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The Impact of High Context Untimed Exams and Mandatory Office Hours in an Engineering Fundamental Course Equity Indices (Work in Progress)

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The Impact of High Context Untimed Exams and Mandatory Office Hours in an Engineering Fundamental Course's Equity Indices (Work in Progress)

Abstract

Different cultures view the purpose of learning through different frameworks. The high context (integrated) cultural framework views the purpose of learning as a means for improving the lives of those close (e.g., family, tribe) while the low context (individuated) framework views it as an individual journey towards goals and the betterment of humanity. Although it is well known that time-limited tests are less valid, inclusive, and equitable than untimed tests, the effects of the later have not been assessed with course equity indices for underrepresented engineering students. Evidence also shows that mandatory office hours result in students' improved learning experience and openness to participate in class. The objectives were to assess the effects of untimed exams including high context questions versus timed exams with only low context questions and problems and qualitatively determine the benefits on student learning of requiring office hours as an exam component. It was observed that Latinx and female underrepresented students were not served with equality in an Introduction to Fluid Mechanics course which is taken by mechanical and civil engineering undergraduate majors. During the 2021-2022 academic year an equity index analysis showed that both groups were underrepresented in the A-grade category, and overrepresented in the C-grade. A pedagogical intervention was carried out in the fall semester of 2022. Out of three partial and one cumulative final exam, the first and third partial exams were modified from in-class 50-minute closed-notes format to untimed take-home. The untimed exams were individual, open notes, closed browsing with a two-week deadline. Thirty percent of the grade was assigned to high-context essays or fill-in-the-gap questions. One mandatory office visit with the instructor was required to discuss test questions which accounted for 5% of the exam grade. To deter students from copying or collaborating with others, three different exam versions were used, and the numeric problems had not been published. The results showed that the class score in the untimed exams was in average 16.6% higher than the timed ones (n = 16; Latinx = 7; female = 3). The Latinx equity index for the A-grade increased from 0 (no representation) to 0.57 (half representation) from the prior year, and for the C-grade it decreased from 3.5 (overrepresented) to 1.14. For females the A-grade equity index increased from 0 to 1.33, and the index for the C-grade decreased from 6.5 to 1.33. End of semester surveys indicated mixed feelings about the high context questions, with twice as many responses stating that the questions were easy and relatable. Positive comments indicated stress reduction, an increase in confidence, allowing rechecking their work, and improved comprehension of questions. The Latinx equity index could further improve by implementing this practice to all exams, and by making it a department-wide or institutional norm. These results seem to indicate that untimed exams with high context questions and mandatory office hours could decrease student testing stress and improve Latinx and female equality indices. The intervention needs to be repeated for several semesters and with larger sample sizes in the future to obtain statistically representative results.

Keywords: untimed exams, high context framework, low context framework, course equity index, Latinx.

Introduction

Chavez and Longerbeam [1] researched the use of high and low context cultural frameworks for teaching at the college level. According to the authors, different cultures view the purpose and means of learning through the lenses of different frameworks. The high context (integrated) cultural framework views the purpose of learning as a means for improving the lives of those close to us such as family, tribe and family. The low context (individuated) framework views learning as a means for individual journey towards goals and thereby improving humanity [1]. They presented a scale of context levels for different cultures. Japanese and native American Indian cultures are considered very high context, French, Spanish and Italian are mid context, while German and Scandinavian are very low context. Neither one is better than the other. Chavez and Longerbeam [1] state that "drawing on both realms creates the balance of comfort and dissonance necessary for complex learning."

Several authors have launched a critical request for the nation's college academy to completely shift the traditional approaches in colleges and universities to culturally responsive pedagogies and assessments [2,3]. The current U.S. college academy serves the most diverse student population ever which includes students of very different races, ethnicities, socioeconomic status, gender identities, sexual orientations, age, and other characteristics [2]. It is expected that by 2050 the U.S. will become a majority-minority country, and underrepresented students are more likely to be first generation and low-income students [4, 5]. According to Montenegro and Jankowski [2], different students such as special needs, nontraditional, undocumented, and members of the LGBTQIA+ groups, all display specific differences and needs for learning. For underrepresented students who began college in 2015, only 44% of African American students and 51% Latinx students completed their degrees after six years, compared to 69% of White students [6].

