Achievement gap in online and hybrid courses versus face-to-face courses among engineering and computer science students

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***Abstract*— This Research Work in Progress Paper presents the comparison of the student achievement gap in online courses and traditional face-to-face courses among engineering and computer science students. The hypothesis of the work is: Online courses in Engineering and Computer Science College do not increase the achievement gap among the underserved groups compared to face-to-face courses. The analyses include the data for about 4800 students which used to evaluate the student performance in about 150,000 courses. The results indicates that there is no sign of the gender gap and low enrolment of underserved populations in online and hybrid courses compared to face-to-face courses. In fact, the data shows that the achievement gap among most underserved populations was reduced in online and hybrid courses compared to face-to-face courses for the college of Engineering and Computer Science at California State University, Sacramento between 2005 and 2017.**

Keywords— Online and hybrid courses, achievement gap, face-to-face courses, engineering college

I. INTRODUCTION

Online education has been continuously growing in the past couple of decades. Nowadays about one third of students take at least one online course. However, the distribution of these students is not even among various institutions and disciplines [1]. In California, the growth rate of the students who took at least one online course between 2012 and 2015 was much higher than that for the nation (18% vs. 11%, respectively) [2]. However, in 2017 only 23% of the total student population took at least one online course in California which was lower than that of about 30% in the nation [2]. Similarly, just over 9% of the state students are taking all their courses online which is again lower than that of the national average at just over 14% [2].

Ironically, while engineers have been largely responsible for the development of the infrastructure required for online education, engineering education has been excruciatingly slow in taking advantage of the resources. This is particularly evident in undergraduate programs. Several reasons for this phenomenon can be identified [3]:

- Hands-on activities (laboratories and machine shops) cannot be provided online.
- Mathematic-intensive topics have been considered more difficult to be delivered online than discussion-based topics.
- Some computation and software tools may not be available off-campus with affordable costs.
- The belief that online courses cannot provide the needed learning community to students.
- Engineering education culture has been slow to adapt.

As elaborated below, in reality most of these problems have been already addressed. Virtual labs, on-campus summer programs for laboratory courses, and centralized lab settings that serve many students in various institutions are being used to provide hands-on activities for students [3]. The latter two approaches are gaining momentum as a model for blended programs. The practicality of these approaches will be clearer if we consider the fact that on average about 55% of students who took online courses lived in the same state as the institution they attended [1]. This percentage is even more favorable in California with about 73% of students being in-state students [2].

Modern online learning tools have provided many means of interactions among students which created a large learning communities. These communities are typically much larger and more diverse compare to traditional ones. Even further some believe that online programs can help students to be exposed to different environments and cultures by removing the physical presence requirement in campuses [3].

Furthermore, online programs and courses can reduce the physical infrastructure requirements, such as classroom spaces, which provides a significant potential for cost reduction for universities and students.

Online programs and courses have the ability to promote some of the Accreditation Board for Engineering and Technology (ABET) criteria more effectively compare to traditional ones [4]. The fact that as of April 2018, there are 27 ABET accredited fully online programs [5] is another sign of greater acceptance of these programs.

While many engineering colleges are trying to diversify the delivery modes of their courses by increasing the share of online and hybrid courses, it seems the biggest hurdle to achieve this goal is "engineering education culture". One problem might be the skepticism of some stakeholders toward effectiveness of online courses and programs in engineering curriculums. Some early works has been published to investigate this issue [6] and how to overcome it [7-10].

This paper looks at online and hybrid courses in the Engineering and Computer Science (ECS) College at California State University, Sacramento (CSUS) between 2005 and 2017. It evaluates the student achievement gap in online

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courses compare to traditional face-to-face courses among engineering and computer science students.

II. Data Collection and Demographic of Students in Engineering and Computer Science at CSUS

The data used in this work was collected from the sources at the Office of Institutional Research (OIR). It included the information for all courses undergraduate engineering students took between 2005 and 2017. In the data analyses, the information for 4,758 students were used to evaluate their performance in 144,915 courses. The definitions and tools presented in the Data Analytics and Equity faculty learning community (FLC) offered by the Center for Teaching and Learning (CTL) at CSUS were vital for the analyses.

The analyses were conducted based on "student-course" (the number of courses student took) rather than the typical student headcount because the former represents the student populations more accurately. For example, the following two tables (Tables 1 and 2) show the distribution of student gender in the college using the student headcount and student-course between 2005 and 2017.

