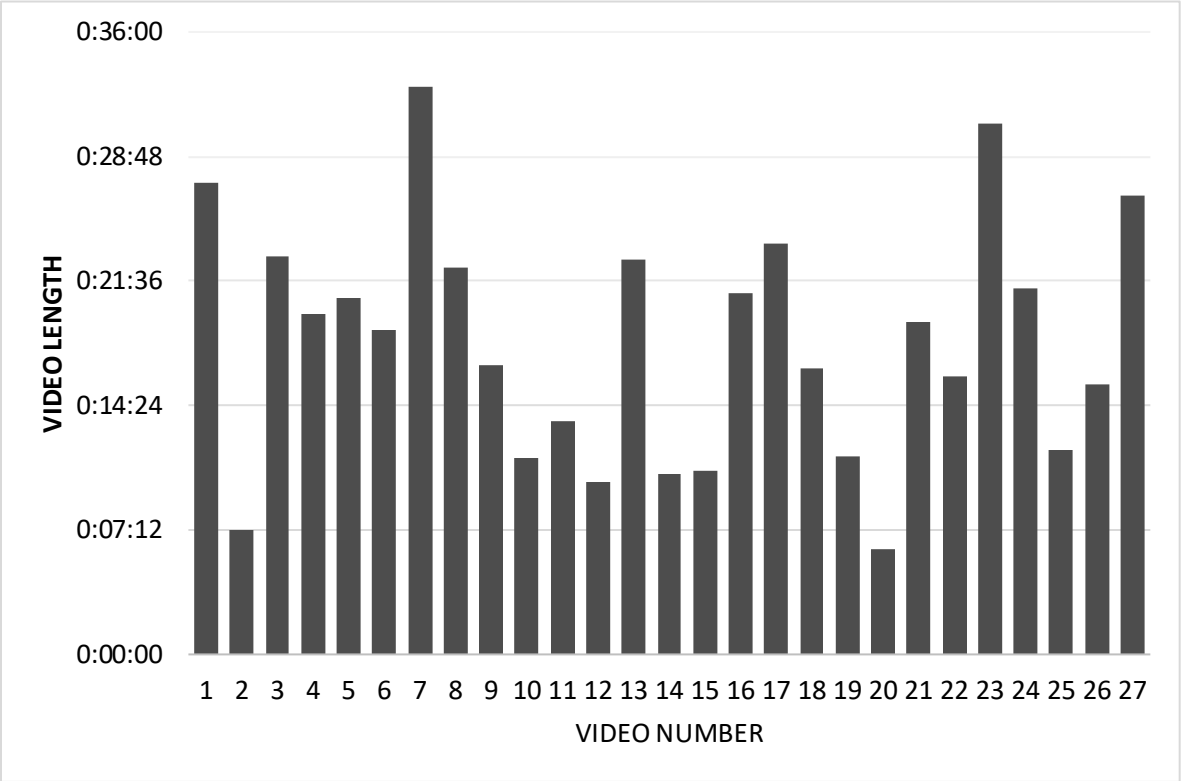

Figure 2. Video length

Quiz Participation Rates

Participation rates remained consistently above 96%, with completion rates above 80% for nearly all students. There was no notable drop-off in participation at any point during the course. These rates exceed those reported in similar studies of asynchronous courses using embedded video interactions [4], [14], [20].

The maximum number of student participants in any quiz was 31, and the minimum was 30. By participants, we mean a student who viewed at least part of the video and attempted at least 1 question within a given quiz. Participation does not imply completion.

Quiz Completion Rates

Completion rates for all quizzes remained above 80%, with 93.75% of students completing between 80% and 100% of the quizzes. Notably, 59.38% of students completed more than 90% of quizzes. Only one student (3.125%) had a completion rate below 80%, and this student withdrew early in the semester. These data suggest consistent participation and quiz completion across the student cohort (Table 1).

