Case Study of Student Grade Distribution Shifts in Online Engineering Fundamental Course

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Abstract

During the pandemic quarantine that started in the spring semester of 2020, most college courses moved to full-online, including those fundamental engineering courses. The present paper investigated the student grade distribution shifts during the online teaching period compared with the regular in-person teaching in a sophomore-level mechanical engineering class, statics and dynamics with the data from 318 students in 5 comparable semesters. The top quartile students shifted to a higher distribution by leveraging the technological advantages during online teaching and learning, while the middle and bottom quartiles still struggled, or even worse. The findings are pretty inspiring to the curriculum designing and development in the future teaching-learning environment.

Keywords

Online, Engineering Course, Student grade distribution shift

Background

Most of the instructors recognized traditional in-person teaching as the best way of teaching fundamental undergraduate engineering courses. The COVID-19 pandemic that started last year restricted the accessibility to conventional classroom learning and switched most of the college courses to full-online, starting from spring 2020. During the past three semesters (summer, fall, and spring), the author executed different non-interference teaching/research methods and studied the student grade distribution shifts between traditional in-person and online teaching modalities.

Statics and Dynamics is one of the courses the author taught with 500 to 550 students every year (three semesters), and the student grades are distributed from the top quartile to the bottom quartile with up to 90 students in one section. The class size in the spring and fall semesters provided a good experiment platform, and this 5-credits integrated course lasted for 115 minutes, 15 minutes longer than two 50 minutes classes. With the experience of teaching individual dynamics and integrated statics and dynamics for many semesters and trained for web-facilitated distance teaching, the author of the present paper has tons of experience teaching statics and dynamics in traditional in-person and full-online environments.

During the online teaching and learning period, the biggest challenge is that both the instructors and students face the challenges of working under unprecedented stress caused by the quarantine. The instructors need to understand what kind of teaching method works the best, what resources to provide to help students learn, and how to manage the online video recording, editing, and post-casting skills (Gibbs, 1998, Baran, Correia, and Thompson, 2011).

Online learning gives some students who need long-distance commutes a better chance to access education without driving back and forth. But, the students need to adjust their learning habits to get better academic performance, at least the same level test grades. From the research of the Dutton, students like the online teaching more if they can complete the whole course, while students who started as online learning did not always go through to the end of the course as the in-person learning students did. (Dutton, Dutton, and Perry, 2001) According to the research of Picciano (Picciano, 2002), the student perceptions, interactions, and sense of presence in the class are also critical factors related to their academic performance. Giving the students a similar experience as the in-person teaching will help them focus on the learning itself instead of the inconvenience caused by the new modality.

Surprisingly, research indicates that online teaching can be as effective as the traditional face-to-face approach in producing comparable test performance only for academically higher-performing students. But struggling students with lower performance tend to get worse grades in their online courses than face-to-face classes (Fu and Lemonde, 2012, Cavanagh & Jacquemin, 2015). And the student evaluation of the two teaching modalities shows no difference, which indicated that distance learning or online learning could be a good substitute for in-person learning (Spooner, Jordan, Algozzine, et al., 1999). The most recent survey shows that more than half of the students claimed that shifting to online learning does not change their views about online learning, and even some said it changed their feelings for the better (Capranos, Dyers, and Magda, 2021).

Research Questions

In the present paper, there are three fundamental research questions to investigate,

- What is the effect of online teaching on engineering undergraduate students?
- Who benefits the most from online learning and why?
- Who struggles the most during online learning and why?

The reasons behind these phenomena were discussed, like what made the differences, which method benefits more students from online teaching, and is there any correlation between the attitude and grade distribution.

Settings

The present study was designed to compare the grade distribution shifts of two teaching modalities, traditional in-person classroom versus full-online teaching, for an introductory undergraduate engineering course taught in the Department of Mechanical Engineering at Clemson University.

