

Evaluating Freshmen Engineering Students' Experience in a First-Year Engineering Program and Lessons Learned during Covid-19 Pandemic

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Leslie Massey is an instructor in the First-Year Engineering Program at the University of Arkansas. She received her BS in Biological Engineering and MS in Environmental Engineering from the University of Arkansas. She previously served as a project manager at a water resources center, but returned to the University of Arkansas to teach general Introduction to Engineering and to coordinator for the First-Year Honors Innovation Experience.

Mr. Brandon Crisel,

I am a 12 year veteran instructor at the University of Arkansas with a BS and MS in Mathematics with emphasis in Statistics and applied Math as well as an MS in Industrial Engineering. I began working in the Math Department, teaching service courses such as College Algebra, Math for Elementary Teachers 1&2, Mathematical Reasoning, and Finite Mathematics. I also helped spearhead the Math Department's online initiative to create an online program for our service courses while simultaneously implementing a flipped course teaching method to the traditional classes. I was also the Testing Coordinator, where I managed the Testing and Tutoring Centers and their staff as well as created, maintained, and supported the Online Math Placement Test and its related documentation. I had worked in conjunction with the First-Year Engineering Program (FEP) to support students that were underprepared in math, and an opportunity arose to take a position that would be a 50/50 split between Math and FEP. I have taught many semesters of Introduction to Engineering themed in Electronics, Robotics, and Structures as well as support courses such as Fundamentals of Success in Engineering Study and Engineering Applications of Math. I have since moved entirely to a full time instructor for FEP, where I have helped redesign the Electronics and Robotics theme and where I have worked to create a common Computing theme for all incoming students.

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Introduction

In Spring of 2020, the Covid-19 pandemic caused great changes to the education system across the country. Both universities and high schools were forced to quickly adapt to distanced learning or cancel classes. Students were left confused and concerned about how their semester would end. What originally was expected to be a short inconvenience was prolonged as universities and high schools continued to utilize distanced learning or practice social distancing within the classroom through the 2020-2021 school year until vaccines became available. The literature is beginning to assess changes in teaching practices and results in student learning necessitated by the pandemic [1 – 3]. In Fall 2021, as cases declined, many schools returned to previous classroom models while incorporating new practices that were successful during the pandemic.

University of Arkansas is a land grant, public university currently serving approximately 23,000 undergraduate students. Prior to the pandemic, minimum admission requirements for new freshman applicants were a high school GPA of 3.0 or higher on a 4.0 scale, and an ACT score of 20 or higher, or the SAT equivalent. The College of Engineering (COE) does not have separate admission standards. The First-Year Engineering Program (FEP) at University of Arkansas was established in 2007 with the intent of increasing student retention and success in COE. Since the creation of FEP, retention rates have increased from 61% to approximately 70%. The typical introduction to engineering course offered by FEP is designed to help transition students from high school to college and to prepare them to be successful in their sophomore level engineering courses.

This paper seeks to explore how FEP adapted through the changes due to Covid-19 pandemic and how their students' performance in Introduction to Engineering courses were affected. We compared FEP students' grade distributions in Introduction to Engineering courses before, during, and after the Covid-19 pandemic related adjustments. We also analyzed how students perceived FEP's ability to adapt in the classroom by comparing their evaluations during the same periods.

Covid-19 Response at the University of Arkansas

University of Arkansas suspended in-person classes at 2:30 PM on Thursday, March 12, 2020 and pivoted to alternate delivery methods beginning Monday, March 16. The expectation was that classes would be delivered remotely the week of March 16 and return to "normal" classes after spring break. However, classes remained remote for the duration of the Spring 2020 semester with many students finishing the semester from home. University of Arkansas also implemented policies by which students could elect to receive scores of Pass (P) if they earned C or higher, Pass with a D (PD), or Non-Credit (NC) for courses they failed. None of these counted toward student GPA.

Through the summer of 2020, classrooms were prepared for Fall with the expectation of maintaining a 6-foot distance between each student and a 10-foot distance from the instructor. This resulted in most classrooms being slated for roughly 1/3 of their normal capacity. Plexiglass barriers were placed in front of teaching podiums. Departments were asked to decide whether they would offer their class completely remote or as hybrid with some students being allowed to attend in-person. All outside meetings such as academic advising or staff meetings were to be held virtually. Additionally, because many high school students had missed the opportunity to take standardized tests, University of Arkansas decided to waive the ACT or SAT requirements for admissions. However, the ACT/SAT requirements for math placement (and other courses) remained the same.