Percent of Quizzes Completed	Number of Students	Percentage of Total Students
90-100%	19	59.375%
80-90%	11	34.375%
70-80%	1	3.125%
50-70%	0	0.000%
30-50%	0	0.000%
0-30%	1	3.125%

Table 1. Completion Rates

The overall high participation and completion rates suggest that the quizzes were well-received and that the course structure effectively encouraged consistent participation. When students regularly participate in course quizzes, it often indicates that they are actively engaging with course material and are motivated to succeed [23].

Quiz Scores

The mean quiz scores were high, ranging from 87.2% to 100%, with an average score of 92.7% (Fig. 3).

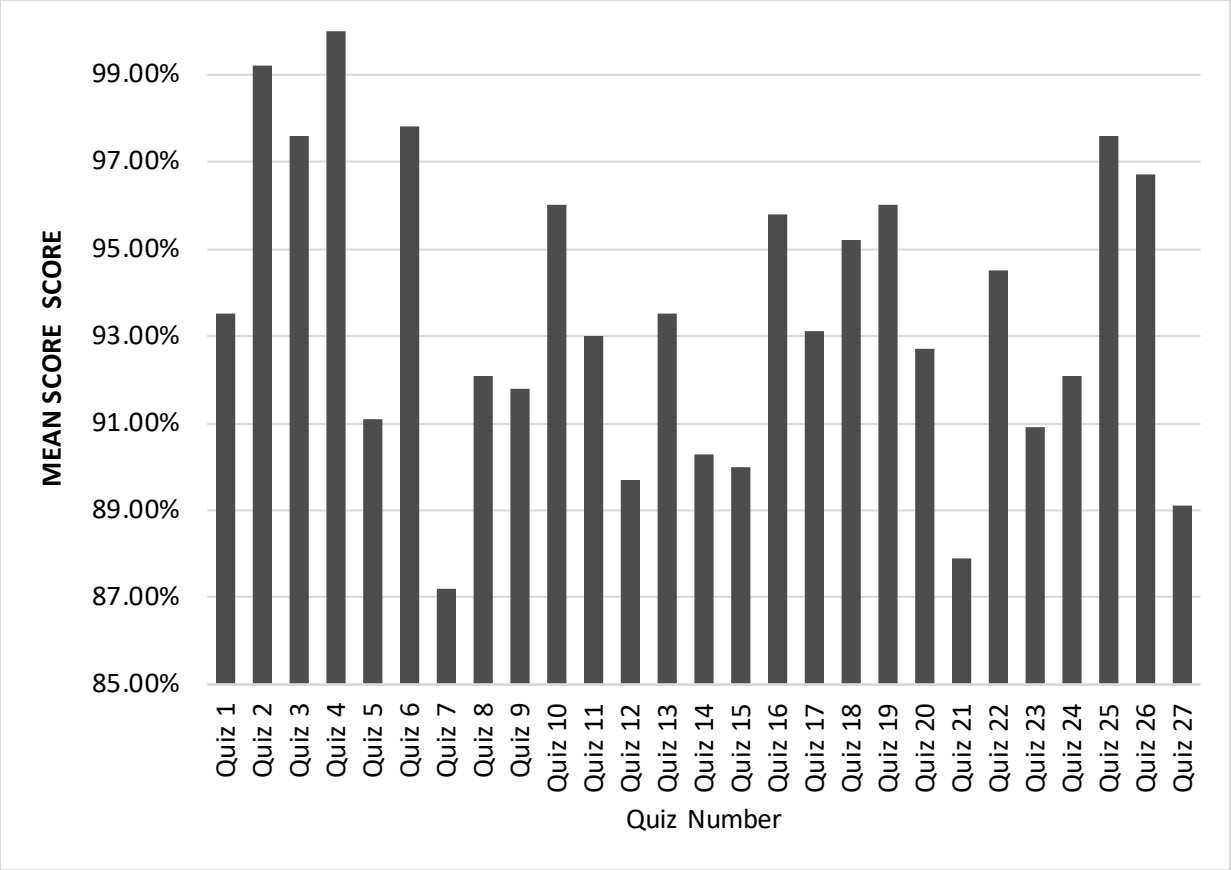

Figure 3. Mean Quiz Scores

We predicted that the course policy allowing unlimited attempts for all quizzes without penalty would contribute to high mean scores and that students would take advantage of this opportunity. However, in our analysis of 935 quiz attempts, we observed that only 48 were retries, accounting for only 5.1% of the total quiz attempts (Fig. 4) 45% of students retried at least one quiz at least 1 time, with 54% of students never attempting any quiz more than once (Fig. 5). Of the 45% of students who retried a quiz, a group of 3 students accounted for 42% of all retries (labeled as Super Retriers), with 22 retries between them. The remaining 26 retries were spread among a group of 11 students (Fig. 5).

The Pearson correlation coefficient for the number of retries and the mean quiz score is approximately -0.25 (Fig. 6). This indicates a weak negative correlation between the number of retries and the mean score: as the number of retries increases, the mean score tends to decrease slightly, indicating that the policy of allowing multiple attempts did not positively affect the mean scores. However, the R-squared value derived from the correlation is approximately 0.0625, indicating that only about 6.25% of the variance in mean quiz scores can be attributed to the number of retries. This reinforces the conclusion that in this course, the possibility of retaking quizzes did not play a significant role in the high performance observed.

Interestingly, there were very few retries on the first half of the course video quizzes (Fig. 7). There were several retries on the first quiz, then no retry attempts on the following ten quizzes. Even

quizzes with low mean scores, such as 3.2 and 4.2, had no retries. Then, at Quiz 6.3, students start retrying quizzes again. There is no immediate explanation for this pattern, but it merits further exploration.

Quizzes were only ever retried 1 time; no student retried a quiz more than 1 time. When you consider the high mean scores for these quizzes in combination with the low number of retries, it indicates that most students were satisfied with their initial scores.