It becomes evident that a one-size-fits-all teaching approach is ineffective. Hence a student-centered culturally responsive pedagogy is necessary for student success [7]. Culturally responsive pedagogy recognizes the need of including student's identities and cultural references in all aspects of learning [7,8]. This results in increased engagement and fostering students to own their own learning. Inclusion looks at how people operate in the established system and how individuals from different groups experience it [9]. To be inclusive an organization must recognize how their daily operations privilege some groups over others and strive to change that. A diverse and inclusive teaching adapts their classroom practices to improve learning outcomes, student experience and engagement by including activities that appeal to all cultures [9]. To foster equity, an educational entity must focus not only on the outcomes of all the students but disaggregate and examine outcomes of underrepresented students [9, 10].

Although debated by authors, evidence shows that Mandatory office hours either in a face-to-face or virtual fashion improve the students learning experience and being more relaxed and open to participate in classes [11, 12]. Novak [12] noted that a very large number of students reported feeling like required office hours were useful or extreme useful to perform well in the class. Besides being helpful to help students solve course assignment, they are also helpful to humanize the instructor to the students, to brainstorm together and provide them with effective sources of information.

It has been widely established in the literature that time-limited tests are less inclusive, equitable and reliable than untimed tests [13]. Untimed tests are those whose time limits are so generous that all participants are assured of completing all tasks. Gernsbacher et al. [13] states that timed tests should be avoided in higher education because they measure students test taking ability rather than their level of knowledge. Timed exams affect students with documented disabilities as well as students who are learning English [13]. Besides being less inclusive and reliable, by removing time limits from exams, levels of test related anxiety in students decrease [14], students are able to follow instructions more carefully [15], respond more creatively [16] and are able to check their work several times [17].

To the author's knowledge, the effects of untimed tests combined with mandatory office hours have not been clearly assessed for underrepresented Latinx undergraduate engineering students, using disproportionality impact indices. Angelo State University (ASU), a primarily undergraduate institution, located in San Angelo, Texas, USA, serves students from this city and neighboring rural regions of West Texas. The student subgroups of interest include Latinx and female students in an undergraduate engineering program. Adequately serving these subgroups is critical given that it is expected that new Latino workers will account for 78% of all new workers between 2020 and 2030 [18] hence colleges must adopt best practices to prepare Latino and remove obstacles that hamper their graduation rates. The objectives of this study were to (i) assess the effects of untimed exams having high context versus timed exams with low context questions, and (ii) qualitatively determine the benefits of student learning by requiring untimed exam's mandatory office hours as opposed to not requiring them. It was hypothesized that Latinx and female students were not being served with equality in some of Angelo State University's undergraduate engineering courses.

Literature Review

For more than a century instructors assume "…that if a student knows the subject in which he is being tested …he requires but a short time to make his answer?" (Longstaff and Porter, as cited in [13]). Untimed tests produce more accurate assessment because these are not confounded by differences in the natural speed of students taking the test [19] and have been considered as "ideal" because they are best for assessing the "complexity of … thought processes" [20]. Gernsbacher et al. [13] suggests timed exams as a form of assessment should be removed from the curriculum as they found evidence that these are less valid, reliable, inclusive, and equitable.

As mentioned in the Introduction, a large number of studies demonstrate gaps in educational outcomes among historically underrepresented groups [21, 22]. The process of analyzing student data with respect to educational outcomes by separating by student gender or ethnic group is called data disaggregation. If a subgroup of students attains an outcome at a rate substantially lower than the benchmark rate, that subgroup is referred to as disproportionately impacted. According to the California Community Colleges Chancellor's Office, "disproportionate impact is a condition where some students' access to key resources and supports and ultimately their academic success may be hampered by inequitable practices, policies and approaches to student support" [23].

Sosa [10] list down several data disaggregation methods to determine potential evidence of disproportionate impact in a subgroup. The 80% rule method is used to answer the question: *Do*

any subgroups achieve an educational outcome less than 80% of the time that the highest achieving subgroup attains that outcome? [24]. A second method called the proportionality or equality index (EI) answers the question: *If a subgroup constitutes 40% of the student population, does that subgroup also represent at least 40% of the individuals achieving the outcome?* If the academic outcome was equitable across all subgroups the answer would be yes, and the EI value = 1.0. A value less than 1.0 indicates a possible instance of disproportionate impact for such subgroup. Bensimon and Malcolm-Piqueaux (as cited by [25]) suggested using values equal or lower than 0.85 to identify a potential instance of a disproportionate impact.

