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Turning Office Hours into Study Sessions: Impacts on Students' Homework and Exam Grades

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Abstract

Interactions between faculty and students play a central role in learning at the collegiate level, and outside of class one of the best places for students to interact with faculty and the course material is office hours. However, office hours are regularly poorly attended. This study aimed to determine the impact of instructor office hours that were transformed into study sessions on students' homework and exam grades. At a medium sized (4000-8000 undergraduate students), public, primarily undergraduate, hispanic serving 4-year institution, hour-long study sessions were held once per week the evening before homework was due for both a dynamics course and a thermodynamics course. The courses and study sessions were led by the same instructor. The study sessions were voluntary and did not directly influence course grades, but attendance records show that on average 17% of students attended on any given week. Data were collected on study session attendance, homework grades, midterm grades on the three midterm exams, gender, ethnicity, and Pell grant status, in Fall 2019 (Dynamics and Thermodynamics) and Spring 2020 (Dynamics only). T-tests showed that for all subgroups of students attending study sessions improved homework grades. Additionally, a linear regression analysis was used to model the relationship between students' exam improvement (between Exam 1 and Exam 2, and between Exam 2 and Exam 3) and their difference in study session attendance before each of the included exams. The analysis showed that students who attended study sessions were positively affected overall, with each 20% increase in study session attendance (typically one study session) increasing grades by 2-3% ($p = 8.35E-4$). One subset of students showed a negative correlation with attending study sessions: Hispanics who did not receive Pell-grants ($p=0.972$) but this relationship was small and had a large p-value. The results presented here are based on a small study (85 students total), and the small improvements and inconclusive p-values indicate that additional data collection is needed to verify results. However, the large number of students who attended these study sessions, low effort from the instructor, and overall improvement, indicate that it is an approach to office hours that is beneficial to students' grades.

Introduction

Interactions between faculty and students play a central role in learning at the collegiate level. Prior research has identified the importance of both the amount of student-faculty interaction and the type of those interactions on: GPA, retention, course success, student confidence, and interest in continued education and jobs in the field of study [1] [2]. The majority of these interactions

typically take place in the classroom, but also happen during office hours and extracurricular activities.

Office hours provide a valuable opportunity for students to ask questions, obtain help for their specific situation, get mentoring, and engage with course content with an expert. This active interaction with a faculty member can provide valuable learning for students, and previous studies have found that office hours can improve student course performance. A study by Guerrero and Rod found that for each office hour attended students saw a 0.77% increase in their grade even correcting for overall GPA, gender, race, and family income [3]. A study by Rezvanifar and Amini found that students who were required to attend office hours after failing a first exam improved their grades on future exams, which was not true for students who were not required to attend office hours [4]. Despite evidence of office hour utilization improving student performance, office hours are generally under-utilized.

A broad review of student opinions of office hours found that the main reasons students didn't utilize office hours were not understanding their purpose, finding office hours inconvenient, and faculty not being approachable [5]. The intervention developed in this study attempts to combat these by having office hours have a clear purpose, a time that is convenient for that purpose, a location that is a more collaborative space, and encouraging students to come without having to approach the faculty member. This research also examines outcomes based on race, gender, and socio-economic status as these groups have been shown to have different uses of and benefits from faculty interactions in other work [6] [7] [8].

Methods

In this work a new strategy for office hours was employed, where one hour per week of office hours was modified to become a study session for a single course. Study sessions were held once per week from 5-6 pm the evening before the weekly homework was due. The sessions were voluntary and did not directly influence course grades. The 5-6 pm time was selected because students did not have major course conflicts at this time. It is noted that some students did have other obligations (work, non-engineering courses, or family commitments) at this time. The study sessions were held in the same room as either the lecture or lab for the course to reduce the discomfort for students working in a new space. The study sessions were typically used by students to finish the homework and the instructor encouraged (but did not force) students to work together. The instructor primarily provided guidance and answer checks on homework, and also provided additional support of course concepts. The instructor obtained permission from the department to count this hour long study session as office hours, so the net work-load was unchanged. The instructor still had 3-4 hours per week of more typical office hours.

This research was conducted at Humboldt State University. Humboldt State University (HSU) is a medium sized (4000 - 8000 undergraduate students), primarily undergraduate, 4-year, institution [9]. Humboldt State University is a Hispanic/Latino serving institution with 33.3% of its student population being from Hispanic/Latino ethnicities [10]. HSU offers a broad range of majors typical at a liberal arts university, and also has extensive environmental based majors such as Forestry, Wildlife, and Rangeland Resources. HSU currently offers only one engineering degree, Environmental Resources Engineering, and all courses and students in this study are in this major. Data

was collected in Fall 2019 in a dynamics (ENGR 211) and thermodynamics (ENGR 331) course and in Spring 2020 in a dynamics course.