Table 1: Demography of students in ECS College: Male vs. female, Student headcount

Gender	Student Headcount	%
Male	4069	85.54
Female	675	14.19
Unidentified	13	0.27

Table 2: Demography of students in ECS College: Male vs. female; Course-student

Gender	Course-Student	%
Male	126181	87.07
Female	18705	12.91
Unidentified	28	0.02

This is more evident in ethnicity distribution of the students in Table 3.

Table 3: Demography of students in ECS college: Ethnicity; both course-student-based and headcount-based

	Course-Student-based	Headcount-based
White	34.5%	32.9%
Asian	26.2%	29.5%
Hispanic	19.8%	15.8%
Unknown	9.3%	12.8%
African American	4.8%	4.1%
Multiethnic	3.6%	3.2%
Pacific Islander	1.1%	1.0%
Native American	0.6%	0.6%
Total	100.0%	100.0%

The values in the tables indicate that the headcount-based data may not be an actual representation of the student populations partly due to the large number of transfer students and nontraditional working students in the college.

It should be noted that the cost of face-to-face courses and online and hybrid courses are the same for the students. While the faculty who teaching online and hybrid courses are not required to participate in various trainings and faculty learning communities available in the school, the eLearing policy of CSUS strongly encourages the practice.

III. Hypothesis and Data Question

While initially the objective was to conduct the analysis for online courses in the mechanical engineering department, after the data gathering, it was determined that the analysis cannot be conducted with the available data set, because only one hybrid course was taught in the mechanical engineering department in the past 12 years (Table 4).

Table 4: Hybrid and online courses in various ECS departments

Department	Number of courses	Course-Student
Electrical Engineering (EEE)	16	819
Computer Engineering (CPE)	4	123
General Engineering (ENGR)	1	280
Mechanical Engineering (ME)	1	36

The research question for this analysis is the following hypothesis:

Online courses in the Engineering and Computer Science College do not increase the achievement gap among the underserved groups compared to face-to-face courses.

The motivation for the data question is that the college of Engineering and Computer Science has planned to increase its share of online courses in a long term.

In this paper, as the first step, the current status of the online and hybrid courses were evaluated in the college. The most important challenge was not the data availability but the lack of online courses in the ECS College. The data showed that between 2005 and 2017, there was no fully online course (according to the description in the catalogue and/or the official course delivery mode in the schedule) offered by the ECS College for the engineering students. Table 5 shows the course-student percentage for the engineering courses when hybrid courses were also included.

Table 5: Online vs. hybrid courses (only engineering courses) in ECS college

	Course-Student	%
ECS College online	0	0%
ECS College hybrid	1258	0.86%

Clearly this data set was too small for any meaningful analysis. To increase the size of the data set, the non-engineering courses that were taken by the ECS students were also added to the data set. In this case, the fully online courses and both online and hybrid courses added up to 436 and 2028 course-students, respectively. This means about 1.4% of

courses (both engineering and non-engineering courses) were online and hybrid courses in the college (based on course-students) between 2005 and 2017.

While these numbers can be discouraging, California State University, Sacramento was one of the top 10 universities in California with the highest enrollment growth in online courses between 2012 and 2015 from 4,913 students to 7,511 students [2]. This is also reflected in the ECS College with a substantial increase in online and hybrid courses between 2014 and 2017 (Figure 1).

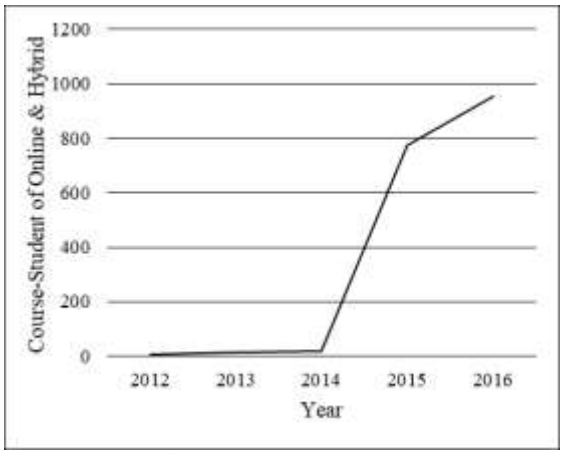

Figure 1: Number of online and hybrid courses (course-student) in ECS College between 2012 and 2016

However, the number of online courses offered by the ECS College has been very limited. One apparent reason might have been the fact that generally online courses have been considered inferior to face-to-face courses by some stakeholders. This is evident in the low number of online courses offered in the college (Table 4). This project tries to change this attitude by showing the effectiveness of online and hybrid courses. This type of research on the effectiveness of engineering (and non-engineering) online courses has recently started to appear in the literature [6-11].

