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# Comparison of Traditional Face-to-Face and Online Student Performance in Two Online-Delivered Engineering Technical Electives

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## Abstract

Besides the traditional face-to-face approach, Arizona State University now delivers one of only two ABET-accredited, fully online baccalaureate degree programs in electrical engineering. As part of the deployment of online versions of two senior-level technical electives, the courses were offered online exclusively to both the online and traditional on-campus students. Other studies tend to compare performance of online students to their on-campus peers who are attending live lectures. In this investigation, both groups of students viewed the same online lectures, completed the same homework, and were administered identical examinations. Comparison of their performance shows that the online student performance is slightly better than their on-campus counterparts. This heightened performance may be attributed to the older age of the online students and perhaps their prior familiarity with taking online courses. In some instances, the courses were offered at an accelerated pace (half semester) which the online students were more accustomed to than the on-campus students.

## Keywords

Student achievement, online course, distance education.

## Introduction

Brick and mortar universities are increasingly providing online delivery of courses. Presently, ABET has accredited just two fully online electrical engineering (EE) programs in the U.S. In particular, Stony Brook University grants a bachelor of science (BS) degree and Arizona State University (ASU) confers a bachelor of science in engineering (BSE) degree in electrical engineering.[1,2] As part of the development of two courses for the latter program, the recorded lectures were initially delivered to both the online and the traditional on-campus students. Faculty are interested in ensuring that online students achieve the same level of learning as do the face-to-face students.[3] This investigation is an effort to determine whether that is happening in these courses. The statistics and probability distributions of the end-of-the-course student scores for the course offerings are used to compare student performance. In addition, a composite record of when students view the lecture recordings is available to compare against the examination and homework assignment due dates.

## Literature Review

This is not the first study to examine differences in the performance of online and traditional on-campus students. In the case of an introductory C++ programming course, online students were

found less likely to complete the course than the students enrolled in the traditional lecture delivery section, while any significant differences in outcomes for students completing the course favored the online students.[4] In comparing online versus traditional on-campus students in an earth science class, Werhner reports that there was no significant difference in student performance on exams.[5] Similarly, Summers et al. state that there was no significant difference in grades earned in a statistics course by online students and those in a traditional classroom setting.[6] Especially noteworthy are two meta-analyses in which data from multiple studies by others are combined to strengthen the statistical validity of conclusions. Shachar and Neumann selected 86 studies and concluded that in two-thirds of the cases, students taking courses by distance education outperformed their counterparts who were enrolled in traditionally instructed courses.[7] In a report for the U.S. Department of Education, meta-analysis of 50 studies determined that on average, students in online learning conditions performed modestly better than those receiving face-to-face instruction.[8]

Most of those studies, however, tend to compare students receiving the material via the Internet vs. live in-person (whereas the present paper examines when both on-campus and off-campus students receive the course via online delivery). In a study similar to that undertaken in this paper, Stack observed that the academic performance of 64 online and traditional students was the same in an online criminology course.[9]

**Present Study**

This paper investigates student performance in multiple offerings of two different senior-level engineering technical electives taught by the same instructor:

1. EEE 460 Nuclear Power Engineering, and
2. EEE 463 Electrical Power Plants.

In 2015, the first fully online versions of these three-semester-hour courses were offered. The online lectures are produced in a recording studio using a green screen backdrop with only the instructor and producer present. Figure 1 shows that the instructor is overlaid onto PowerPoint slides, with closed captioning available. The Blackboard course management system provides access to the recorded lectures, a discussion board, test administration, and homework submission and grading.

This paper compares the performance of two separate cohorts of students within each course. First, there is the on-campus, normally face-to-face, undergraduate students; and second is the online undergraduate students who complete their entire curriculum remotely without ever stepping foot on campus. Table 1 compares demographics of the on-campus and online undergraduate electrical engineering students at ASU. The noteworthy differences observed are that the online students have a larger relative population of veterans and are about 10 years older, on average, than the on-campus students—both these factors would lead to the expectation that the online students are more mature.

All students viewed the same online lecture recordings, had the same homework assignments, and completed identical exams. Traditional on-campus students enroll in what is termed the "hybrid section" which differs in that the midterm and final examinations are administered to the

entire cohort at a preset time in a large on-campus classroom (the exams were the only scheduled meeting times during the entire course offering), and these students potentially have the benefit of face-to-face access to the instructor during office hours. For the online students, the university has contracted with a remote proctoring service that utilizes the student's webcam to monitor them during the exam period and while they upload written exam solutions to Blackboard. All students have access to the instructor via email, telephone and the online discussion board. Although online students were presented with the option of office hours with the instructor via web conferencing software (Adobe Connect), surprisingly, no one took advantage of the offer.