Most of the students involved in the present research are sophomore to junior engineering students from various engineering majors, including mechanical engineering, general engineering, civil engineering, industrial engineering, etc. The course is a five-credit sophomore engineering course, as an integrated course of two three-credit courses, statics (EM201) and dynamics (EM202). Students need to get a final grade of "C" or above to pass this course and continue according to the policy at Clemson University. This course is their first engineering course with engineering applications of the concepts and knowledge from physics and mathematics (Iwasaki, Tada, et al., 2019). According to the previous research results, students will learn the concepts, principles,

applications, and skills of statics and dynamics as an organically intertwined system, which benefits most students (Orr, Biggers).

All students in the present paper were taught by the same instructor (the author), covering the same content, using the same assessment methods, and delivered over a similar period (fall versus fall and spring versus spring) to make them comparable. In addition, the learning objectives are the same for all semesters and both teaching modalities.

Traditional in-person Classroom Teaching

Before the pandemic, this course was taught as conventional in-person lectures, with a web-assisted learning management system, CANVAS system, and Connect homework system provided by McGraw Hill. Students can access the necessary materials, homework, and other related resources provided by the instructors, including:

- Syllabus and course schedule.
- Contact information of instructors and office hours.
- Assignments.
- Previous tests and solutions.
- Extra slides and hand-outs.
- Practice problems.
- Other learning resources.

Compared to the traditional classroom, our in-person lecturing happens in a Student-Centered Active Learning Environment with Upside-down Pedagogies (SCALE-UP) classroom designed for this course since 2014. Instead of sitting in fixed seats facing the instructor, our students sit at round tables in a dedicated classroom facing all directions, as the figure shows. Each table can hold eight students. No matter which direction they are facing, the students can see the lecture slides projected onto the five pull-down screens on each wall in the classroom, plus the giant whiteboard as an additional teaching kit.

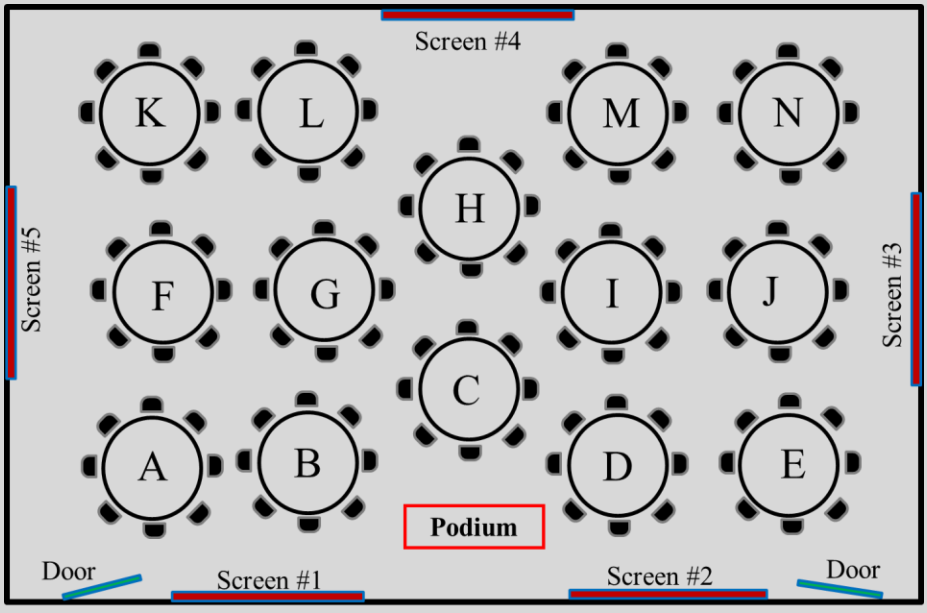

Figure 1. SCALE-UP classroom layout

Since the summer semesters have fewer students involved, the present study only compares the Spring and Fall semesters. Generally, this course has 75~90 students/section in Spring and Fall semesters. According to the course policy, the students can drop the course before the due date without penalty, and some of them tend to do so, especially when they see their current grades and test scores are not satisfying. Most of the students who dropped the course or did not go through to the final exam did not put their full effort into this course and could not reflect the actual situation of the course itself. It will be more appropriate and convincing to consider only those students who stayed through the whole class by taking the final exam.

