

Equity of Voice in the Classroom

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Abstract— This WIP study examines the effectiveness of three pedagogical interventions aimed at reducing persistent equity gaps in a senior-level engineering course. An analysis of two class cohorts found that despite no difference in the pass/fail rate, underrepresented students were earning proportionately more C grades and fewer A and B grades in the class. Although students will successfully obtain their degree, the impact on their GPA can perpetuate inequities in graduate school acceptance, funded research opportunities, and starting salaries for entry-level positions. The innovative aspect of this work includes a disaggregated equity analysis followed up with pedagogical strategies to construct classroom interactions that are culturally responsive to Latinx students. Relevant pedagogical interventions were developed aimed at facilitating equity of voice in the classroom so that all students can question and reflect on course content. The interventions focused on quantitative calculations in homework and exams, conceptual questions on quizzes and exams, and in-class interactions between the instructor and students. Students are provided structured opportunities to revise work, reflect on their errors, and master the material. Together, these three strategies characterize a robust approach to student success that are grounded in previous research. Final grades for two semesters prior to the pedagogical changes were compared to four semesters of final grades with interventions. Preliminary analysis of final course grades indicates a reduction in the equity gap, with higher gains for minoritized male students than for minoritized female students.

Keywords—*equity gap, reflection, culturally responsive pedagogy, Hispanic-Serving Institutions*

I. INTRODUCTION

Humboldt State University (HSU) has transitioned over the past two decades from an institution that served primarily white students to one that currently serves 43% underrepresented students (UR) including 33% Latinx students and 1% Native Americans [1]. This transition has resulted in HSU becoming a federally recognized Hispanic Serving Institute (HSI) and while the HSI designation based on demographics and geography is an indication of an increasingly diversified student body population, a diversified student population does not ensure an inclusive learning environment for underrepresented students [2,3]. HSI institutions are increasingly aware of important differences that must be bridged in comparison to other Minority-Serving Institutions (MSIs) such as Tribal Colleges (TC) and Historically Black Colleges and Universities (HBCU) whose mission to serve their students is based on a foundational recognition of the relevance of culture.

The purpose of this study is to better understand the underlying reasons that contribute to passing grades that are lower than average for minoritized students in a senior-level engineering course. This equity gap exists despite the high

probability that all students will successfully move toward degree completion. The impact of lower passing grades on minoritized students' GPAs can perpetuate inequities in graduate school acceptance, funded research opportunities, and starting salaries for entry-level positions.

To address this inequity, culturally relevant pedagogical interventions were developed aimed at facilitating equity of voice in the classroom based on training provided by ESCALA, an educational consortium dedicated to underrepresented student success in higher education [4]. The goal of these interventions is to build classroom structure to provide all students the opportunity to question and reflect on course content. Pedagogical interventions are framed to maximize the opportunity for students to be acknowledged and to process knowledge in groups and individually.

Johnson and Johnson [5] found that when students are provided with structured and embedded ways to process content information in group and individual settings, their comprehension improves, and they are more apt to socially construct meaning. Additional research suggests that when minoritized students are provided with structured pedagogical and social ways to construct meaning, they tend to be more academically successful [6,7,8]. In contrast, when students experience feelings of exclusion and alienation, their academic performance can be significantly and negatively impacted [9]. Equity strategies include structure that explicitly welcomes all students to verbally participate, to see their personal connections to the material, and to reflect, construct, and revise their knowledge [10]. Otero-Diaz and Salazar [11] note that culturally responsive teaching will create learning environments where Latinx students feel both validated as learners and engaged with the content. Self-reported levels of engagement were highest for activities that required frequent contact with both the learning community and the course content.

II. STUDY DESIGN

This study examines the effectiveness of three interventions aimed at reducing persistent equity gaps in a senior-level engineering course. Pedagogical interventions are framed according to three dimensions of course work and interaction. All three are highly interconnected, so disaggregating them to determine direct causation on any positive impact compromises the immediate goal to reduce the equity gaps. Consequently, this study examines the extent to which a multi-faceted integrated pedagogical approach has a positive impact on equity gaps as evidenced by student grades on exams and final grades. This notion of equity of voice is further extended to include student voices in both qualitative and quantitative concepts in the course.

A. Pedagogical Interventions

The first pedagogical intervention focuses on quantitative calculations in homework and exams. Students are assigned a weekly assignment that they work on in-class learning teams over the week. When assignments are submitted, they are graded on a simplified scale based on the final answer as completely correct, complete but incorrect, incomplete, and not submitted (Table 1). The solutions are posted, and students can earn credit back on the assignment by correcting their errors and reflecting on their misconceptions. Students must tell the instructor where their errors are and reflect on their misconceptions to earn credit – corrections alone are not enough. The assignments are complex, often involving spreadsheets with numerous calculations or modeling analyses, so finding errors is non-trivial even with the solutions, and provides additional learning opportunities.