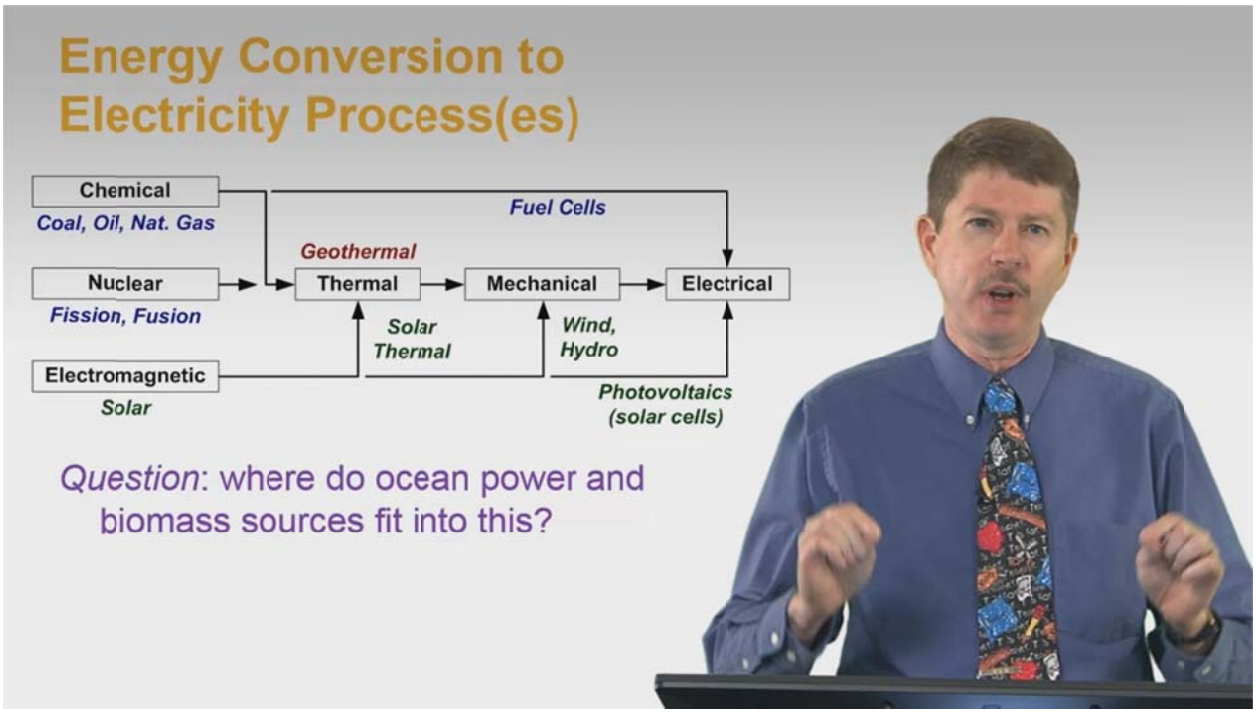


Figure 1. Screen snapshot of an online lecture from EEE 463.

Table 1. Comparison of On-campus and Online Undergraduate Students

| Electrical Engineering Student Group | On-campus (Face-to-Face) | Online |
|---|---|---|
| Fall 2015 Undergraduate Enrollment | 976 † | 802 ‡ |
| Average Age | 22 | 32 |
| Veterans | 7% | 37% |
| Female | 11% | 11% |
| Arizona resident | 75% | 15% |
| International | 15% | 0% |

† https://facts.asu.edu/Pages/Enrollments/Enrollment-Trends-by-College-and-Dept.aspx
‡ https://facts.asu.edu/Pages/Enrollments/Online-Enrollment-by-College-and-Department.aspx