Data Analysis and Results

The first finding was that less than two percent of the courses that were taken by the engineering students were online and hybrid courses (Figure 1).

Figure 2 illustrates the percentage of course-students versus the student gender in face-to-face courses and online and hybrid courses. The diagram indicates that there is no gender gap between the two modes of delivery and the popularity of them is independent of the student gender.

Figure 3 illustrates the student ethnicity distribution in face-to-face courses and online and hybrid courses for the students in the ECS college. The diagram shows that while the share of white and unidentified (in terms of ethnicity) engineering students were lower in online courses compared to that of face-to-face courses, the share of Asian engineering students was higher. The share of other ethnicities, including African-American and Hispanic engineering students, were almost identical in online and face-to-face courses. This diagram also indicates that the old notion that "most online students are nontraditional and Anglo American" [12] is no longer applicable.

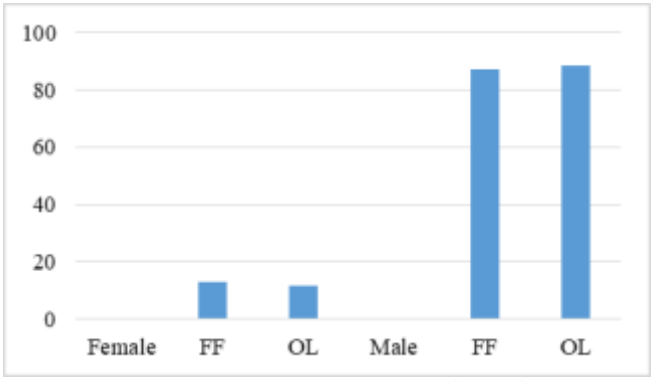

Figure 2: Gender distribution among students taking face-to-face courses and online and hybrid courses

Figure 4 shows the student pass/fail rate (%) in face-to-face courses compared to that of online and hybrid courses. With the assumption that both modes of delivery are equally rigorous, this may be interpreted as the comparable achievements of the course outcomes.

Figure 5 illustrates the rate of failure (%) in face-to-face courses and online and hybrid courses for various ethnicities. As the diagram indicates, the rate of failure was lower or comparable in online and hybrid courses compared to face-to-face courses for all groups except for the group identified as multiethnic.

The most important finding was presented in Figure 6. The figure shows the achievement gap among underserved groups. The achievement gap was defined as follows by the Center for Urban Education at University of Southern California [13]:

Percentage point gap = Course completion* rate (%) for a disaggregated subgroup – Course completion rate (%) for all students

* course completion means passing the course.

The diagram indicates that the student achievement gaps were smaller for all ethnic groups except for the multiethnic group in online and hybrid courses compared to face-to-face courses in the ECS College.

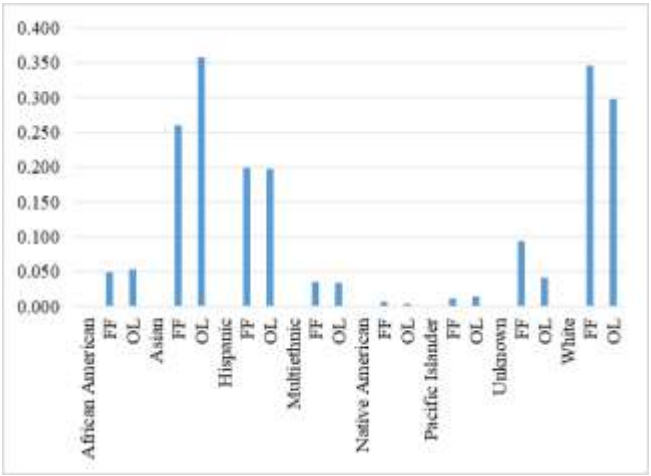

Figure 3: Ethnicity distribution among ECS students taking face-to-face courses and online and hybrid courses

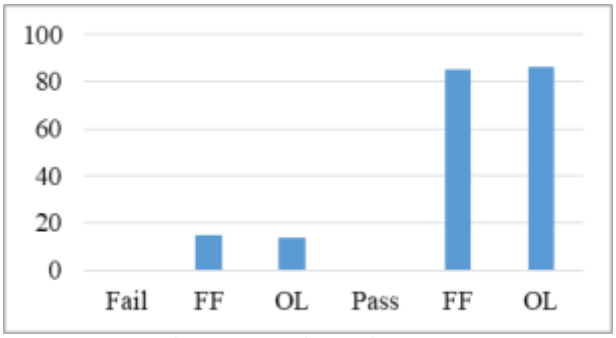

Figure 4: Student pass/fail rate (%) in face-to-face courses compared to that of online and hybrid courses

