

## **COVID-19: Reversing the Gains of Active Learning**

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### **Abstract**

*COVID-19 and its ensuing pandemic ignited an atomic bomb on educational systems across the world invoking an emergent and abrupt transition to remote learning. The aftershocks were unpredictable but left a crippled educational system where students were forced into their bedrooms, sometimes deported to their homelands in different time-zones and isolated from their friends and peers. Learning quickly transitioned from social face-to-face interactions to an estranged and detached face-to-computer dependence. Although some introverted students welcomed this transition, many were dissatisfied, and their performance reflected this sentiment. In this study, we compare students' performance in an undergraduate mathematics class in a large research-intensive university in the Western United States of America over a 2-year time period from 2019 to 2020. This started as a traditional lecture-style course for 3 quarters, transitioned to a hybrid lecture style with integrated adaptive team-based quizzes for 2 quarters, and abruptly changed with the COVID-19 pandemic to online lectures with team-based quizzes for 1 quarter. We demonstrate in our retrospective data analysis that the performance gains from the traditional lecture-style transition to active learning were subsequently lost in the movement to remote learning. We discuss the many obstacles that may have accounted for this loss of performance and suggest future directions for improving remote active learning methodologies.*

**Keywords:** active learning, remote learning, COVID-19, team-based quizzes, asynchronous lectures, traditional learning

### **Introduction**

When I first started teaching an introductory undergraduate math finance course using the traditional lecture-style, I noticed that students were rarely engaged and occasionally even nodding off during class, despite my best efforts. As I searched for ways to motivate and inspire students, California's first academic building fully dedicated to active learning opened with fifty-five thousand square feet of contemporary learning spaces. After 3 quarters of traditional lecture-style teaching, I modified my class to incorporate adaptive team-based quizzes every other week in hopes that students would cooperate and engage in productive team-based learning. With the introduction of active learning for the next two quarters of the same math finance class, overall performance improved, the activities were more inclusive, and students provided positive feedback.

As I reviewed the literature, it was apparent that active learning in the form of student engagement

and collaboration has been well known in the recent years to lead to higher student performance and deeper learning as compared to traditional lecture-style learning (Bolden, et al. 2017, Deslauriers 2019, Hake 1998, McCarthy & Anderson 2000) specifically in the science, engineering and mathematics courses (Freeman, et al. 2014). In fact, the study by Freeman (2014) showed that active learning leads to better exam performance, raising grades by half a letter on average. Furthermore, failure rates under traditional lecturing increase by 55% over the rates observed under active learning in Freeman's study. Although active in-person learning has now been widely accepted as an excellent tool to enhance education, especially in the university setting, there had been limited data examining the effects of active learning in the remote setting. All of this changed when the COVID-19 global catastrophe arrived in 2020.

When COVID-19 swept through the United States of America, the transition to remote learning was abrupt. Emergent mask mandates, social distancing and stay-at-home orders virtually eliminated student in-person collaboration overnight. Professors hurriedly prepared online lectures for asynchronous learning in place of in-person teaching and students were forced to sever social ties with friends and learn online instead. Were there benefits to the sudden shift to distance learning? How did this transition affect student performance, specifically on team-based quizzes? What were some of the obstacles that may have impeded learning? In this paper, we seek to answer these questions.

## **Literature Review**

We begin with a literature review of the positive effects of remote learning. In a large meta-analysis review examining 86 studies and data for over 15,000 students, Shachar & Neumann (2003) demonstrated that in two-thirds of the cases, students in the distance education classes actually outperformed their counterparts in traditionally instructed courses. Additionally, Hassenberg (2009) explained that distance learning allows freedom, expands access to those in rural areas, may be more affordable, may suit a more flexible lifestyle, and allows one to pause and rewind lectures. Students who may be more introverted and less likely to speak in front of their peers in the in-person setting may be more motivated to communicate through online forums, text, or email instead (Thorpe, 1998). Buerch (2003) also found in a study on computer science courses that academic success didn't differ amongst the face-to-face versus the online learning style. These studies indeed support a positive role for remote learning in the recent past.