By mid-fall, the decision was made that Spring 2021 classes could still have the option of being in-person, remote, or hybrid. Classrooms remained socially distanced with mask-mandates. Emphasis was placed on the expectation that students who registered for in-person courses or in-person seats in hybrid courses to attend barring illness or exposure. Outside class meetings remained virtual. With an increasing number of students, faculty, and staff vaccinated, and cases dropping in the state and surrounding areas, University of Arkansas decided Fall 2021 courses would be in-person with classrooms at full capacity but with mask-mandates. Standardized tests scores continued to be optional for admission but used for math placement.

Covid-19 Response in First-Year General Engineering (GNEG) Courses

As part of their first-year coursework, engineering students take GNEG 1111 Introduction to Engineering I in the Fall and GNEG 1121 Introduction to Engineering II in the Spring. Students that qualify for the Honors College may elect to take GNEG 1111H & GNEG 1121H which are taught concurrently with the regular sections. These courses are taught through a flipped classroom model with about half-semester spent on interactive, hands-on team projects [4]. The course content includes basic engineering skills (such as unit conversion and dimensional analysis) and Excel-based activities on charts and graphs, descriptive statistics, engineering economics and data management. Fall semester also focuses on basic programming logic using an interactive e-textbook and these concepts are reinforced with hands-on team projects using programmable devices such as Arduino Unos or Lego Mindstorms robots. Students pick one of the four project themes (Biosystems, Electronics, Robotics, or Structures) while enrolling in a GNEG 1121 course in spring. Students also enroll in a drill section while enrolling in GNEG courses. The drills are primarily used for outside speakers including each of the departments, career services, multicultural center, and other student support services such as academic coaching. During drills, students learn about all engineering majors, and go through series of talks that foster transition from high school to becoming a quality engineering student. Lastly, as a part of GNEG courses, students meet once a week with a peer mentor. Peer mentors help students to build an understanding of the campus resources and guide their mentees through topics such as time management, interacting with faculty, and effective study habits.

In March 2020, when classes transitioned to remote learning, the hands-on projects typically offered in GNEG 1121/1121H were put on hold and Excel assignments that originally was planned for later in the semester were shifted to replace them. When it was clear that students

would not be returning to the classroom, additional Excel topics on data analysis were deployed to replace the hands-on projects and the exam was given remotely through Blackboard.

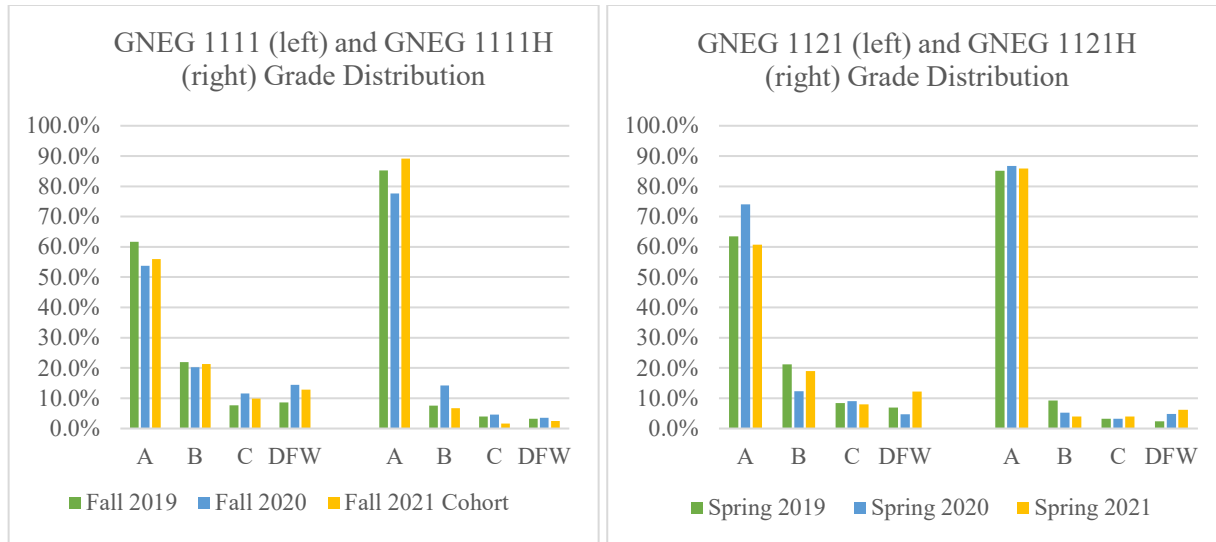
Fall 2020, we were able to rearrange our classroom to fit nearly half of a full-size section. GNEG 1111/1111H courses were delivered in a hybrid manner, in which students were divided into groups A and B. Group A could physically attend on the first day of class (Monday or Tuesday), group B could attend on the second day of class (Wednesday or Thursday), and students also could choose not to attend physically. Students not attending in-person were expected to login to the Zoom broadcast live. Students unable to watch their class live could watch a recording of the classes' events (same for all 12 sections) and get help through TA office hours also held on Zoom. Since most the topics were delivered as a flipped classroom, the hybrid format only caused minor issues to engineering skills and Excel topics. The hands-on programming projects were replaced by similar lessons on TinkerCad (www.tinkercad.com) which utilized a virtual Arduino Uno at no cost. Because there was not suitable space, drills were each recorded by the presenters. Students were required to watch the appropriate video each week and complete a quiz to show they understood it. Since in-person attendance was not required, the number of students attending in-person in the classroom continued to fall throughout the semester.