Table 2, which summarizes the initial online offerings of these courses, shows that the on-campus cohort is larger in most academic terms. In fact, the total population of this study comprises 242 on-campus students and 73 online students. During these terms there was not a face-to-face offering of either of these courses such that the on-campus could not select a different mode of course delivery. This is different from a study by Helm in which students were permitted to self-select their own delivery modality.[10] Within a given term listed in the table, the same homework and exams were administered (e.g., even though there was a one week difference in the length of the first EEE 460 offering in 2015 and the online undergraduate students took the course in summer rather than spring, all other aspects were identical). Initial findings that an accelerated (7–8 week) schedule for the course seemed too demanding for the on-campus students partially motivated changing the second (spring 2016) offering of EEE 460 and the third (fall 2016) offering of EEE 463 to full 15-week semester classes. In particular, Table 2 reveals that the on-campus withdrawal rate is higher than that of the online students in 4 of the 5 terms. Quantitatively speaking, the withdrawal rate for the online students varied from 0% to 8% with an average of 4%, whereas for the hybrid students the range was from 6% to 24% with an average of 15%. For reference, the withdrawal rate in the traditional face-to-face classroom setting in the most recent offering prior to these online delivered versions was 12% and 8% for EEE 460 and EEE 463, respectively.

Table 2. Initial Online Course Offerings

| Course | EEE 460 | | EEE 463 | | |
|---|---|---|---|---|---|
| Academic Term | Spring/Summer 2015 | Spring 2016 | Fall 2015 | Summer 2016 | Fall 2016 |
| Course length | 7 or 8 weeks† | 15 or 7 weeks‡ | 7.5 weeks | 8 weeks | 15 or 7.5 weeks§ |
| *Enrollment at end of course (such that the students were assigned an actual letter grade)* | | | | | |
| UG Hybrid | 50 | 69 | 58 | 13 | 52 |
| UG Online | 14 | 9 | 16 | 23 | 11 |
| Total | 64 | 78 | 74 | 36 | 63 |
| Student withdrawals* | 3 / 1 (6% / 7%) | 8 / 0 (10% / 0%) | 18 / 1 (23% / 6%) | 4 / 2 (24% / 8%) | 8 / 0 (13% / 0%) |

† The 7-week spring and 8-week summer 2015 terms comprised, respectively, on-campus and online students.
‡ The 15-week and 7-week spring 2016 sessions consisted, respectively, of on-campus and online students.
§ The 15-week and 7.5-week fall 2016 sessions contained, respectively, on-campus and online students.
* The students withdrawing (on-campus / online) from the course are not included in the enrollment totals.

## Student Performance in the Courses

Online and on-campus student performances are now compared in these two courses. In both courses, the final student grade average comprises 25% homework, 35% midterm exam, and 40% final exam. While comparing these final average scores, the length of the course term is important to consider.

*EEE 460 Results*

Table 3 gives statistics for the end-of-course grades in EEE 460 with bolded values denoting significantly better performance and N being the number of students. For this course, the two cohorts exhibited similar performance, with the online students outperforming the on-campus students in 2015, and vice versa in 2016 but by a smaller margin. A closer examination shows that for the 2015 offerings with near equal term lengths, the online students (8 weeks) had an average of about 10 points higher than the on-campus students (7 weeks). This significantly better performance might be attributed to (1) the maturity (age) of the online students, and/or (2) the fact that students in the online program were accustomed to completing their courses in half-semester terms whereas the on-campus students were not. In 2016, when the on-campus students were given the usual 15 weeks, they had a modest 2.5 point advantage over the online students who took the course in a 7-week session.

Other academicians have also observed differences in student performance based on the course term length. For example, students in the 16-week offering of a management accounting course performed better on exam problems than those in the 8-week class, except that no significant difference existed with respect to the points earned on multiple-choice questions.[11] In contrast, Austin and Gustafson examined a database of over 45,000 observations from all classes at the University of West Georgia from spring 2001 through summer 2004, and found that intensive courses result in higher grades than traditional 16-week semester length course and that these higher grades reflect a real increase in knowledge, with the improvement benefit peaking at about 4 weeks.[12] In still other cases, no difference in performance was observed. For instance, Anastasi reported that academic performance was similar in summer and full-semester length offerings of three psychology courses.[13] In addition, Shaw et al. found no statistical difference in student achievement or engagement between six online psychology courses with half being taught in a 16-week semester while the other half were delivered in an 8-week term.[14]

Figure 2 provides plots of the probability density functions (pdfs) for EEE 460 based on a Gaussian distribution with the mean and standard deviation presented in Table 3 (the actual data skewness was –1.9 to 0.1). The averages and standard deviations for the two hybrid classes (7 and 15 week sessions in 2015 and 2016, respectively) were amazingly similar even though their homework assignments and examinations were different from one year to the next. The 2016 online pdf is also very similar to the two hybrid pdf curves. We can only speculate as to the noticeable difference in the 8-week online class, in particular, of the 4 classes, it was the only one of the four held in the summer such that perhaps the online students had a lighter load since EEE 460 was the only senior-level technical elective offered online in summer 2015.

