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The effect on student performance and course perception given an interactive module in online learning

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Abstract
Online education has been rapidly becoming the norm for Generation – Z education; however, the pandemic catapulted the movement of online learning in ways educators were not prepared for. Due to this rapid change, several aspects of online education need to be evaluated to ensure the best integration. For starters, GenZ is the first truly digital native generation, making it challenging to focus on a single device in an educational environment like an online lecture. Educators are also competing with the myriad of resources online that students often use to supplement online education. Finally, we are missing evidence-based research that can help provide guidelines for providing the best online education in today's society. Therefore, this work investigates using active learning in an online course to determine the effect on students' performance and perceived learning outcomes. Measures used to evaluate performance are exam grades. Course evaluation data is evaluated to determine students perception of active learning modules. In this course an "active" assignment replaces a traditional weekly quiz. The active assignment uses recorded lecture with required exercises included to continue engagement with the material via practice problems. This work is a continuation of a work-in-progress paper submitted in 2022 and included data from three semesters that were not included. This work shows no statistically significant evidence that replacing traditional assignments with an active module will affect a students performance outcome. There are trends observed through course evaluations of how students perceive this type of assignment to affect their learning outcomes. Therefore, there is no evidence that replacing traditional assignments with an active module in an online course will affect student learning outcomes. However, there is evidence that by providing the opportunity for students to engage in the material in a different way can improve course evaluations and how students perceive the course.

Introduction
This work explores the results from a Work in Progress paper published in 2022 "The effect on perceived and performance learning outcomes from active online learning." Therefore, some of this document is pulled from the original paper. This work expands on the data over five semesters and explores course evaluation data that was not previously considered.

Engineering Economy is a course that teaches students the concepts of "Time Value of Money." This course is often taught as a "service" course, meaning that many different majors may be enrolled in the course in a given semester, and it usually has a high enrollment. At the University of Florida, this course is taught three semesters a year (Fall, Spring, and Summer), with enrolments averaging 160 students per semester. The course has been taught online for the past decade to accommodate many students from different engineering majors, including Industrial, Mechanical, Aerospace, Civil, and more. Although the course has been redesigned recently with the help of an instructional designer, course evaluations are still below the department's mean. Students continue to request more examples to practice and more interaction with the material. However, most students do not engage with the material currently provided and instead use online resources to find answers to questions. Therefore, this work tests the theory of whether active online lecture videos can improve student performance and course perception by increasing course evaluations.

Literature

Active Learning Framework

The theoretical frameworks of Behaviorism [1] and Cognitivism [2] support that learning is best achieved when supplemented with activity [3]. Behaviorism indicates that when students perform a behavior, they learn that topic on a deeper level. For example, consider a class in college that you felt was the most useful. Most of the time, that class had a lot of examples and practice in class in which you could apply the material. Cognitivism allows students to apply the topics through open-ended assignments like case studies or group discussions to better learn the topic [4]. By applying the concepts directly in activities in class, students can achieve a higher order on Bloom's taxonomy (analysis, synthesis, and evaluation) [3]. Moreover, the framework aligns with constructivist theories of learning [4] where students learn best when they actively construct knowledge through experience and reflection.

Modern active learning encompasses a range of student-centered teaching practices designed to foster deeper engagement, critical thinking, and collaborative problem-solving. Techniques such as peer instruction [5], think-pair-share, problem-based learning [6], and flipped classrooms [7] have been widely adopted across disciplines. Research consistently shows that these strategies improve student learning outcomes, particularly in STEM fields [8], reduce failure rates, and increase conceptual understanding compared to traditional lectures.

Despite these innovations, online active learning presents challenges related to digital equity, student motivation, and cognitive load. Students may struggle with time management, lack of immediate feedback, or limited access to technology. Instructors, in turn, must master digital tools and adapt their facilitation strategies to maintain engagement in asynchronous or remote contexts.

Active Video Framework

However, for an online course that reaches over 160 students a semester, including "active" exercises, is not straightforward since students work at their own pace in an online environment. In addition, students often complain of attention wandering and lack of immediate feedback in an online course, and they expect high-quality videos [9,10,11]. Active videos were created to continuously engage students, provide real-time feedback, and provide high-quality videos to address these concerns. In this study, the test group watched an *active video* that interjects required interactions in the video during the lecture. The control group watches a traditional online lecture video and completes a follow-up quiz at their own pace after. The interactions in the active video and the quiz questions for the control group are the same questions with different values.