Full-Online Zoom Meeting Teaching

As transitioned to full-online, the current courses were taught via zoom with adjustments and modifications to help the students to follow and understand. With the previous online teaching experience, the author adapted to the complete online teaching modality and developed more add-ons to help students leverage the whole advantages of internet accessibility, including the following besides the items mentioned above,

- New pre-recorded theory videos for each chapter students can access before the lectures.
- Live zoom lectures with all students involved.
- Modified lecture slides specified for the online learning environment.
- More flexible office hours.
- At least two student discussion groups each semester.
- More online peer-assisted learning (PAL) sessions and tutor sessions.

At the same time, the online class has fewer students than regular in-person teaching semesters, especially spring 2021, the second full-online semester. The enrollment dropped from 71 in spring 2020 to 42 in spring 2021. The students who took the final exam dropped from 61 to 29 accordingly. One of the reasons is that some of the students are tired of the full-online teaching and do not have the patience to persist the two-hour-lectures, three times a week.

Research method

The present research deployed non-interference research methods, with no student noticing the differences with their precedents. The author compared the final grade distributions of four semesters, two fall semesters, and two spring semesters. At the beginning of each semester, there were more than 75 students in each section, but it will drop to 47-69 at the end of each semester which is still a reasonable sample size. The author deliberately excluded the spring 20 semester because the hybrid or mixed teaching modality deployed.

The present paper compared the following data of the chosen four semesters: average grades of 4 quartiles, median grades of average grades of four quartiles, percentages of the student who got a final grade of A or B, raw passing rates including those students still enrolled but did not participate in class activities and final exam, and actual passing rates considering the dropped students, plus those stopped joining the classes. The results and discussion are below.

The author has tried to bracket himself out to avoid the biased opinion(s) on the online teaching from previous personal experience.

Results and discussion

The comparison of the student grade distribution of two spring and two fall semesters is shown in Figure 2 and Figure 3.

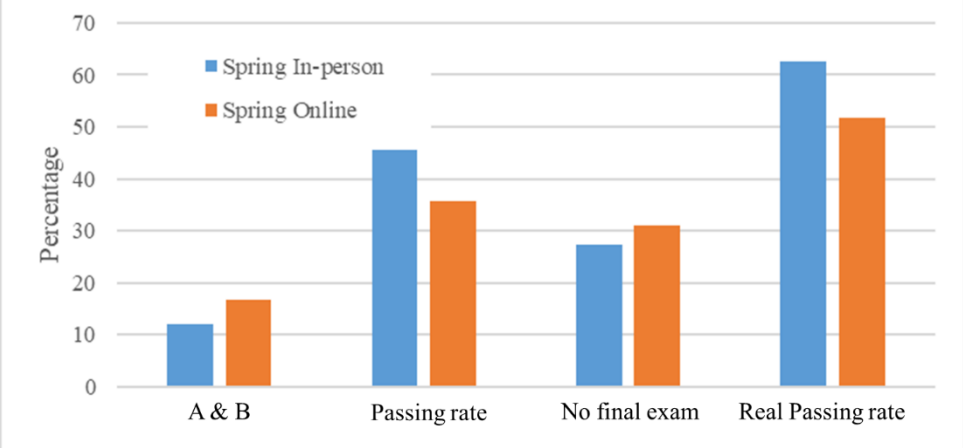

Figure 2. Comparison of in-person and online teaching in spring semesters

Figure 2 indicates that the raw passing rates of this course do not change much when switched from in-person to online in spring semesters, nor the actual passing rates excluding those students who did not work through the final exams. Similar phenomena happened in the fall semesters, as shown in Figure 3. Both figures showed that online semesters have more students who did not take the final exam than in-person semesters. The percentage of the students who got a final grade of A or B in the online semesters (spring 21 and fall 200) is almost 5% higher than that of the traditional in-person teaching semesters (spring 19 and fall 19) before the pandemic. The improvements are even better when excluding those who did not complete the final exams.