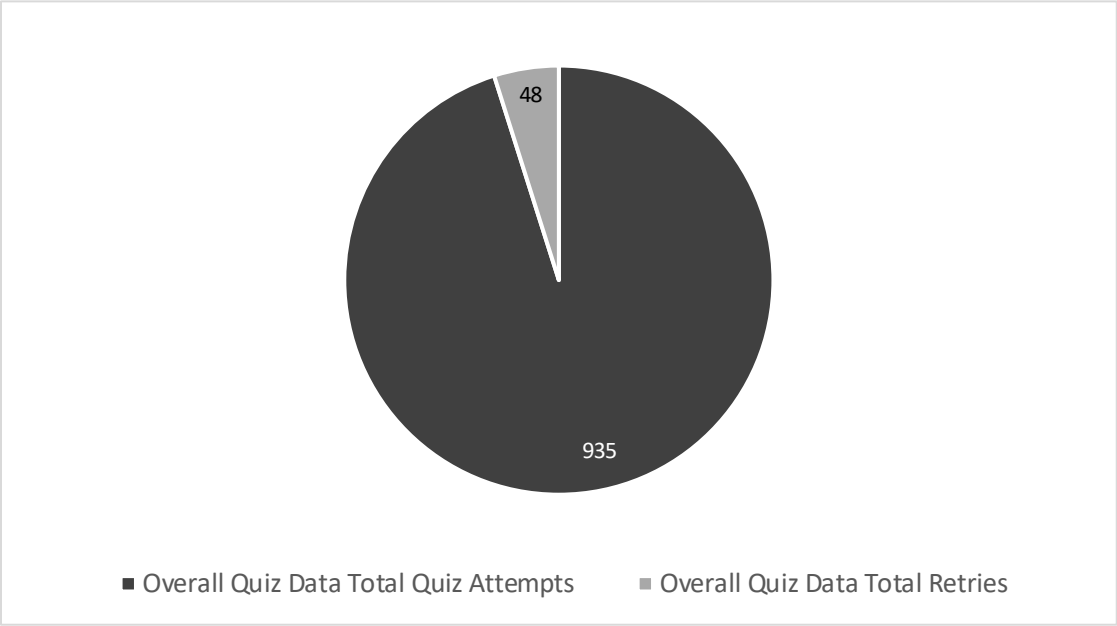

Figure 4. Retries vs All Quiz Attempts

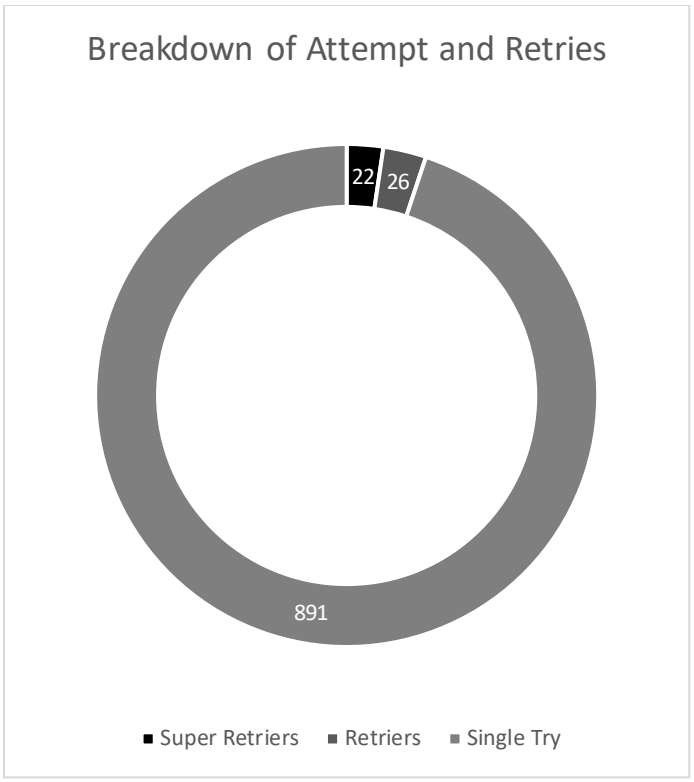

Figure 5. Number of Tries and Retries by Group

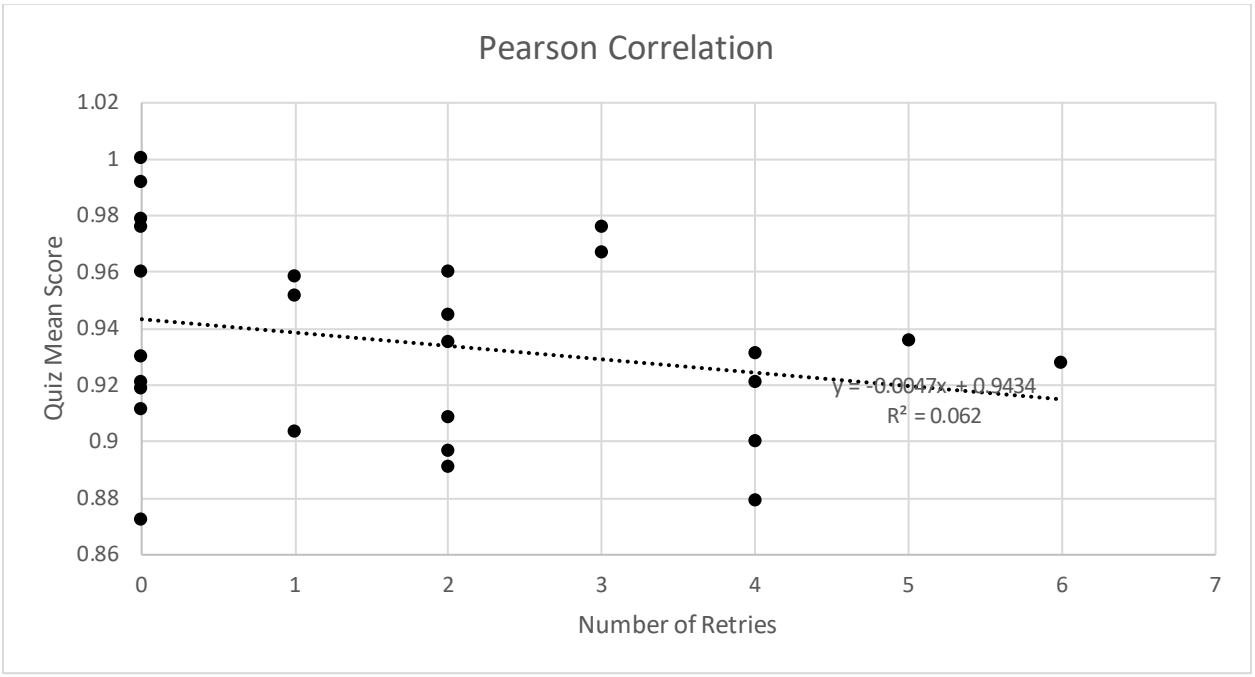

Figure 6. Relationship between Number of Retries and Mean Quiz Score