Additionally, the COVID-19 pandemic accelerated the convergence of these frameworks, pushing educators to explore innovative combinations of synchronous and asynchronous engagement. Studies during this period highlighted the importance of maintaining instructor presence and fostering community in online settings [13], principles that are foundational to active learning regardless of modality.

In previous work, the team evaluated the interaction time of students in a flipped learning modeling course [9]. Students overwhelmingly preferred a single long video to several short videos in that work.

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Methods

Students were presented with the opportunity to choose between which method (passive or active) of engagement they wanted to complete for one module of an Engineering Economy course. Both groups watched the same content and answered the same questions. The distinguishing factor between the two groups is how and when the interactions are presented to the students.

Passive online inte ractions are a series of online lecture videos followed by weekly quizzes. The videos are not monitored for completion. The follow-up quizzes are timed, and students have two attempts. These quizzes are worth 15% of the overall grade and are intended as a learning opportunity for students, not to measure how well they understand the material. This group is the control or passive group. There were six videos and three quizzes in the control group.

Active online interactions are a series of videos where the quiz questions are built into the video lectures as interactions during the video. After presenting a formula or topic, students are presented with a follow-up question in the video. They have 2 attempts at the question. After the first attempt, they have the option to watch the solution video before making their second attempt. Solutions are solved with different values than those presented to the students, so they must solve their specific problem on their second attempt. The videos and the questions in the active videos are the same as the passive videos and quizzes, just presented in a different method. Students can speed up but not skip through the video during the active videos, and they must complete the interaction before moving on. This group is the test or active group. There were four videos, three of which contained interactions in the active group.

Figure 1 is a screen shot of the active video window. This is a screen shot from the lecture video which paused to offer the students the interaction on the left window. In the status bar students can see their progress as well when interaction will appear. Students can also access the video settings in the status bar to increase the speed of the video. However, students *cannot* skip forward to each interaction but must watch the video in its entirety. Students are presented with the same questions in video as the students who complete the passive post lecture quizzes.

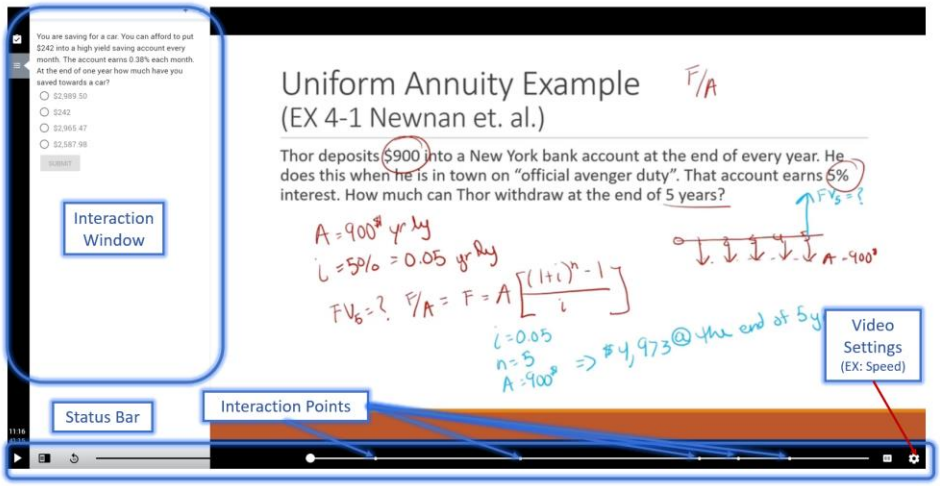

Figure 1. *Example of the interaction window for an active exercise in video.*

Data was collected over five semesters (Fall 2021, Spring 2022, Summer 2022, Spring 2023 and Summer 2023). There are 926 students in the study. The same professor was the lead instructor for all semesters evaluated. More specifics about sample size and distribution are shown in Table 1. It is important to note the difference in sample size in each semester.

	Fall 21	Spring 22	Summer 22	Spring 23	Summer 23	Total
Active	145	120	102	90	84	541
Passive	29	82	76	103	95	385
Enrollment	174	202	178	193	179	926

Table 1 *Sample size of students across all five semesters included in this study.*

Students enrolled in Engineering Economy chose to opt into the test/active group or remain in the control/passive group. There is no clear understanding of why students self-selected into each group. However, based on anecdotal evidence, those that do not opt-in often think it will be "more work" than the traditional method. Students could only see their respective assignments in their portal. Meaning the active group could not see the passive quizzes and vice versa. The difference in sample size is substantial in most semesters.