Without the opportunity to revise, students can internalize the belief that the material is too difficult for them when they receive a poor grade on an assignment or exam, and this belief negatively impacts their approach to learning and the ultimate learning outcome [12]. The opportunity to revise encourages mastery, allows students who reflect and revise to earn full credit for the assignment, and reinforces the idea that learning comes from constructing knowledge rather than passive reception of facts from experts. The opportunity to revise and resubmit also mitigates the stress associated with assignment deadlines.

Table 1: Grading Scheme for Weekly Assignments

Assignment Problem	First Submission	Resubmission	Total possible score
Complete and Correct	10	0	10
Complete and Incorrect	8	2	10
Incomplete	5	2-3	7-8

The second pedagogical intervention focuses on conceptual questions in quizzes and exams. Students answer an online quiz each week that is a single conceptual question. An example question is “Explain how and why you expect pan evaporation measurements to differ from actual evaporation from a lake”. The question is due after students have started to work on their weekly assignment. Students' answers are discussed in class the following day with a dual focus of understanding the technical concepts and communicating their understanding in a concise and organized manner. The students' words are used to illustrate strong answers with the focus on communicating knowledge in using their own words and not words imposed by the instructor. Students are encouraged to revise their answers after the class discussion. The instructor selects student answers so that all students are acknowledged at some time over the semester. Students know that their comments and questions will be incorporated into the content delivered in the classroom. The students come to class prepared and already engaged in the material. The instructor has already assessed the students' acquired knowledge, as well as misconceptions, and so can better utilize active learning strategies in the classroom and knowing that their voices are heard and acknowledged by the instructor. This is also a low stakes assignment and quiz answers are graded on the quality of the thought and the detail in the information provided. Students can receive full credit for a quiz answer that is incorrect, if they have articulated their

assumptions and thought processes in a way that makes it clear to the instructor where the student's error occurred. This strategy is aligned with the Just-in-Time approach pioneered by physics faculty and has been used by faculty at numerous institutions across the country [13,14,15].

The third intervention focuses on in-class interactions between the instructor and students where the instructor systematically distributes attention to maximize the opportunities for all students to answer and ask questions. The instructor intentionally requires each student to ask a question or make a reflection in class and once a student has already asked a question, they must wait for all students to participate before they can ask a second question. Students are sitting in learning teams so that in practice, each learning team gets to hear 3-4 questions per class period. The instructor uses a system that the students are fully aware of (popsicle sticks or index cards or a checked list) so there is no perception that some students are being preferentially called upon or attended to. This method has been promoted as helpful in encouraging students to engage with each other for learning [10] and promoting a more equitable distribution of voices in the classroom. Specifically, asking questions as well as providing elaborations are two evidence-based practices linked to improved understanding and command of content [16]. Moreover, when such actions are systematically embedded within classroom structures, students are more apt to socially construct meaning thereby augmenting the instructor's pedagogical actions [17].

Together, these three strategies characterize a robust approach to student success that are grounded in previous research. The innovative aspect of this work includes a disaggregated equity analysis that goes beyond the traditional pass/fail evaluation followed up with pedagogical strategies to construct classroom interactions that are culturally responsive to Latinx students.

B. Data Collected

The study population was undergraduate students enrolled in an upper division required engineering course on hydrology. Equity gap analysis was conducted on two semesters of students (n=42) before the pedagogical interventions and four semesters of students (n=105) after the pedagogical interventions. The course was taught by two different instructors, one in F18-F20 and a second in S20-S21. The instructors collaborated on the curriculum to maintain consistency in both the content coverage and the pedagogical delivery.

An equity ratio was calculated as follows:

$$\frac{\% \text{ of students in each category earning a grade of } x}{\% \text{ of students in the class earning a grade of } x} \quad (1)$$

The data collected included anonymized demographic data and historical final course grades. Detailed grades on assignments, quizzes, and exams is available, however for this WIP paper, only final course grades were analyzed.

Student grades were categorized as white males (WM), white females (WF), underrepresented males (URM), and underrepresented females (URF). Underrepresented students were grouped as any non-white student. The majority of UR students in our program identify as Latinx, with less than 4% of students identifying as American Indian, Black, or Pacific Islander. A small percentage of students in each class were

identified as unknown and those scores were removed from the analysis. Grades were categorized as A, B, or C for the equity ratio calculation. Non-passing grades or withdrawal were removed from the analysis as these grades accounted for less than 3% of the total students over the entire period making the numbers too small to be representative. Additionally, an equity analysis on pass/fail rates before interventions did not indicate an equity gap for passing the class.

III. PRELIMINARY FINDINGS AND DISCUSSION:

Final grades for two semesters (S18,F18) prior to the pedagogical changes were compared to four semesters of final grades (S19, F19, S20, F20) with interventions. There were a total of 42 students in the pre-intervention cohort and a total of 105 students in the post-intervention cohort (Table 2).