Remote learning may have its benefits, however there are many more obstacles and frustrations that may impede learning. First and foremost, distance education naturally segregates students from their peers and forces interaction through computers and technology. This instantaneously eliminates the in-person interaction. Thus, communication and collaboration may be hindered by the lack of in-person interaction. Hassenberg (2009) eloquently states that:

Evidently there is a certain atmosphere in being physically present and interacting with a human teacher in a set time and place that is crucial to learning. When there is separation between teaching and learning, the instructors' responsiveness to student needs is compromised, instructors are unable to be flexible in changing classroom dynamics, and communication is certainly inadequate compared to the traditional system.

The lack of in-person communication has been shown to impair relationships with others, specifically in the business world. In an article in Forbes Insights (2009) face-to-face meetings are preferable to foster deeper and more productive business relationships and allow for better bonding, social interaction and higher quality decision-making. A Harvard Business Review (2009) conducted a survey of 2,300 subscribers and found that 89% said meetings are the most effective way to “seal the deal” and almost all (95%) concur that face-to-face meetings are essential to building lasting relationships.

Additionally, remote online learning requires a basic digital competence as defined by Ferrari (2012) as “the confident, critical and creative use of Information and Communications Technology (ICT) to achieve goals related to work, employability, learning, leisure, inclusion, and/or participation in society.” Students with low digital competence may have difficulty collaborating and may consequently suffer. Wei and Chou (2020) found that students’ computer/internet self-efficacy and motivation for learning had a positive impact on their course satisfaction and online discussion score. Not only are students required to have basic digital competence, but it is just as important for teachers to have digital competence and adapt to online teaching during COVID-19 (Konig 2020). Along with digital competence, administrative issues, internet connections and technical difficulties provide added stress to the remote learning process (Adedoyin 2020, Muilenburg & Berge 2007).

Distractions are yet another obstacle to successful remote learning instruction. Family members, pets, and temptations to cheat make it extraordinarily difficult to accurately conduct online teaching with integrity (Berkey 2015). With the anonymity of remote teaching, students may be less motivated to complete their work on time and procrastinate till the last minute. Thorpe (1998) in a London study found that student participation in online discussions and collaborative work was a near failure since students would procrastinate. The groups that met face-to-face made much more progress.

Lastly, the social disconnect and lack of sense of community provides yet another impediment to remote learning. Otter et al. (2013) found in a study that compared to traditional lectures, students felt more disconnected from peers and the professor with remote teaching and felt like they were working independently by teaching themselves. The sense of community seems to vanish with remote learning.

Given the vast number of obstacles students face with remote learning, especially with the abrupt transition from COVID-19, it’s not surprising that performance may have dwindled. Orlov, et al. (2020) found in a study examining seven economics courses, that students performed worse during the Spring of 2020 when teaching went remote compared to the Spring or Fall of 2019. In this paper, we have the luxury of examining the same math finance undergraduate course over 6 quarters and comparing the student performance based on overall scores and team-based quiz scores. We corroborate the sentiment that active learning improves student performance as compared to traditional lecture-style teaching, however the transition to remote learning during the COVID-19 era reversed these improvements.

## **Results / Discussion**

The COVID-19 pandemic introduced unique and unprecedented challenges with the sudden and drastic transition to remote learning in the Spring of 2020 for many undergraduate institutions. As students were thrust into this natural teaching experiment, some were grateful for the anonymity and convenience

of remote learning while many more were fraught with anxiety, stress, and frustration. In our retrospective data analysis, we demonstrate that the negative effects of remote learning due to COVID-19 reversed the improvements in educational outcomes created by adaptive team-based active learning.