Methodology

Past Fluid Mechanics Grade Equality Indices

The course ENGR 3404 Introduction to Fluid Mechanics taught at the primarily undergraduate institution Angelo State University in West Texas, U.S. was selected to perform a disproportionate impact analysis and a pedagogical intervention. Angelo state is a Hispanic Serving Institution (HSI) with a current enrollment of 11, 542 students in both face-to-face and online programs [26]. This course is a junior level mandatory for all engineering majors and due to the small attendance (the average enrollment has been thirteen students in the last three semesters), both Civil and Mechanical engineering majors take the same course. This course is offered every long semester, and it is face-to-face class with a physical laboratory and online content.

The author who is the course coordinator in the small ASU engineering program has taught this course eight times, on and off since spring 2018. In the fall 2021, spring 2022 and fall 2022 semesters, covered by the same instructor, a total of 40 students registered for this class. Out of the 40, 35 were male and five were female. This female to male ratio is lower than the 17.1% women compared to 82.9% men recently reported for practicing civil engineers of the U.S. in 2022 [27]. These numbers are very similar to other engineering fields such as mechanical and chemical engineering. The number of males and females was obtained by the class roster however in future semesters a survey will be administered to ask students to identify themselves as male, female or non-binary gender. Nineteen out of the total identified as Latinx, eighteen as white and three were categorized as international students. During the fall 2021 and spring 2022 semesters there was 0% withdrawals, zero students received a D or F grade (which is typical) and 100% received a grade of C or better. It is important to note however that is relatively easy to get a C or B in the class but moderately difficult to get an A. Only 16 percent of the class got a score of A in those two semesters.

The EI was computed with the following formula [10]:

$$EI = (\text{proportion in outcome subgroup})/(\text{proportion in cohort})$$

Table 1 lists the results of past data disaggregation and disproportionate impact analyses on the Latinx, and female students' subgroups enrolled in the abovementioned course from an undergraduate engineering program in West Texas, U.S. The results show proportions and the EI values for the entire cohort and different subgroups. Results indicate that the female and Latinx subgroups are totally absent in the A-grade category, and both are overrepresented in the C-grade

category. This indicates that such subgroups are likely not being served with equality with the current assessment methods.

Table 1. Fall 2021 and Spring 2022 introduction to fluid mechanics student subgroup proportions and equality indices (EI) for final course grades

Grade	Cohort Proportion	Male Proportion	Male EI	Female Proportion	Female EI	Latinx Proportion	Latinx EI
Fall 2021 Semester							
A	0.09	0.10	1.10	0.00	0.00	0.00	0.00
B	0.64	0.60	0.94	0.14	0.22	0.57	0.90
C	0.27	0.30	1.10	0.00	0.00	1.00	3.67
D/F/W	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Spring 2022 Semester							
A	0.23	0.25	1.08	0.00	0.00	0.00	0.00
B	0.62	0.67	1.08	0.00	0.00	0.63	1.02
C	0.15	0.08	0.54	1.00	6.50	0.50	3.25
D/F/W	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Examination Format Change

A culturally responsive assessment was implemented in ASU's introduction to fluid mechanics course in the fall of 2022. Out of three partial and one cumulative final exam, the first and third partial exams were modified from the in-class 50-minute closed-notes exam format to untimed take-home exams. The format of the untimed exams was individual, open notes, closed browsing with a fourteen-day deadline. The exam was approximately solvable in 120 minutes using the three-to-one instructor to student ratio and had problems with difficulty level like the ones solved during class, but some needed to be solved in new contexts. Out of the 100% grade, 37% were assigned to theory questions (multiple choice, short essay, fill in the gap) and from that percentage, high context questions which included two types of questions, ranged between 15-25%. The first high context question asked students to explain in detail an example from their own personal experience relating to one of the topics covered in the course materials. The second high context question was a fill in the gap series of questions in which they needed to identify the name of the concept or equation after providing a description of a real-case scenario. See Figure 1. To deter students from copying or collaborating with others, a total of three different exam versions were released and the included numeric problems were not previously published so they could not be found online. ChatGPT had not been released yet so it had no effect on this investigation, but it would need to be addressed for future applications.