Spring 2021, University of Arkansas decided not to have hybrid classes and allow students to either register for in-person sections or remote sections. FEP offered four remote sections and eight in-person sections of GNEG 1121/1121H. Because students were to remain distanced within the classroom, themed hands-on projects were not utilized. Instead, all students participated West Point Bridge Design (normally utilized in the Structures theme section) and completed the Button Hero Arduino assignment on TinkerCad (normally utilized in Electronics with Arduinos). These projects were selected because they could be done alone and virtually. The Data Analysis topics added in Spring 2020 were kept in the curriculum. Drills focused on career development and were delivered remotely with corresponding quizzes.

Fall 2021, University of Arkansas returned to normal class capacities and interactions with a mask mandate. GNEG 1111/1111H returned to essentially the same content as Fall 2019 except for Lego Mindstorm EV3 robots replaced Arduinos for the hands-on projects. We also returned to in-person drills. In Spring 2022, GNEG 1121/1121H returned to themed based hands-on projects. The mask mandate was lifted mid-semester.

Grade Distribution in GNEG courses

Figures 1 and 2 show the grade distributions in GNEG 1111/GNEG 1111H and GNEG 1121/GNEG 1121H classes for 2019, 2020, and 2021. As easily predicted, honors students have a higher success rate in the Introduction to Engineering I and II classes regardless of the academic year. We observe that in spring 2020, when the pandemic put a sudden halt to the in-person delivery of the course, more students earned As in GNEG 1121. This is mostly because the hands-on projects were replaced by self-guided skills assignments and instructors were very flexible on due dates. In the following fall, the pandemic precautions did not have a big impact on the grade distribution for the students earning A, B, or C.



Figures 1 and 2: Grade distributions for GNEG 1111/GNEG 1111H and GNEG 1121/GNEG 1121H courses (grades of D, F, and W are combined). Fs were converted automatically to NC in spring 2020, fall 2020, and spring 2021. Ds were converted to PD in spring 2020. Student who chose “P” were counted in the C grade column for spring 2020.

Next, we focused on students who earned a D, F, or withdrew from the course by examining the DFW rates for the courses. To have a broader view of the rates, we also included the mean of DFW rates for fall 2015- fall 2019 semesters for GNEG 1111/1111H course and spring 2015 – spring 2019 semesters for GNEG 1121/1121H. These results are shown in Table 1. We observed a decrease in DFW rates for GNEG 1121 students in spring 2020; this follows a similar discussion to why we saw an increase in As in the course. In contrast, we observed an increase in DFW rates during fall 2020 in GNEG 1111/1111H. There can be several reasons for this increase: some students had less than ideal conditions attending classes (especially those who chose to do virtual), some students might not have adapted well to the hybrid delivery method, while others might have been less motivated since lower grades did not impact their GPA during fall 2020 semester. We continued to observe an increase in DFW rates in most courses in 2021. An increase in DFW rates during the pandemic is not unique to first-engineering courses or even our university and was observed at most colleges across SEC institutions [6].

Table 1. DFW rates for Fall GNEG 1111/GNEG 1111H and Spring GNEG 1121/1121H classes. Fs were converted automatically to NC in spring 2020, fall 2020, and spring 2021. Ds were converted to PD in spring 2020.

DFW Rates	GNEG 1121	GNEG 1121H	GNEG 1111	GNEG 1111H
Mean of Spring 2015-2019 / Fall 2015-2019	5.8%	1.4%	9.7%	2.3%
Spring 2019 / Fall 2019	7.0%	2.4%	8.6%	3.3%
Spring 2020 / Fall 2020	4.7%	4.8%	14.4%	3.5%
Spring 2021 / Fall 2021	12.2%	6.2%	12.8%	2.5%

Course Evaluations in GNEG Courses

At the end of each first-year or sophomore level course, students are asked to complete an online anonymous survey through a system called CourseEval. Students rate both the course and instructor on a 5-point Likert scale and answer additional questions about the course. Results are provided to the instructors for course improvement. These results are summarized in Figure 3 for the semesters examined.