In Table 1 we show the mean, variance and ratio of mean to variance for students’ overall class score. This overall class score is a percentage-weighted combination of their homework, midterm, and final exam. The average score for the traditional lecture-style in-person learning period was 79.2 and the variance was 277.1. With the subsequent incorporation of active learning via team-based quizzes, the average score rose 5% to 83.5, while the variance decreased 16% to 232.7. The effect on educational outcome of an increase in average final score is obvious: students presumably learned more. The effect of decrease in variance, especially one as substantial as 16%, may be interpreted as an increase in inclusivity: fewer students were left behind. To quantify the two effects that active learning produced higher mean and lower variance, we provide in Table 1 the ratio of mean to variance. This metric improved by 15% from 4.8 to 5.5, as shown in Table 1.

Table 1. Table of Students’ Overall Performance for In-person (Traditional), In-person (Active) and Remote Learning Periods

Learning Period	Average	Variance	Mean / Variance
In-Person (Traditional)	79.2	277.1	4.8
In-Person (Active)	83.5	232.7	5.5
Remote (COVID-19)	81.2	275.8	4.9

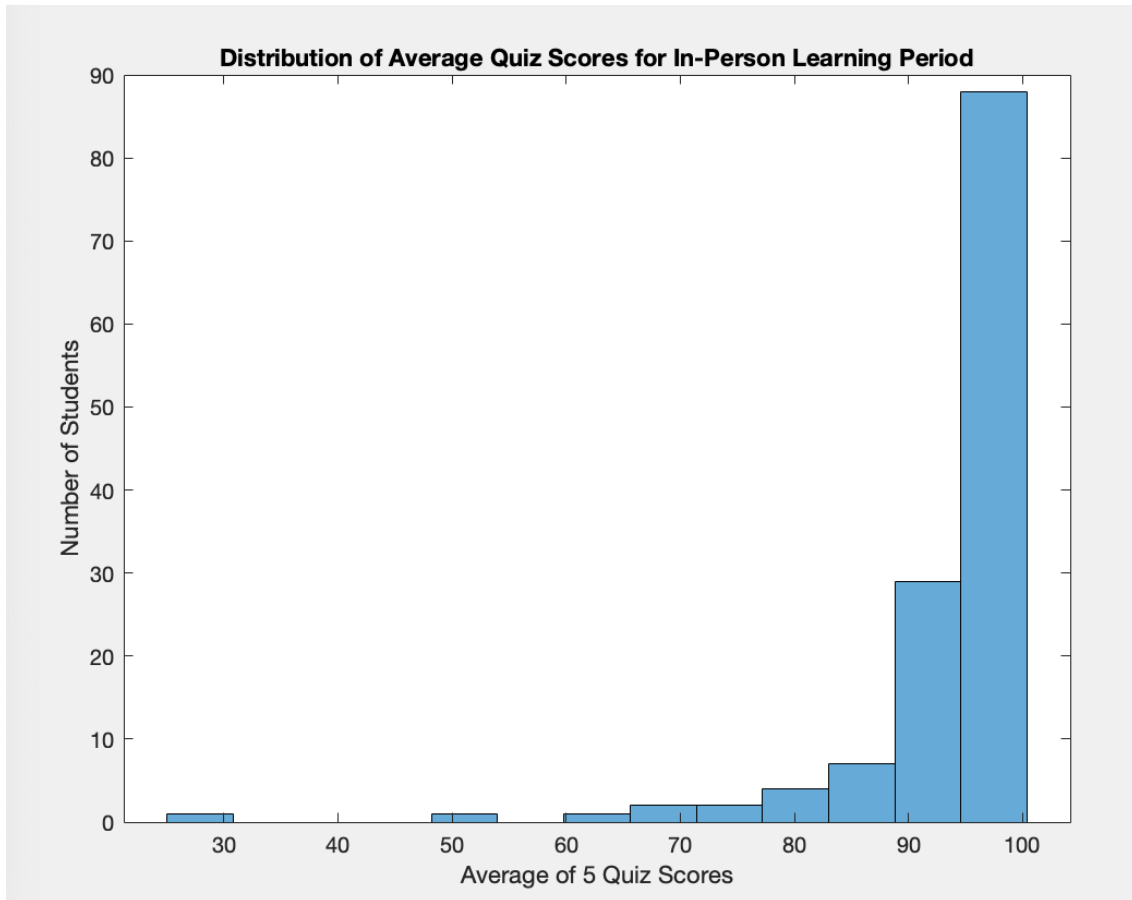
Also, in Table 1 we show the change in average scores for the transition from in-person active to remote learning with the COVID-19 pandemic. The average score decreased 3% to 81.2, while the variance increased 19% to 275.8. The ratio of mean to variance decreased 11% to 4.9. This may indicate that the transition from in-person to remote learning had the effect of reducing educational outcomes and simultaneously reducing inclusivity. This created a truly daunting challenge for students and educators in the remote setting.