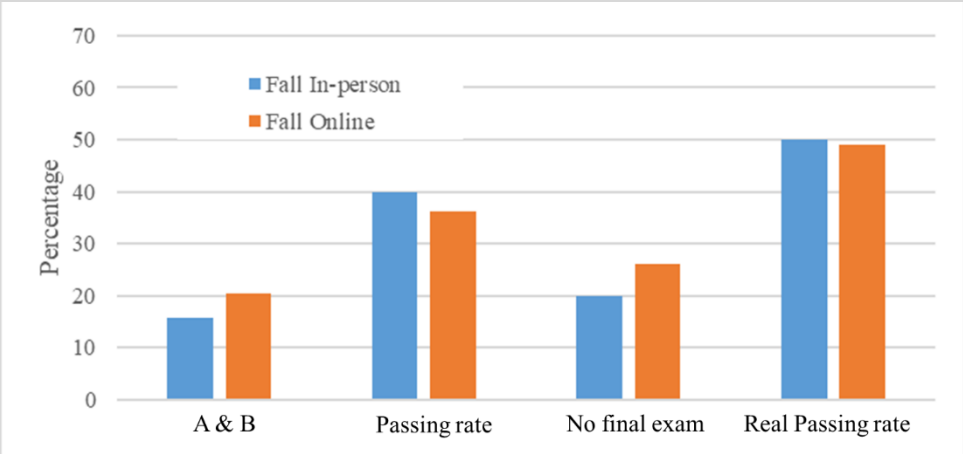

Figure 3. Comparison of in-person and online teaching in fall semesters

Figure 4 and Figure 5 showed the average grades of the four quartiles in the four semesters, two in spring and two in fall semesters. In Figure 4, there are no noticeable differences in the average grades in online and in-person teaching modalities in the spring semesters.

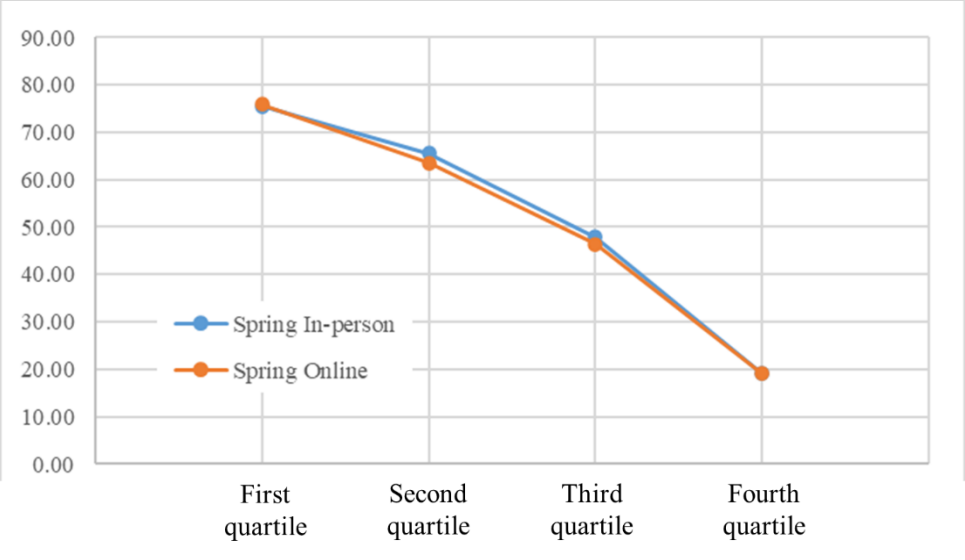

Figure 4. Comparison of the averages of 4 quartiles in spring semesters

Figure 5 shows the average grades of the four quartiles in the four semesters, two in spring and two in fall. The top quartile students shifted to a higher distribution, especially in the fall semesters. At the same time, the average grades of the bottom and middle quartiles decreased significantly, about 8 points.