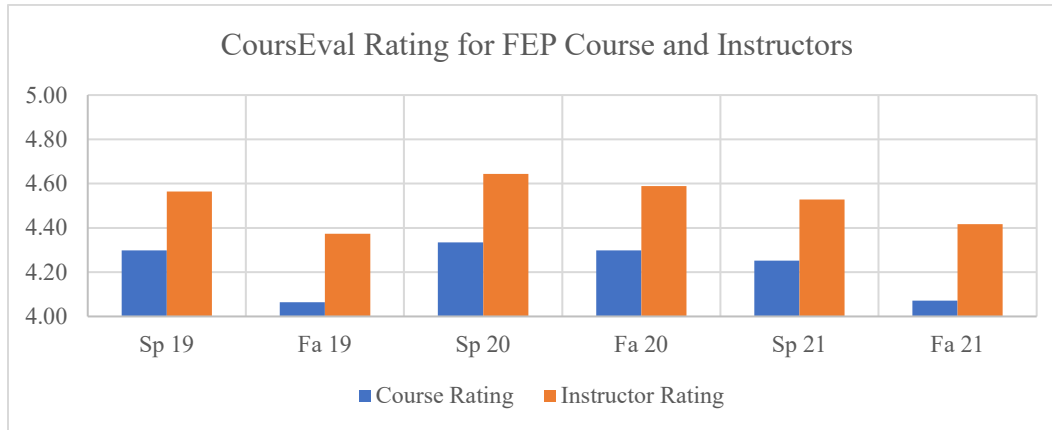


Figure 3: Cumulative Course Evaluation Ratings in GNEG 1111/GNEG 1111H (Fall) and GNEG 1121/GNEG 1121H (Spring) courses

The course rating for Introduction to Engineering courses have historically been lower than the instructor rating for the course. Because this course serves students ranging from precalculus ready to calculus II and above ready, some students find the course challenging while others find components of the course to be “busy-work”. Some students do not like the flipped-classroom nature of the class because it is a different learning style than what they encountered in high school. Course ratings for fall semester GNEG 1111 ranged from 4.06 to 4.30 while spring semesters GNEG 1121 ranged from 4.25 to 4.33. T-tests indicate there was no significant change to course evaluations of GNEG 1121 courses over the 3-year period. However, for Fall 2020, we see a significant spike in course rating compared to the year before and after. This is possibly due to GNEG 1111 being one of the very few courses FEP students were able to attend in person after finishing high school remotely. Instructor ratings were slightly higher in 2020, but we did not find a significant increase.

Summary and Conclusion

This paper focused on the effects of pandemic related adjustments in first-semester Introduction to Engineering course. We summarized the changes to the course delivery method due to pandemic and discussed the variations in grade distribution and course evaluation ratings during the last three fall semesters. We observed minimal changes in the grade distribution for students who earned A, B or C; however, the DFW rates increased starting Fall 2020. We also looked at the course ratings as a possible way to understand students’ perception on how well FEP adapted to pandemic adjustments. We observed spike in course rating for Fall 2020; we attribute this to students appreciating our efforts to stay in-person/hybrid while nearly all their other courses

were fully online. We have seen no significant change in instructor ratings over the period but seeing the slight increase in spring 2020 was encouraging for all FEP instructors since we persevered under difficult conditions to help each one of our students while they transitioned from high school to college in a challenging period.

This past two years helped us to learn that while flexibility was necessary during the height of the pandemic, most students do much better in our course with strict deadlines especially when hands-on projects are involved. We feel justified about the structure of our course with set deadlines, but we also are more aware of the mental health and other challenges; we will continue to be flexible as needed by individual students. For the course delivery method, we learned that most of our students prefer in-person classes. The hybrid delivery method did not work for the instructors; we felt like we were not serving our students well. We also learned some new tools such as TinkerCad and tried new features of Blackboard. We plan to combine TinkerCad with a hands-on Arduino project in near future. We also plan to have one recorded summary video for Introduction to Engineering every week for students with excused absences. Lastly, we noticed that students were more inclined to use virtual office hours. We will continue to schedule some online TA and instructor office hours to create more opportunities for students who need help with assignments.

We expect the effects of pandemic to continue to impact our students' performance and attitude in our classrooms. We also acknowledge that as instructors, we are also still adjusting to a new normal. Our hope is to continue to adapt to the students' needs while helping them understand what is required to be a good sophomore engineering student.

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