Research Question: Do active online lectures affect performance learning outcomes and perceived learning outcomes compared to traditional online lecture videos and assignments?

Performance learning outcomes are measured based on students' performance on the midterm and final exams. There are two parts to the exam. Part I is online, proctored, and timed, while part II is take-home. Part I helps mitigate the possibility for students to cheat since their

computers are locked to the exam and video-monitored. While Part II provides challenging questions for students to develop in-depth answers.

Perceived learning outcomes are measured by assessing course evaluations to determine if there is evidence of students rating the course higher when the opportunity for an active module is in place. Course evaluation comments are also assessed for general themes among students to determine if specific aspects of the course or experiment had an impact on their perception of the course.

Results

Sample size in each group are shown in Table 1. There are two factors to consider. The first is semester enrollment. Since each group took the course at different times there could be variability in the course, although the instructor was consistent. The second factor to consider is the participation in passive or active assignments. A single factor ANOVA test among semesters showed significant difference between semesters for both the midterm (p-value = 1.62E-13) and final (p-value = 3.45E-11). Therefore, semesters cannot be combined to form two large data sets. Instead, each semester will use a t-test to determine if there are significant difference in performance between the passive and active groups on both the midterm and final exams. These p-values are show in Table 2. There was no significant difference observed in most groups. There was a significant difference between groups for the Midterm (Fall 21), Final (Spring 23), and Midterm (Summer 23).

Semester	Exam	p-value
Fa 21	Midterm	0.0131
	Final	0.4093
Sp 22	Midterm	0.0687
	Final	0.4000
Su 22	Midterm	0.2572
	Final	0.4444
Sp 23	Midterm	0.0653
	Final	0.0297
Su 23	Midterm	0.0039
	Final	0.0678

Table 2. *p-value outcome from t-test with unequal variances between passive and active groups for each exam in the semesters evaluated.*

Table 3 shows the average grades among each group in the semesters which had significant results. This shows that in Fall 21 the active group performed better than the passive group. However, in the other two semesters the passive group performed better.

Semester (Exam M/F)	Group	Average
Fall 21 (M)	Passive	73.65
	Active	79.93
Spring 23 (F)	Passive	90.61
	Active	87.80
Summer 23 (M)	Passive	80.30
	Active	90.63

Table 3. *Average grades from semester which had significant results between passive and active groups on the Midterm (M) and Final (F).*

Figure 2 shows the results of the averages of each group by exam and semester. Notice there is no obvious trend among performance of students in correlation with their group.

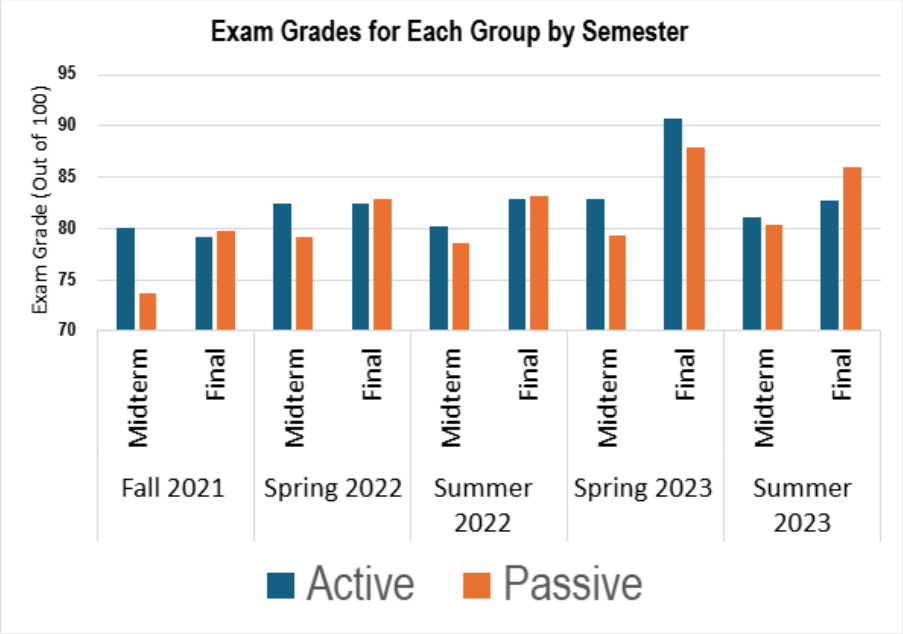

Figure 2. *Average of each exam based on group and semester.*

In the analysis of course evaluations, we focused on three key questions that provided the most relevant feedback regarding the active learning modules: (1) “Please identify the instructor’s