IV. Conclusion

In this paper, the effectiveness of the online and hybrid courses was compared with those of face-to-face courses for the Engineering and Computer Science students at CSUS between 2005 and 2017. The first finding was that only 1.4% percent of the courses that the engineering students took were online or hybrid courses which included both engineering and non-engineering courses. This percentage for engineering courses was merely 0.86%.In terms of ethnicity of the students who took the online and hybrid courses, while the share of white students was lower in online courses compared to face-to-face courses, the share of Asian students was higher. There was no meaningful difference among underserved student populations on this respect. The pass-to-fail ratio in online courses and face-to-face courses were almost identical when the entire engineering student population was considered. This might be considered as an indication that both delivery approaches were equally rigorous and effective in fulfilling course outcomes. The most important finding was that the student achievement gaps were smaller for all ethnic groups except for the multiethnic group in online and hybrid courses compared to face-to-face courses. The reason(s) for this improvement has not been determined yet. One speculation might be that the anonymity of online courses helped the underserved student populations to achieve their full potential without the fear of stereotyping.

Another theory is that the flexibility of online courses might disproportionately benefited the underserved student populations. The identification of the reasons for this phenomenon requires further in depth data collection and analysis. Nevertheless, this proves that not only online courses did not increase the achievement gaps among engineering students, but also the achievement gaps were reduced to some degree. It should be noted that the small number of online courses in the ECS College requires further analysis to determine how statistically significant the reported results are.

The most important challenge during the analyses was not the availability of data but the lack of online courses in the ECS College. This may affect the reliability and the degree of confidence of the results. Considering the rate of increase in the online and hybrid courses in the past few years (Figure 1), very soon there will be much larger data set to work with. So in the few next years, this analysis will be repeated with hopefully much higher percentage of online and hybrid courses. Also, currently the author is in the process of collecting similar data for the entire campus to repeat the analysis for the campus-wide data set.

It should be noted that the study did not take into account or control the differences among the students who took online courses and face-to-face courses including their GPA or SAT/ACT scores.

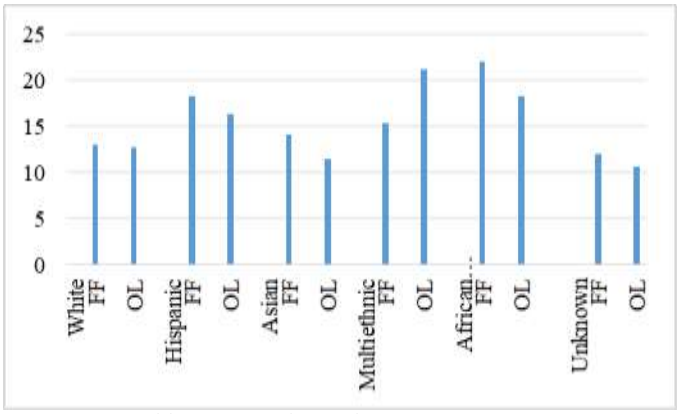

Figure 5: Rate of failure (%) in face-to-face courses compared to online and hybrid courses for various ethnicities

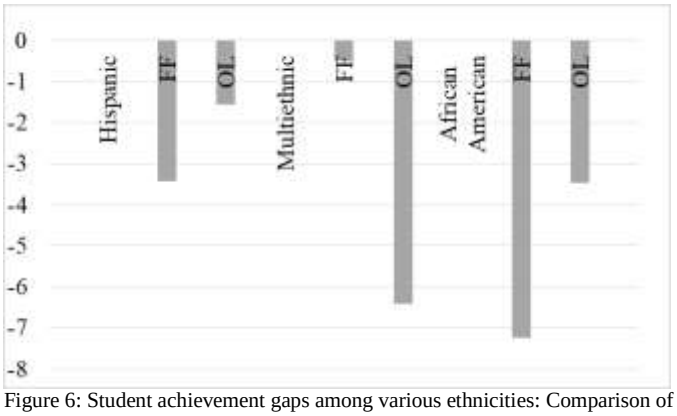

Figure 6: Student achievement gaps among various ethnicities: Comparison of face-to-face courses and online and hybrid courses

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