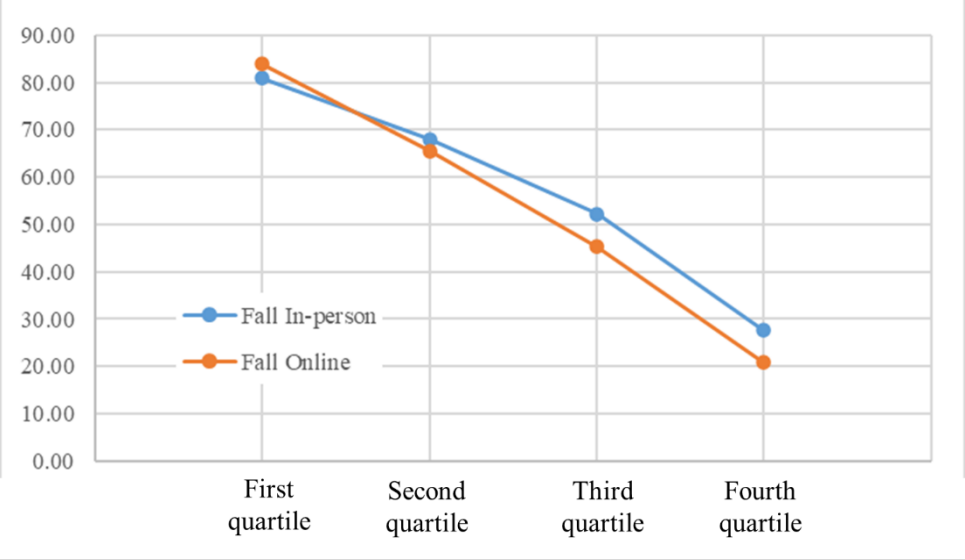

Figure 5. Comparison of the averages of 4 quartiles in fall semesters

Preparedness: One of the reasons is that the top quartile students have built their learning habits and better preparedness for mathematics (calculus, algebra, geometry, trigonometry, vector, differentiation, integration, solving simultaneous equations, etc.), and the previous science knowledge before they take this course. The online teaching gave them some advantages by saving their time, like commuting daily, rushing between classrooms, finding parking positions, walking to the office hours, joining the PAL or tutoring sessions, etc. With pre-recorded theory videos and newly provided online materials, the students could prepare for the lectures better than the conventional in-person semesters. This group of students can put those time into previewing the coming classes, learning other courses, or just relaxing to give their brain a rest. In addition, they have access to more online resources that they never had before, such as the pre-recorded theory videos and zoom recorded videos.

Ability to work independently: Online teaching makes the learning-groups or learning-buddies impossible, at least physically impossible. Those students who relied on learning with others in the in-person learning environment have to work alone or study in some online studying groups, like Discord. It hindered their initiatives of proactive learning and the leveraging of all available resources provided. In comparison, the top quartile students have the advantage of having some time to watch the pre-recorded theory videos to preview the coming lectures, the recorded live lecture videos before or after they finished their homework and other assignments. Out of class, the top quartile students have more flexible options to access the office hours for any questions they have met in and out of the classroom, from anywhere.