TABLE 2: NUMBERS OF STUDENTS IN EACH COHORT WHO EARNED A PASSING GRADE IN THE COURSE.

Year	Spring Semester	Fall Semester	Total
2018	18	24	42
2019	35	34	69
2020	21	15	36
All years			147

The demographic distribution among the four identified categories indicated 45% UR students in the pre-intervention population as compared to 29% UR students in the post-intervention population (Fig. 1). There was a significant decline in enrollment overall during 2020 in part due to the COVID-19 pandemic. Research analysis of the decline suggests a differential impact of the COVID-19 pandemic on UR students as these students are more negatively impacted financially and socially and are less likely to be able to continue their education during this time [18].

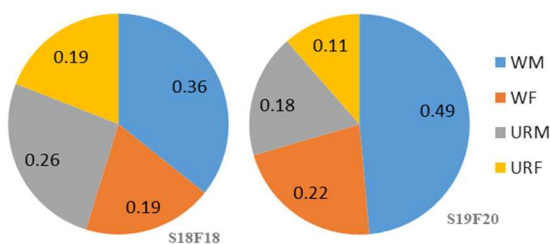


Fig.1. Demographic distribution between four categories of student identities for pre-intervention semesters (S18-F18, n=42) and post-intervention (S19-F20, n = 105).

The equity ratio calculation using the final course grades from the two semesters prior to the course intervention indicate that both white males and white female students are overrepresented in earning A's (1.68 and 1.58 respectively) while underrepresented students are underrepresented in earning A's, with no underrepresented males earning an A in the course. This equity ratio of 1.68 means that white males earn 60% of the A's in the course, while they only make up 36% of the students in the course (Fig. 2). Vise-versa, underrepresented students earned a disproportionately higher number of C grades in the class with equity ratios of 1.48 for 1.17 for males and females respectively.

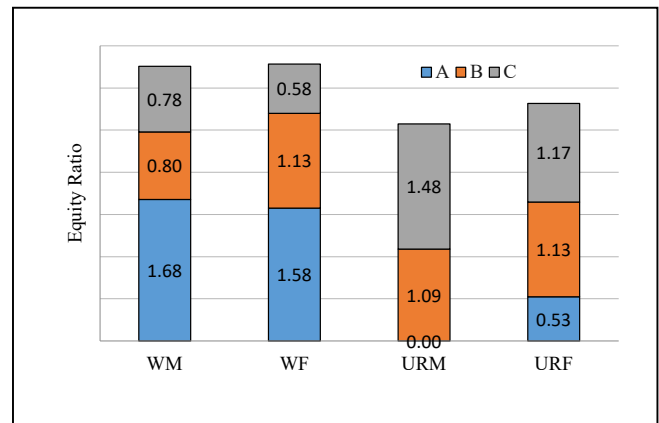


Fig. 2. Equity ratio for all students earning A, B, or C in the course over the 2018 calendar year (spring 2018 and fall 2018). The total n for this analysis is 42 students.

The equity ratio analysis shows a marked improvement (reduction in equity gaps) for the students in the year after the pedagogical interventions with the exceptions of C grades for underrepresented females. Most notable is the improvement in the equity ratio for underrepresented males increasing from a 0.00 to 1.28 in the A category (Fig. 3). There is considerable variation in the data as demonstrated by the ratios for the following year (Fig. 4) where the equity gap increased from 2019 but remained improved from 2018.

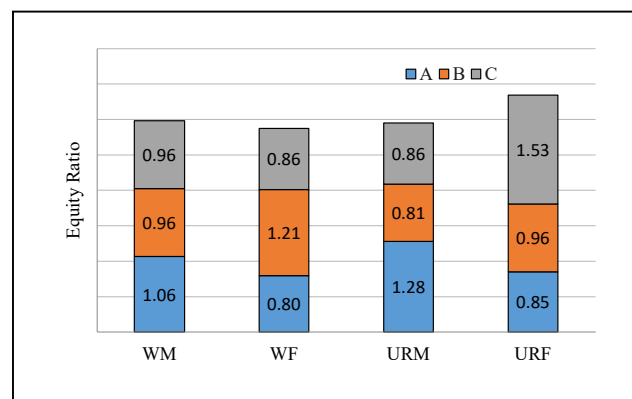


Fig. 3. Equity ratio for all students earning A, B, or C in the course over the 2019 calendar year (S19 & F19). The n for this analysis is 69 students.