Table 3. EEE 460 End-of-Course Grade Statistics

| Term | | Student Cohort | N | End-of-Term Student Grade Averages | | | |
|---|---|---|---|---|---|---|---|
| | | | | Minimum | Mean ± Std. Dev. | Median | Maximum |
| 2015: | 7-week spring | Hybrid | 50 | 14.0 | 72.4 ± 14.6 | 74.0 | 96.8 |
| | 8-week summer | Online | 14 | 67.2 | **82.4** ± 9.1 | **81.9** | 97.3 |
| 2016: | 15-week spring | Hybrid | 69 | 25.5 | 72.3 ± 14.7 | **76.6** | 92.4 |
| | 7-week spring | Online | 9 | 45.9 | 69.7 ± 14.7 | 69.4 | 91.4 |

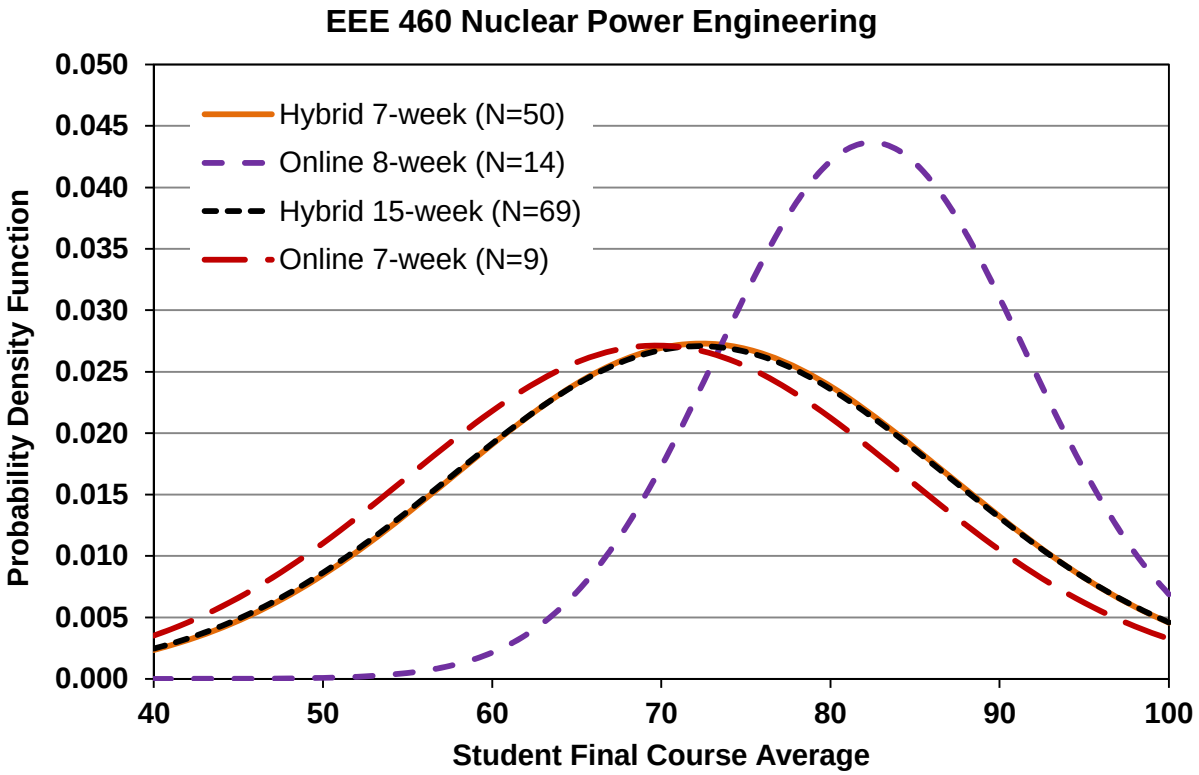


Figure 2. Stylized pdfs for online and on-campus students in EEE 460.