2. (8 pts) Carefully read the practical examples or problems given in the in the right column. Then in the left cell write down the name of the principle or the title of your Textbook chapter section that explains/solves that problem.

Name of Principle or Textbook chapter section	Problem or example description
	One of eight large spillway radial gates failed at Folsom Dam in California during reservoir releases on July 1995. Spillway radial gates transfer the reservoir load to the trunnion pin through compression of the gate arms. These radial gates are most vulnerable to failure when they are initially opened, with the hydrostatic load on the gate combined with the maximum hoist load and trunnion friction. The sum of these loads caused the failure.
	Clay soil has the smallest particle size of all soil textures, and therefore the soil pores could be thought of small conduits or tubes. When a 10 ft PVC pipe is filled with different soils and placed on a bucket filled with water. Clay soil inside the tube will wick water moisture to about 5 ft high above the bucket water level
	My uncle tried building a 4.5 ft tall rectangular water basin (80 ft^2) out of concrete blocks at the ground level. My cousin (civil engineer) told him that he should put soil in the bottom 1/3rd depth all around the external walls for support but he didn't listen. After having water for two days the basin cracked near the bottom along the perimeter

Figure 1. Excerpt from a fill-in-the gap question series to identify the name of the concept or equation by providing them a description of a real-case scenario.

Mandatory Office Hours

During the modified exam assignment period, one mandatory office hour visit with the instructor was required. Since two of the exams had the new untimed format, each student had to attend a total of two office-hour visits during the semester. The office-hour visit required the student to discuss questions or issues with the exam and accounted for 5% of the exam grade. While questions related to the exam were mainly covered the answers were not directly shared with the student.

On the last day of the course an anonymous three-question short essay questionnaire was proctored for five minutes to capture student attitudes towards the pedagogical intervention. A total of twelve out of sixteen students answered the questionnaire by paper and pen. Answers were scanned to maintain the responses in a database. This survey form can be found in Appendix 1.

Results and Discussion

Fall 2022 Course Grades and Equality Indices

The results showed that untimed exams improved the overall class performance and produced higher equality indices for Latinx and female engineering students (Table 2). Untimed exams 1 and 3, had class score averages of 83.6 and 85.3 out of 100 respectively, while timed exams 2 and 4 (final) had average scores of 69.6 and 66.2, respectively, with an average difference of 16.55% which is significant. Latinx EI Index for the A grade increased from 0.0 to 0.57. For the same ethnic subgroup for the C grade, the EI index decreased from 3.3 (fall 2021) and 3.7 (spring 2022)

to 1.14 in the fall of 2022. Although they were still partially underrepresented in the A-grade category, they were able to increase substantially and enter to this grade category. Additionally, they were no longer overrepresented in the C-grade which could mean that the pedagogical intervention leveled substantially the playing field for this subgroup. Regarding the Female subgroup, their EI index for the A-grade increased from 0.0 to 1.33, and the same index for the C-grade decreased from 6.50 in Spring 2022 to 1.33 in Fall 2022 (there were no females enrolled in the course in the Fall 2021). This indicated that females were no longer disproportionately affected by the courses former biased assessment methods, and judging by the slightly larger A-grade EI value, they were at the same or better proficiency levels than the white male subgroup.

Similarly, in the theory section of the untimed exams, the scores in the high context questions were consistently higher than the rest of the theoretical questions. The average scores for the regular theory questions were 79.68% and 77.34% while the average score for the high context questions was 87.19% and 93.61% for exams 1 and 3, respectively. Given the small sample numbers, no statistical analyses were performed. However, the same intervention is planned to be repeated in the spring 2025 and fall 2025 semesters to combine the three-semester data and ensure minimum subgroup samples of 10 students, the minimum size recommended by the California Community Colleges Chancellor's Office to compute the margin of error or the z-standard deviate [10, 28].