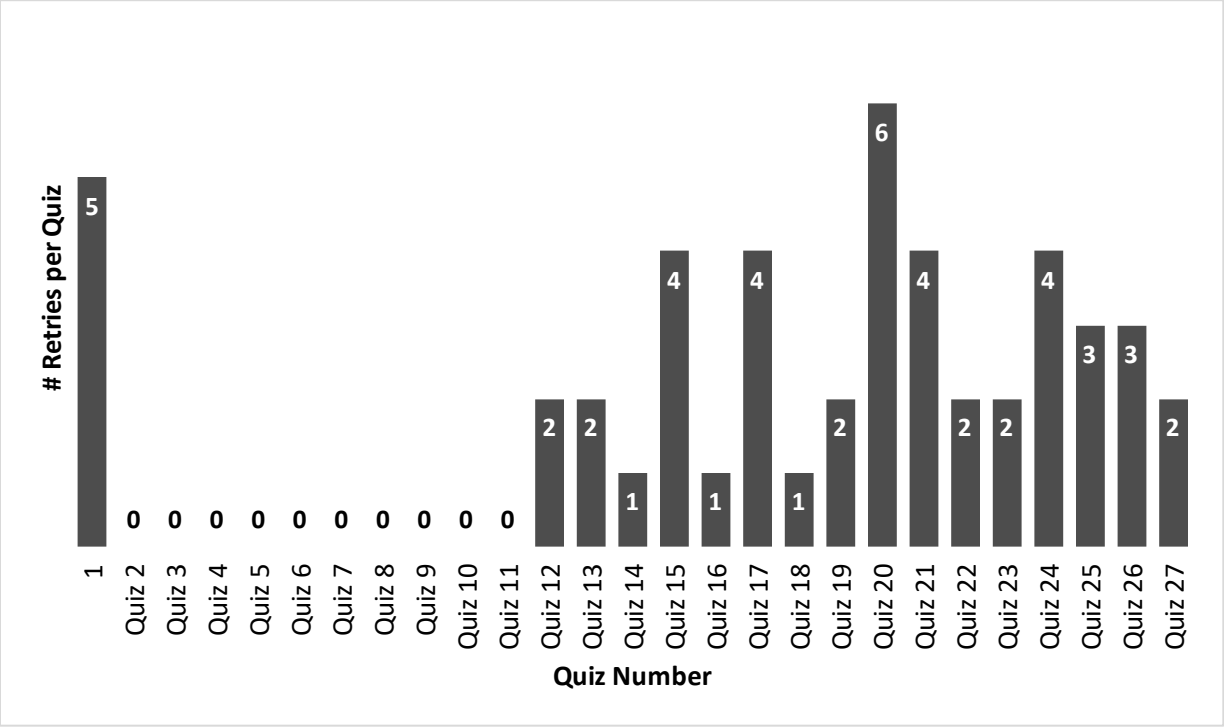

Figure 7. Retries by Quiz

Quizzes with Lower Mean Scores:

Quiz 7 and Quiz 27 had the lowest mean scores, 87.2%, and 89.1%, respectively. These quizzes were examined to determine any design factors that may have contributed.