*EEE 463 Results*

Table 4 and Figure 3 provide the statistics and stylized pdfs (the actual data skewness was –2.1 to –0.5) for the six EEE 463 classes taught thus far. The term lengths and dates of the EEE 460 course were different for the online and hybrid students; however, that was not the case for the fall 2015 and summer 2016 offerings of EEE 463 which occurred within the same 7.5 and 8 week periods, respectively, and as such more direct comparisons can be made. Upon analyzing these direct class comparisons, the online students as a whole performed modestly better (4 points greater) in 2015 and more significantly better (9 points higher) in summer 2016 than the traditional on-campus students. This enhanced performance (which was also noted in EEE 460 when the term lengths were near equal in 2015) may be attributed to (1) the maturity of the online students, and/or (2) the fact that students in the online program were accustomed to completing their courses in half-semester terms whereas the on-campus students were not.

When the on-campus students were given the entire fall 2016 semester to complete the course, their performance became essentially identical to that of the online students who finished the class in half that time. Interestingly, and similar to the EEE 460 for summer 2015, the online students in summer 2016 outperformed the on-campus cohort by about one standard deviation. Again, EEE 463 was the only senior technical elective offered by the academic unit to (online and on-campus) students in summer 2016.

Table 4. EEE 463 End-of-Course Grade Statistics

| Term | | Student Cohort | N | End-of-Term Student Grades | | | |
|---|---|---|---|---|---|---|---|
| | | | | Minimum | Mean ± Std. Dev. | Median | Maximum |
| 2015: 7.5-week fall | | Hybrid | 58 | 0.0 | 72.0 ± 15.8 | 74.3 | 92.0 |
| | | Online | 16 | 50.2 | 76.3 ± 11.3 | 79.3 | 94.5 |
| 2016: 8-week summer | | Hybrid | 13 | 47.6 | 72.4 ± 11.6 | 73.0 | 90.2 |
| | | Online | 23 | 57.5 | **81.5** ± 9.2 | **82.7** | **97.4** |
| 2016: | 15-week fall | Hybrid | 52 | 40.3 | 77.0 ± 12.0 | 77.1 | 96.2 |
| | 7.5-week fall | Online | 11 | 52.7 | 76.8 ± 12.0 | 78.6 | 93.1 |