Time management skills: Some middle quartile and bottom quartiles students still struggled, or even worse. The students complained that they lacked time to study, but the instructor witnessed that they lacked time management skills. Compared to the higher-performing students, they spent more time understanding and digesting the previous lecture and completing their assignments. Thus they barely have time to watch the lecture videos provided, let alone watch the pre-recorded theory videos, prepare for the following lectures, visit the zoom office hours, etc. Partially this was caused by their under-prepared prerequisite knowledge and skills, such as mathematics and physics, but the main reason is the lack of pressure from the in-person teaching and the interaction between students and instructor. According to the observation and survey, some of the bottom quartile students are not good at time management and self-regulated learning, which reduced their time and effort on the course works.

Motivation and self-discipline: Based on one of the surveys the author made several years ago, many students just chose this course (statics and dynamics) and gave it a try to see if they could pass it and move on to mechanical engineering major. If not, they will take advantage of the "three-attempts" and "academic forgiveness" policy to waive it. Their motivation for learning this course as the fundamental knowledge of the future studies is not very strong, and the effort put into learning is far less than expected. In the online semesters, some students stopped joining the lectures after test #2 and didn't take the final exam, which is inconsistent with the research findings by Dutton (Dutton et al., 2003). The percentage of students who didn't take the final exam in online teaching semesters is much higher than that of the regular in-person semesters.

Adaptivity: The top quartile students can quickly deal with the new learning environment and adapt to the novel communication channels. It's sporadic to hear this group complaining about the stress during pandemic online learning. While most of the bottom quartile students complained

that they were very stressed about the new learning environment and teaching methods, or the teaching method was not acceptable. When the students perceive that online learning is inferior to in-person learning, their grades will worsen.

The effort put into the course: This ability is closely related to motivation and time management skills, but different from it. Some students treat "effort" as an interchangeable word like "time", but the effort is more about effectively using the learning time. The author heard many students struggle described as "… I have studied for xxx hours during the past weekend…." But the effort is much more than time.

Communication: The interactive inter-personal communication played a critical role, including student and instructor(s), student and student (learning buddy), student and teaching assistant(s), student and tutor(s), and teaching assistant(s) and instructor(s). Some students are not good at communicating with the instructor, PAL leaders, teaching assistants, etc.

Below are factors that might affect the research questions, but the author didn't explore them because of limited access to those data.

Individual needs and perceptions: Even though we provided the accommodations to some students with special needs, it could not cover all individual needs during the online teaching period. Let alone a course with more than 90 students. Also, the personal perception of certain concepts differs drastically.

Academic dishonesty: Even though we deployed the Lockdown Browser to prevent cheating happen for all the tests in this course, academic dishonesty still happened someway during the online teaching period and can raise the grade a little bit, but the amount is minimal compared to the total student number of 500-550, so it played a trivial role.

First-generation college students: There is no data about this category in the present study, but it will influence how the students prepare for college-level engineering courses.

Anxiety and stress: Anxiety and stress play a critical role, but there is no way to investigate the actual effects in the present study.

Conclusion

We have heard many complaints about the stressful and dreadful online learning environments. Yet, the results showed no significant differences in the overall academic performance, including passing rates and average final grades of the course, compared with in-person teaching, with appropriate adjustments and interventions deployed.

Online teaching benefits the well-prepared, high-performing students with better time management skills and self-regulated learning ability the most. One of the reasons is the availability of the additional materials provided, including pre-recorded theory videos, zoom recorded live lecture videos, more flexible zoom office hours, flexible schedule, etc., compared with conventional teaching environments. The performance of the top quartile students moved higher with better learning and time management skills.

Even though the underprepared students have the same advantages of having "extra" time as the top quartile students, they still struggle, and even worse. To be successful in their future careers as their peers, the underprepared students need to improve all abilities mentioned above, but the most important and urgent is to make up their prerequisite pieces of knowledge.

The features of online teaching/learning, such as synchronous/asynchronous, remote impersonal communication, requires self-regulated learning ability, time management skills, time management skills, stress management skills, how to work effectively and independently for the students. It requires both the instructor and students to quickly adapt to the new teaching and learning environments to achieve comparable academic performance as the in-person modality.

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Bibliography:

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