Table 2. Fall 2022 introduction to fluid mechanics student subgroup proportions and Equality indices as function of final course grades

Grade	Cohort Proportion	Male Proportion	Male EI	Female Proportion	Female EI	Latinx Proportion	Latinx EI
A	0.25	0.23	0.92	0.33	1.33	0.14	0.57
B	0.50	0.54	1.08	0.33	0.67	0.57	1.14
C	0.25	0.23	0.92	0.33	1.33	0.29	1.14
D/F/W	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: Number of students = 16, Latinx = 7; females = 3.

Student Attitudes Towards the Examination Change and Mandatory Office Hours

End of semester surveys indicated mixed feelings about the untimed exam and the high context questions used in the untimed exams. Out of twelve respondents, five provided positive comments about the exam format change. Two students had negative comments about the intervention but one acknowledged that had procrastinated, while the other one stated that not properly using the office hours resulted in a low grade. Six out of nine felt that solving the high context questions and interpretations were easy or relatable versus three who said it was more challenging than low context problems.

The most common positive qualitative answers about the untimed exams were the following:

- *Not having the pressure of a short deadline increased my confidence and reduced stress* (6 respondents)
- *It allowed more time to think and comprehend better the questions and problems* (4 respondents)
- *It allowed me to recheck my work several times* (2 respondents)
- *It made it more flexible/convenient* (2 respondents).

Regarding the question *Describe in detail an example from your own personal experience in which one of the topics covered in Module X which directly applies to the situation* (*must be from your own experience and not from a textbook or online source*), only a few students carefully reflected on the task, while the majority thought of very simplistic examples or seemed to search for generic examples online. Those who took the time to reflect on their own personal experiences came up with elaborate complex examples that also demonstrated their own funds of knowledge. An example of this is a student who liked to work on cars, noticed that his 1985 Trans Am car included a digital barometric gage to automatically adjust the fuel-air ratio intake to the carburetor. He wrote about how the gage reads absolute pressure and reduces the amount of fuel at higher elevations where the air density (and pressure) is lower. These examples helped the instructor to enrich the applications used to illustrate examples in the following semesters, adding more high context elements to the class.

Despite the low participation for the office hours in the prior two semesters (fall 2021 and spring 2022) the students were welcoming of the two mandatory office hour visits during the fall 2022 semester. Students were particularly excited about the 5% grade assigned to the office hours for each of the two modified exams. All the students completed their two visits, except for one student who missed his second visit. Unfortunately, the question used in the end of semester survey, *how did having two weeks to complete your exam and the mandatory office hours affect your confidence towards your exam grade?* prompted the students to combine the effects of both the untimed exam and the office hours in their responses and the great majority only mentioned the effects of time and not office hours. Only one person indicated finding time to make it to office hours difficult and he/she would have preferred to meet virtually. A specific question on the usefulness of the office hours will be included in upcoming semesters when the same intervention is repeated.

Conclusion and Future Work

This study evaluated the effects of high context untimed exams and mandatory office hours in an undergraduate engineering course. The female EI became equal to the white male subgroup with the intervention and a significant improvement was achieved for the Latinx equality index although they were still partially underrepresented in the A-grade category. Qualitative results indicate that untimed exams with high context questions and mandatory office hours decrease student testing stress and improve student experience. The Latinx equity index could further improve by implementing this practice to all exams, and by making it a department-wide or institutional norm. These or similar culturally responsive assessment practices will also be beneficial to other underrepresented groups such as African American or Native American students.

The intervention needs to be repeated for several semesters and combined to achieve a larger sample size in the future to obtain statistically representative results. The author is planning to repeat the same culturally responsive assessment strategy in the upcoming two semesters. Based on feedback and experience, minor changes will be made. These include a better designed student survey which will be available online and applied two times rather than just one time at the end of the semester. The mandatory office hours will be changed to be carried out in person or virtually.

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Appendix 1. End of semester In-Class Survey:

Instructions: answer the following questions regarding your experience with the take home exams 1 and 3 for this semester.

1. In the take home exams, relating the practical real-world examples to the topics covered in the lecture was (select one answer)_____easy / difficult_____ for me because _____ _____ _____ _____ _____.

2. How did having two weeks to complete your exam and the mandatory office hours affect your confident towards your exam results?

3. If you had the opportunity to choose between an in-class exam versus a take home exam with the same format as the ones given for exams 1 and 3, which one would you choose and why?