In Table 2 we focus specifically on the team-based quiz performance during the in-person and remote (COVID-19) periods. We can see clearly that there is a drastic drop in the average quiz score, as well as a significant increase in quiz score variance. The average quiz score dropped 8% from 94.1 to 87.1, while the score variance more than doubled from 93.4 to 198.8. This suggests that the COVID-19 pandemic produced a widespread range of educational outcomes as students and teachers struggled to endure the remoteness of education and social life during 2020. The ratio of mean to variance dropped by more than a third.

Table 2. Table of Students’ Performance on Team-based Quizzes for In-person and Remote Learning Periods

Learning Period	Average	Variance	Mean / Variance
In-Person	94.1	93.4	9.7
Remote (COVID-19)	87.1	198.8	6.2

In Figure 1 we show a histogram of the distribution of average team-based quiz scores for the in-person learning period which spanned the 3 quarters during the 2019-2020 academic year.



In Figure 2 we provide a histogram of the distribution of average team-based quiz scores for the remote (COVID-19) learning period during the final quarter of the 2019-2020 academic year. On visual inspection of the histograms, there is a marked drop in quiz scores for a large proportion of students during the remote learning period as compared to the in-person learning period.

Figure 1. Distribution of Average Quiz Scores for In-Person Learning Period

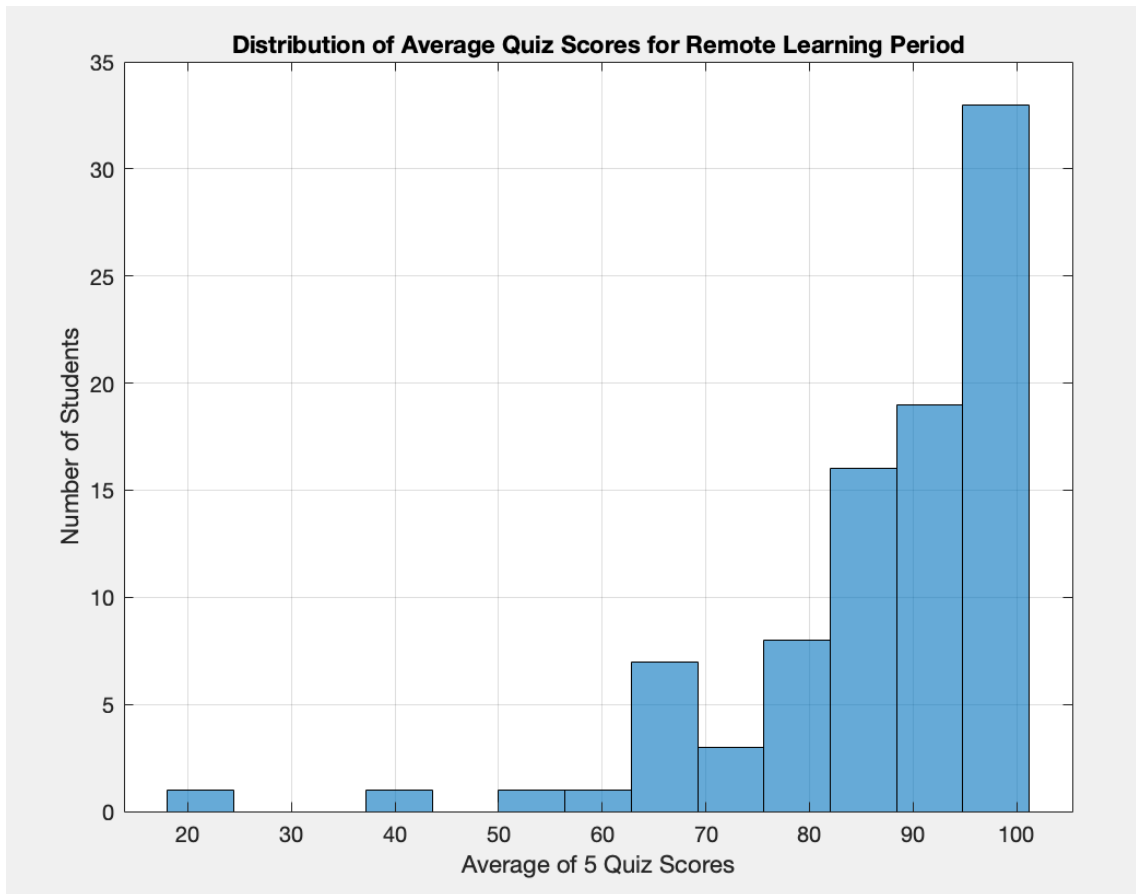


Figure 2. Distribution of Average Quiz Scores for Remote Learning Period

### Limitations

One limitation to the study is that the sample size (n=90) of the one quarter of remote learning in the Spring of 2020 was smaller than the other sample sizes including three quarters of traditional lecture-style teaching (n=153) and two quarters of active learning with team-based quizzes (n=135). This may lead to more variation in the student performance scores for the smaller sample size. However, this was the last quarter of this math finance course before it was changed by the university, making future studies to increase the sample size impossible.