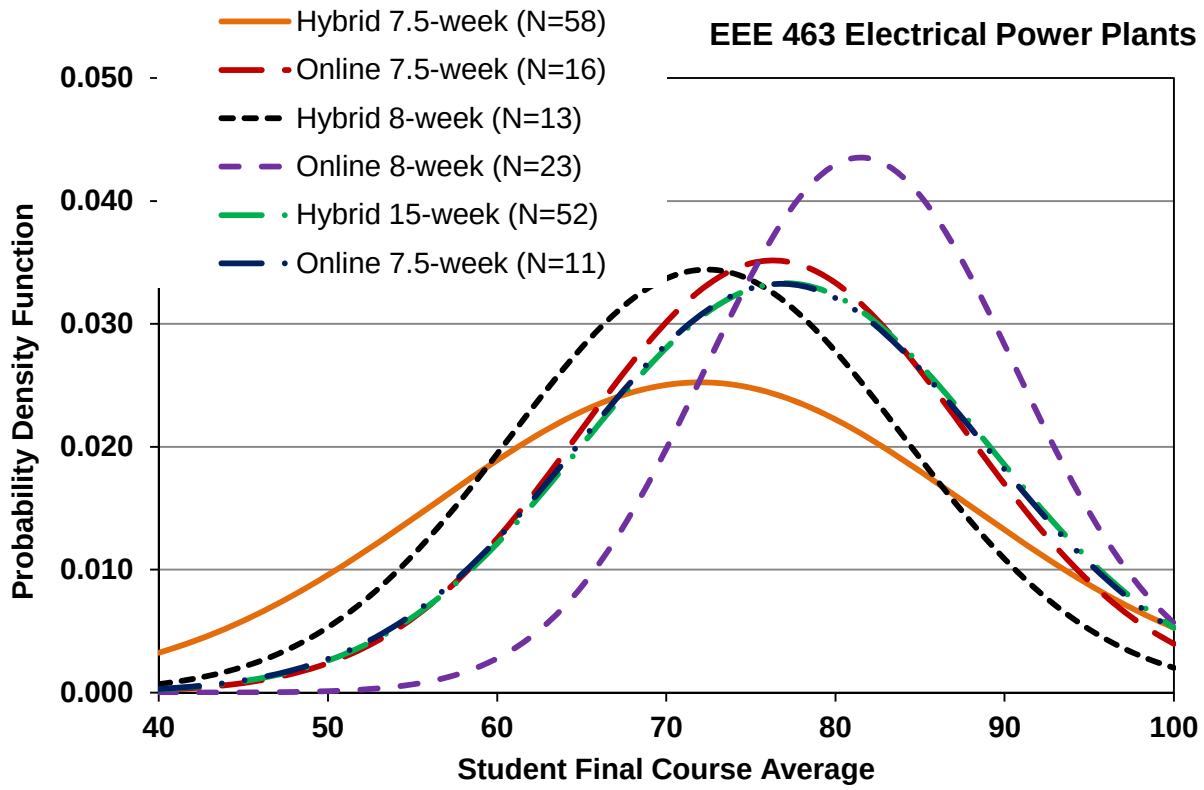


Figure 3. Stylized pdfs for online and on-campus students in EEE 463.

*Student Procrastination*

Because of the online nature of the courses, a unique opportunity presented itself in terms of assessing student procrastination. The number of plays of any course lecture is tallied and plotted in Figure 4 (the green and gray coloring provide the capability of identifying plays for specific lectures when the unannotated versions of these graphs are viewed in the online software). The graph reveals increased viewing (peaks) which correspond to the examinations and homework submission dates. The bimodal peaks associated with Homeworks 4 and 7 can be explained: (a) Homework 4 was due was the night of a collegiate (PAC-12) football game such

that some students may have been motivated to complete the assignment in advance to attend the home game, and (b) Homework 7 was due the day after a national holiday (Veteran's Day) giving them a chance to get ahead. With 20% of the students withdrawing in the fall 2015 EEE 463 courses, the decreasing number of plays toward the end of the term is expected. It is important to acknowledge that some of this peak viewing may be due to replays to provide assistance for solving the homework problems. Interestingly, data from the spring-summer 2016 offerings of EEE 460 showed that both the on-campus and online students demonstrate very similar procrastination behavior, even though the online students have been assumed to be more mature.

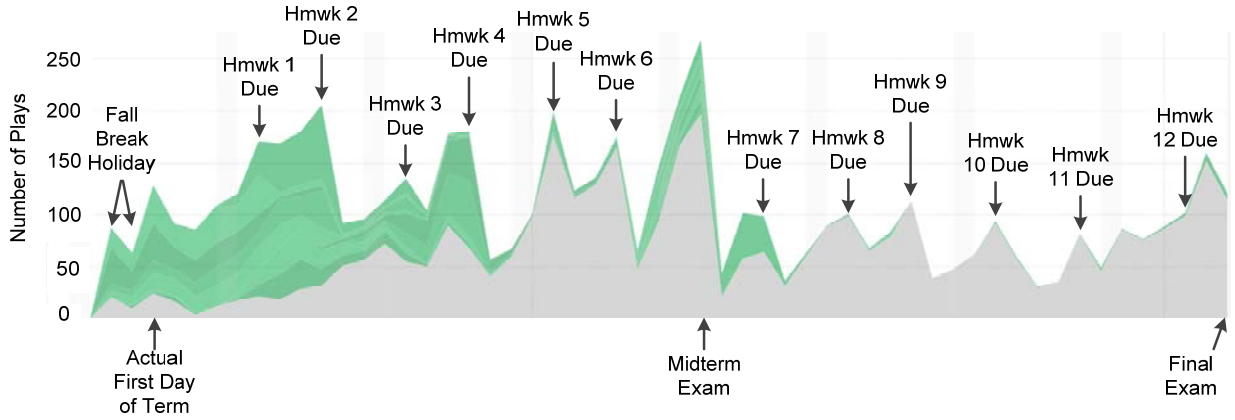


Figure 4. EEE 463 lecture plays during the 7.5-week fall 2015 term.[15]

## Conclusions

The gratifying result from this study is that the online and on-campus students are receiving very similar experiences and both groups are learning the material. Overall, the online students seem to perform better than the traditional on-campus students. While in some instances the lower course scores appear to be due to accelerated terms, the lower course grades for on-campus students may also be attributable to those students requiring an adjustment to the online course delivery format. For example, discussions with on-campus students revealed that the lectures are sometimes viewed late at night when their concentration is reduced, and that there is a difference between simply watching the videos versus attentively viewing the videos and taking notes like in a regular classroom setting. Several traditional students mentioned that after the midterm examination, they had to modify their approach due to the online nature of the course. Spring 2017 is providing the first opportunity to compare online and on-campus student performance in EEE 460 for identical term lengths, specifically, a full 15-week semester.

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