In Quiz 7, a closer examination of question responses determined that the source of the lower scores was a "Multiple Answer" format question, which 63% of students were unable to answer correctly. This format is likely more challenging than a simple multiple-choice question and contributed to the lower mean score. This video was also one of the longer videos at 32 minutes, well above the recommended guidelines for video length, which may have discouraged students from revisiting the video or attempting the quiz again. Likewise, Quiz 27 was also quite lengthy at 30 minutes and had several fill-in-the-blank questions that proved challenging for students. Both videos would likely benefit from revision, either by rewriting the material more concisely or by reorganizing it into several subtopics, each with its own video.

The data for all quizzes were analyzed to determine if there was a correlation between quiz mean score and video length. The Pearson correlation for these was -.29 (Fig. 8), indicating a weak negative correlation; as video length increases, mean scores slightly decrease.

In some longer videos, embedded interactions were used to structure and organize content internally, serving a chunking function within a single video file. However, the lower performance on these longer videos suggests that this approach may not be as effective as ensuring that instructional videos

are concise and focused to optimize video length. This aligns with research that supports limiting the length of instructional videos, as well as segmenting and organizing content [1], [8], [9], [24], [25].

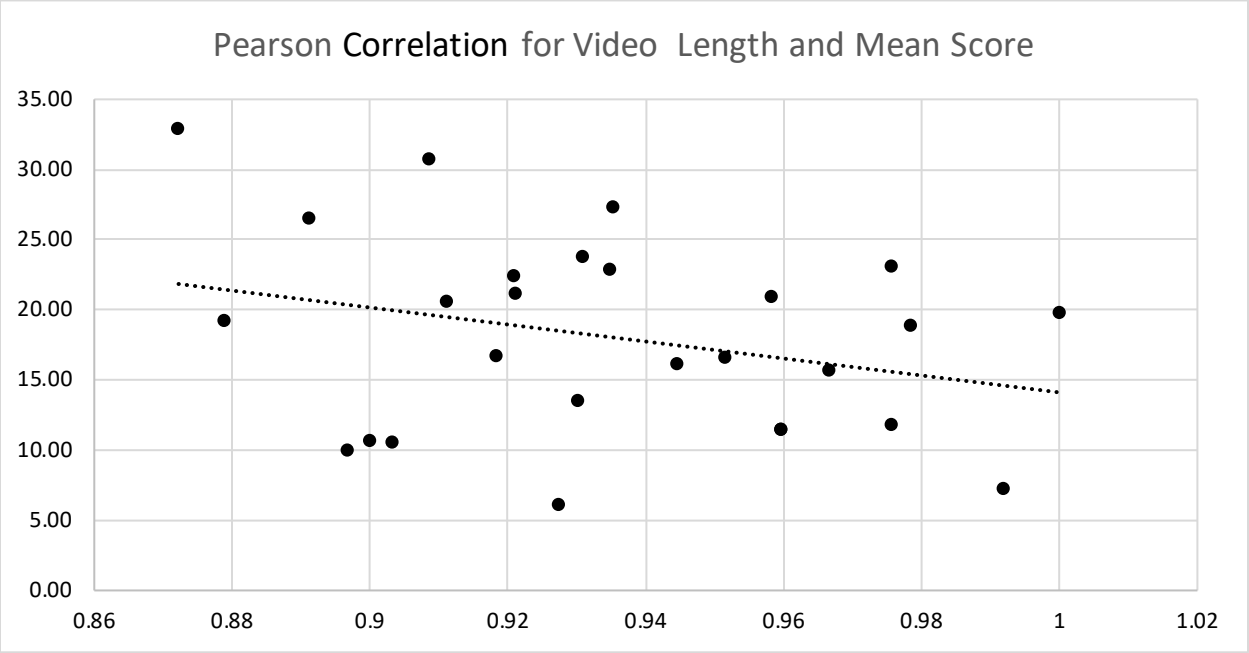

Figure 8. Relationship of Video Length and Mean Score

Quizzes with High Mean Scores:

Quiz 9 has the highest average points earned and also a higher number of embedded questions. This quiz implemented an incremental problem-solving question placement strategy to walk students through a worked example. This approach allowed students to work through the example with the instructor, while strategic pauses before the instructor confirmed the answer for each step allowed students to check their understanding of the question. While there are other possible contributing factors, the high mean score may indicate that this approach can be particularly practical in eliciting cognitive engagement with course materials.