Another limitation is that student test scores may not be the only indicator of overall student performance, however this is the simplest way to quantify the students' ability to solve problems. Subjective comparisons on student performance would be much more challenging and nebulous. One might argue that although student performance on the team-based quizzes in the remote setting dropped, the students may have developed skills of independence and self-reliance in order to complete the quizzes themselves with minimal help from others. This life skill would not be reflected in a higher test score but may be valuable for future career endeavors.

Lastly, one might suggest that just the COVID-19 pandemic itself, not the remote teaching style, was responsible for stress and anxiety that caused the drop in performance. This may indeed be the case, however, future studies on remote active learning once the pandemic subsides will have to investigate whether or not this was true.

## Summary and Future Directions

In summary, this study quantifies the negative impact on educational outcomes that was caused by the COVID-19 pandemic. Prior improvements due to the introduction of the active learning methodologies were reversed. This result simultaneously corroborates the outcomes found in the other studies during the COVID-19 pandemic (Orlov et al. 2020).

Although our study demonstrates a decrease in student performance on active learning team-based quizzes during the transition to remote learning, we propose future directions to enhance remote active learning. Instead of simply allowing students to take the quizzes online themselves, educators may consider engaging the students in live problem-solving sessions with active feedback instead. A recent study by Venton and Pompano (2021) had particular success in the Department of Chemistry at the University of Virginia by having students watch a pre-recorded lecture and then engage in live problem-solving sessions thereafter. Furthermore, hybrid virtual classrooms connecting both on-site and remote students during synchronous teaching with live quizzes may also be promising (Raes et al. 2020). Despite the fact that many students prefer face-to-face activities and discussions over remote learning (Kemp & Grieve 2014), the truth is that COVID-19 may have permanently scarred the teaching community and we may be encouraged to explore hybrid in-person and remote methodologies to ensure optimal student performance.

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