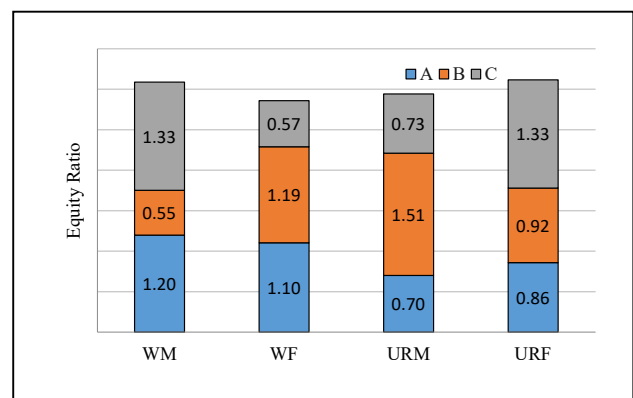


Fig. 4. Equity ratio for all students earning A, B, or C in the course over the 2020 calendar year (S20 & F20). The n for this analysis is 36 students.

The low numbers of UR students in this population, particularly the female underrepresented students make a statistical analysis of the changes difficult at this point. However, a Student's t-test was conducted to look for significant differences in final grades between UR and White students in all three cohorts of students (2018, when no interventions were in place; 2019, when interventions were initiated in class; and 2020 when interventions were used but student learning was disrupted by COVID). We found that there was a significant difference between the average final grades of UR students and white students only in 2018 ($p=0.03581$), further evidence of a decrease in the equity gap.

TABLE 3. DIFFERENCES IN MEAN FINAL GRADES BETWEEN UNDER-REPRESENTED AND WHITE-IDENTIFYING STUDENTS DURING THE THREE YEARS OF THE STUDY. SIGNIFICANT DIFFERENCES IN GRADES BETWEEN THE GROUPS WAS ONLY FOUND DURING THE FIRST YEAR OF THE STUDY.

Year	Average UR student final grade	Average white student final grade	Significance Level
2018 : Pre-Intervention	80%	85%	0.036 *
2019: With Intervention	86%	89%	0.199
2020: With Intervention and online learning	86%	87%	0.699
2019 & 2020 With intervention years	86%	88%	0.135

Final grades distributions (as a % rather than a letter grade) are shown in Fig. 5 comparing pre and post intervention distributions. Despite the challenges presented by COVID-19 and the switch to an online format, the data shows an increase in course grades for all students as well as a decrease in the equity gap for UR students.

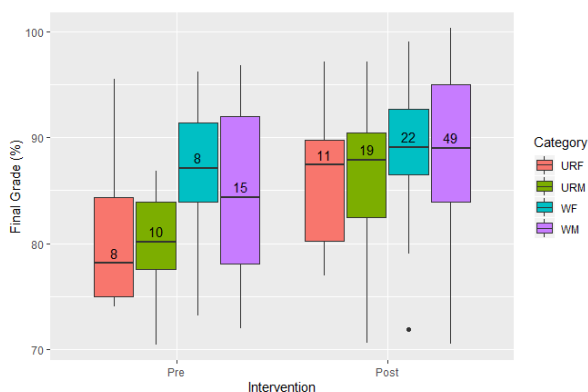


Fig. 5. Class grades broken up by intervention (Pre=Pre-Intervention 2018, Post = Post Intervention 2019-2020) and minority status and gender. Numbers represent the number of students represented in each category.

There were two different instructors over the six semesters with one instructor teaching the course from Spring 2018 through Fall 2019 and another taking over the course in Spring 20. The instructors have collaborated on the pedagogy and content of the course to maintain as much consistency as possible. However, there are unavoidable differences in delivery due to personal styles of teaching. It is more likely

however, that the impacts of the COVID-19 pandemic and the course converting from a face-to-face course to a course that is largely online dominates any impacts that would be seen between the two instructors.

IV. THOUGHTS FOR CONTINUED WORK AND CONCLUSIONS

Preliminary analysis of final course grades indicates a reduction in the equity gap, most notably for underrepresented males. The implications of this study and others that are similar are particularly relevant across California as California enrolls a high percentage of Hispanic undergraduate students (43.3% in 2018-19) on par with only New Mexico and Texas in 176 institutions with 46 emerging HSI [19].

Future analysis is planned to include an investigation of disaggregated scores on quantitative versus qualitative questions to identify potential differences in equity gaps for different learning objectives. Additionally, this analysis is solely focused on course grades, an imperfect measure of learning and engagement. Future work could include student feedback to gain perspectives on their experiences in the course.

A recent critique of the equity gap analysis [20] suggests that aspiring to close the equity gap between underrepresented students and majority white students has the potential to perpetuate systemic privilege and racism by centering the achievements of white students as the norm. The authors suggest that while it is useful to disaggregate performance by student background to evaluate relative success, ultimately success is not measured simply by closing the gap, but by meeting goals set for all students. In this application, it would suggest that student learning success is not simply closing the equity gap in grades distributions so that all students are achieving grades independent of their background, but success in learning must be measured against aspirational goals for learning for all our students.

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