Average Time Spent

PlayPosit collects data on how long the video window is open and active until quiz completion as a proxy for time spent actively watching each video quiz. The nature of how this data is collected means that the presence of outliers, a small group of students who spent an unusually long time on the video, skewed the averages.

To get a clearer picture of typical behavior, the time spent data was organized to show how much time each student spent on the quiz over the video length. Analysis found that 72% of students spent less than 15 extra minutes on the quiz (meaning that time spent was equal to or less than the sum of the total video length plus 15 minutes). 59% of students engaged with the quiz for less than seven excess minutes (Fig. 9), and 27% of students showed a time spent within 30 seconds of the video

length. This shows that most students completed the video and quiz questions in one watch-through with minimal interruptions or time spent replaying or scrubbing back and forth in the video.

28% of the students took longer than 15 additional minutes beyond the video length to complete the quiz, which could be due to many factors, such as differences in individual background knowledge, learning pace, or external circumstances such as distractions, interruptions, or technical issues.

Finally, the outliers, a group representing 11% of students, spent more than 60 excess minutes completing the video and, in some cases, logged up to 24 hours of time.

Given that this data measures only whether the video window was open and in focus, it seems that some students left the quiz window open and idle for long periods, later returning to complete the quiz. In the future, pairing this data with student interviews could help interpret this information.