strengths that contributed to your learning in the course," (2) "What additional constructive feedback can you offer the instructor that might help improve the course?", and (3) "What constructive suggestion(s) do you have for improving the course materials, organization, and assignments?" Student comments included both positive and negative perspectives. For example, a positive comment noted, I think having more active videos would help the students interact and learn rather than just being tested on it," whereas a negative comment stated, "Active learning assignments are not successful at having students learn material."

Across all semesters analyzed, we reviewed a total of 1,437 student comments, of which 98 (6.81%) explicitly mentioned the active learning modules. Table 4 and Figure 3 summarize these comments by semester, categorizing them as positive or negative. Notably, Fall 2021 had the highest proportion of active learning-related responses, with 15.5% of student comments referencing these modules. This finding is especially meaningful given that Fall 2021 marked the initial implementation of the active learning modules. 88% of the comments provided about the active learning modules were positive.

	Total	**Active**	**Positive**	**Negative**
Fall 21	271	42	39	3
Spring 22	338	21	18	3
Summer 22	234	6	4	2
Spring 23	304	18	14	4
Summer 23	290	11	10	1
All Semesters	1437	98	85	13

Table 4. *Distribution of positive and negative student evaluation comments that reference active learning modules by semester.*

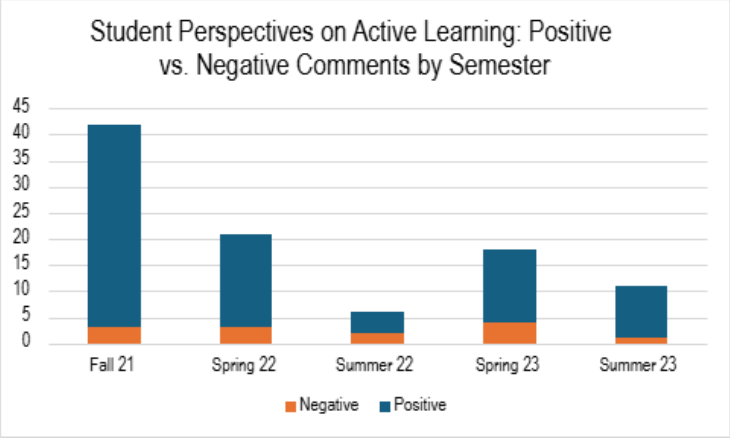

Figure 3. *Distribution of positive (blue) and negative (orange) student comments on active learning modules by semester.*

To evaluate whether students were significantly more likely to comment positively than negatively on the active learning modules, we conducted a t-test comparing the number of

positive and negative mentions across all semesters. The results indicated a statistically significant difference ($p = 0.03$), suggesting that students were significantly more likely to provide positive feedback than negative when discussing the active learning components of the course.

Course evaluation data was also analyzed to assess trends in students' perception of the course overall. Figure 4 shows the progression of 4 different questions which are relevant to this work. Notice Spring 21 and Summer 21 are included in the graphs. These semesters the active modules were not offered but the professor was the lead instructor for the course. There is no clear change among all four questions to show a trend in student perception from Fall 21 when the active module was introduced. However, there is drastic increase beginning in Spring 22. This was the first semester the professor offered an in-person section and provided the in-person recordings to online students as well.

Figure 4*. A sample of relevant response averages from student evaluations. Questions are evaluated on a scale from 1 to 5. Where 5 is the most positive outcome. Note: The active exercises were deployed in Fall 21. Therefore, previous semesters are shown to compare outcomes after the active assessment strategies were introduced.*

Discussion

The purpose of this study was to assess whether replacing traditional online quizzes with active learning modules in an online Engineering Economy course could impact student performance and perceived learning outcomes. Through an analysis of exam scores and course evaluation data collected over five semesters, we were able to address the research question regarding the effectiveness of active learning on student engagement, performance, and perceptions of the course. The findings reveal that while students performance does not seem to be effected by the assignment method their perception of the course material is altered.

Performance Learning Outcomes

Despite the promising theoretical foundation for active learning, the data from this study show no consistent, statistically significant difference in students' exam performance when comparing the active learning group to the passive group. While some semesters, such as Fall 2021 and Summer 2023, showed a slight advantage in performance for the active group, other semesters indicated the opposite trend, with the passive group performing better, particularly in the Spring 2023 semester. These inconsistencies suggest that while the method of engagement might influence student performance in certain contexts, it is not sufficient to claim that active learning unequivocally leads to higher exam scores.

The variability in performance across semesters may stem from several factors. First, the self-selection of students into either the active or passive group introduces a potential bias, as students who opt for the active learning module might have different learning habits or motivations than those who choose the passive format. Second, the differing cohort compositions across semesters, as indicated by significant differences in enrollment size and group distribution, might also contribute to the variation in results. The instructor's consistent approach, though an attempt to control for teaching style, could not fully account for the dynamic learning environment across different student populations.

Additionally, while the analysis found some instances of statistical significance, such as in the midterm exam for Fall 2021 and Summer 2023, these results were not uniform across all semesters, indicating that the impact of the active learning intervention may be more context-dependent than initially anticipated. Therefore, while active learning may hold promise for enhancing student engagement, its direct impact on exam performance appears to be limited or contingent upon other factors, such as the timing of the course, the nature of the material, or the characteristics of the student cohort.

Perceived Learning Outcomes

In contrast to the mixed results in performance, the analysis of course evaluation data suggests that students perceive active learning modules as a positive addition to the course structure. Course evaluations consistently show higher ratings for questions related to student engagement and satisfaction in semesters where active learning modules were implemented. Notably, comments from students overwhelmingly praised the active modules, with many indicating that these interactive elements helped them better understand the course material. This aligns with findings from prior research suggesting that active learning can improve students' perceptions of their learning experience, even when it does not necessarily lead to better objective performance outcomes [3,9,10].

The increase in course evaluation scores seen in Spring 2022, following the introduction of in-person recorded lectures for online students, is particularly noteworthy. While this effect could be partly attributed to the added benefit of in-person content for online learners, it also suggests that providing students with more interactive and engaging content can positively affect their overall course experience. This trend highlights the importance of student perceptions in shaping educational success, as students who feel more engaged with the material are likely to have a more positive view of the course, even if their performance outcomes are not significantly different from those of their peers in the passive group.

Furthermore, the positive student feedback on active learning modules supports the idea that incorporating interactive elements into online lectures can be an effective way to enhance engagement, which is a key challenge in online education [8]. Although active learning did not consistently improve exam scores, it provided a valuable opportunity for students to engage with the material in a way that seemed to resonate with their learning preferences. This finding is consistent with research suggesting that active learning strategies, even in online environments, can lead to improved student engagement and satisfaction [10].

Limitations and Future Directions

The findings of this study should be interpreted with caution, particularly due to the self-selection bias introduced by students' choice to opt into either the active or passive learning group. Future research should aim to randomize group assignments to minimize potential biases and more rigorously assess the causal effects of active learning on student outcomes. Additionally, further exploration is needed to understand the specific aspects of active learning that students find most beneficial. While students generally reported positive experiences with the active modules, it is unclear whether it was the interactivity of the video, the real-time feedback, or the opportunity for self-paced learning that contributed most to their perceptions of improved learning outcomes.

Lastly, as the transition to digital learning continues, further research should consider the broader implications of active learning in online courses, especially as Gen Z students, the first true digital natives, become the predominant demographic in higher education. Understanding how to best meet the needs of this generation through interactive, technology-driven educational practices will be crucial for shaping the future of online education.

Conclusion

In conclusion, while active learning modules did not yield statistically significant improvements in exam performance in this study, they did have a positive effect on students' perceptions of the course and engagement with the material. These findings suggest that, while active learning may not be a panacea for improving academic performance in online courses, it can play an important role in enhancing the student experience. Educators should consider incorporating interactive, engaging elements into online courses to increase student satisfaction and engagement, even if performance outcomes remain relatively unchanged. As online education continues to evolve, it will be essential to explore and refine active learning strategies to maximize their potential impact on student learning and success.

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