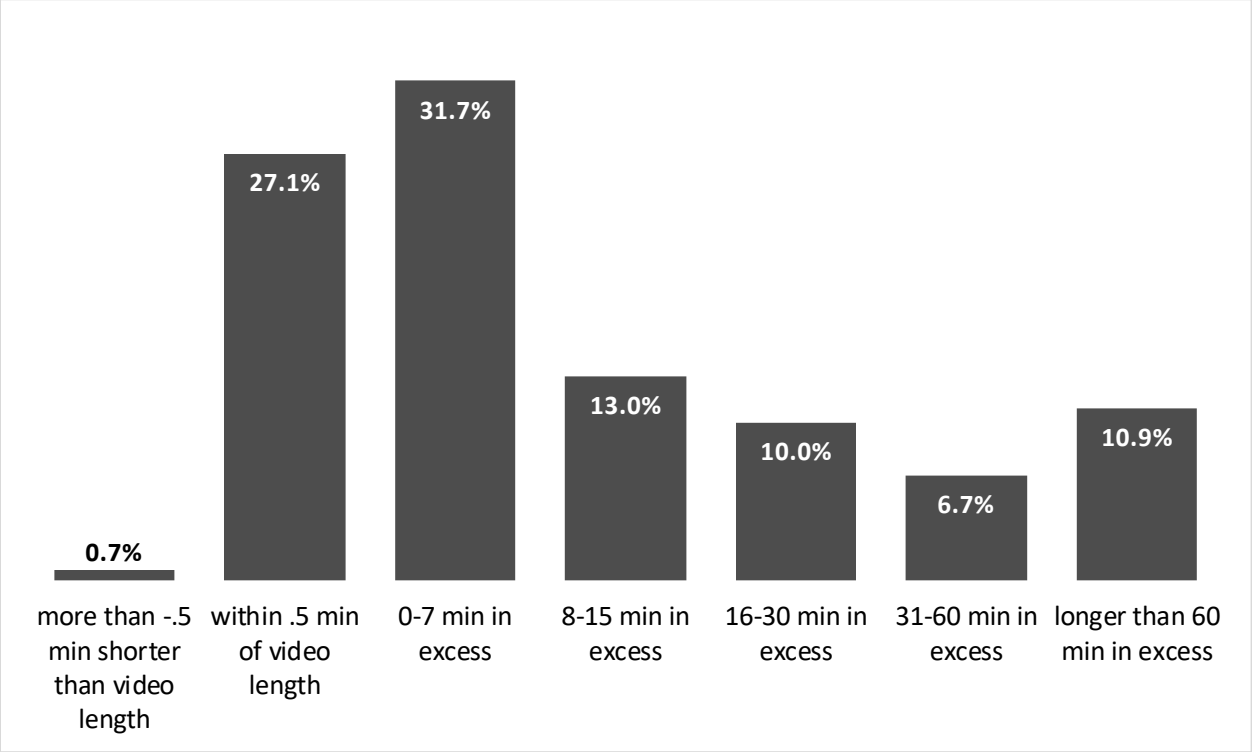

Figure 9. Time Spent in Excess of Video Length

Conclusions

Reflections

The findings of this study offer some insights into integrating embedded video interactions within asynchronous online courses.

Firstly, implementing new technological tools, such as video interaction tools like PlayPosit, is not a panacea but part of a broader educational strategy that includes course design and policy, as well as

instructor presence, among other factors. The data underscore that such tools are most effective when paired with deliberate pedagogical strategies, instructor investment, and enthusiasm. Our high participation and completion rates, which exceed those typically reported in similar studies, can be attributed to these factors.

Moreover, our analysis reveals that video length continues to play an important role in student interaction. Despite the integration of interactive elements, shorter videos maintained their efficacy over longer ones, suggesting that the potential of technological enhancements has its limits within the framework of video-based content delivery.

The utility of embedded interactions as a formative assessment tool is also evident. Embedded video interactions support a learning environment where students are encouraged to engage with content actively without the risk of grade penalties, fostering a willingness to attempt and learn from interactive assessments. This aspect of the course design aligns with broader educational theories that advocate for low-stakes formative assessments to enhance learning.

Although weak, the unexpected negative correlation between the number of retries and mean scores on quizzes may indicate an underlying issue with the quiz, such as a poorly worded or confusing question, a mistake in the answer key, or even technical issues with that quiz. Such factors should be investigated further to rule them out.

Finally, despite the overall high mean scores suggesting successful comprehension and retention, they also raise questions about the rigor of the quiz questions. A more detailed analysis of question design, perhaps examining their alignment with Bloom's taxonomy, might provide deeper insights into whether the high scores truly reflect content mastery and high levels of cognitive engagement or if adjustments are needed to ensure that assessments robustly evaluate student learning outcomes.

This study contributes to a nuanced understanding of how embedded video interactions can enhance learning in asynchronous settings. Future research should continue to explore these dynamics, perhaps comparing these strategies across different disciplines or student populations to build on the preliminary insights presented here.

Limitations

This study acknowledges certain limitations. We do not have access to final course grades, which limits our ability to examine how quiz participation correlates with overall student success.

Additionally, the data collection method impacts some metrics' reliability and usefulness. The time spent metric does not accurately distinguish between active engagement and periods of inactivity, as evidenced by outlier completion times of up to 22 hours. The max video viewed timestamp does not tell us how long students viewed the video; it only shows the furthest point in the video the student viewed. Since students could freely scrub through the video, the max video timestamp almost always corresponded to the last interaction, regardless of how long the student viewed the video. And, because each video concluded with a final embedded quiz question at the very last second of the video, the maximum video viewed time corresponds with the video length almost precisely.

Additionally, it is important to consider the influence of the grading policy for this particular course since it was designed to strongly influence student behaviors regarding embedded video interactions.

Thus, the results of this study reflect not only the effects of integrating embedded video interactions but also the impact of course design and policy decisions.

Future Plans

For future research, comparing quiz participation rates with final grades and test scores will be essential to establish a more comprehensive understanding of the quizzes' effectiveness in enhancing overall course success. Analyzing questions using a framework such as Bloom's taxonomy may improve the quality of the interactions. Additionally, investigating the specific areas where students face difficulties, as indicated by lower quiz scores and completion rates, will be crucial in refining the course design and content to further improve learning outcomes.

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