The prerequisites for the dynamics course are: Calculus ll (Math 110), Statics (ENGR 210), and Introduction to Design (ENGR 215). The prerequisites for thermodynamics are: Calculus lll (Math 210) and Dynamics (ENGR 211). Both dynamics and thermodynamics are core engineering courses that form the middle of an engineering sciences sequence at HSU. These courses are typically taken at the end of the second year (dynamics) and the beginning of the third year (thermodynamics) by students in the environmental resources engineering major.

The Fall 2019 dynamics course had a population of 24 students, the thermodynamic course had a population of 30 students, and the Spring 2020 dynamics course had a population of 32 students. All three courses were taught by the same instructor and consisted of two 50-minute lectures, and one 2-hour and 50-minute lab per week, and the term is 15 weeks of instruction and a final exam week. The instructor who taught the previously mentioned courses was a 4th year assistant professor.

To explore the relationship between students' success and attendance of instructor lead study sessions researchers collected attendance data each week at the study session - students who attended for any length of time were marked present. Additionally homework and exam grades for each student were collected. Homework was graded on effort, completion, and clear communication style (guidelines for this are provided to the students) and was not graded on getting the correct answer. Students regularly scored very high grades on homework for both courses, and low homework grades were indicative of students not submitting or not completing the homework. Exams were graded on demonstration of understanding course content (correct approach and implementation and getting the correct answer). Exam grades were more variable, and were more indicative of student understanding of course material. The homework grades of students who did and did not attend the instructor-led study sessions, each week, were compared with t-test analysis. For exams, a linear regression analysis was used to model the relationship between students' exam improvement, their improvement ratio (IR), between subsequent exams, and their change in study session attendance, attendance difference (AD), before each of these exams. This was done twice for each course once with Exam 1 and Exam 2, and a second time with Exam 2 and Exam 3 (there are three total exams in all courses). This approach is based on methods from Trenshaw and collaborators [2]. This approach was selected to remove errors associated with easy or difficult exams, and to compare students more directly. This study has a low sample size, and this approach allows for the intervention to be examined without a control sample. However this does mean that it is possible that results from this study are not related by causation. The analyses were performed for the total population and the following subcategories: ethnic identities (Caucasian, African, Hispanic/Latino, Asian, Native American, Two or more Ethnicities, Unknown Ethnicity, or Non Resident Alien), gender (woman, man), and Pell grant status (Pell grant received, Non-Pell grant received). The Non Resident Alien category is for international students where this is the ethnicity data that was provided by the Office of Institutional Effectiveness. The ethnic subcategories were further analyzed for their gender and Pell grant status, and the gender categories were analyzed for Pell grant status. Equation (1) depicts the linear model used in the regression analysis.

$$IR = \beta * AD + c_1 \tag{1}$$

where IR is the improvement ratio calculated for each student between each pair of exams by:

$$IR = \frac{Exam_i / Exam_{i,avg}}{Exam_{i-1} / Exam_{i-1,avg}} \tag{2}$$

with $Exam_i$ and $Exam_{i-1}$ are the exam grades for a student with i being the current exam and $i-1$ being the previous exam and avg indicating the class average for these exams. AD is the attendance difference calculated as:

$$AD = \frac{SSBE_i}{TSSBE_i} - \frac{SSBE_{i-1}}{TSSBE_{i-1}} \tag{3}$$

with $SSBE_i$ being the number of study sessions a student attended before exam i and $TSSBE_i$ being the total number of study sessions offered for that course before exam i, and the same for the previous study session $i-1$. β is the slope of the relationship between IR and AD and is calculated based on data collected in this study, and c_1 is a constant for the linear model.

Typically there are 3-5 study sessions before each exam with differences being caused by exam timing, holidays, and other interruptions. In 2019, from October 9th to November 1st, 30 counties in Northern California had their electric power turned off as part of Public Safety Power Shut-offs (PSPSs), a preemptive effort to reduce wildfire occurrence during extreme weather [11]. As a result of the PSPS, the study session scheduled for October 29th, 2019 was canceled due to the lack of power. A makeup study session was not offered to students, therefore the total number of study sessions before exam two, in the 2019 ENGR 211 class, was reduced to three sessions instead of four. In the Spring semester of 2020, the COVID-19 pandemic caused Humboldt State University to transition from in-person to online classes. After Spring break, one study session was cancelled due to faculty work days for the transition to online instruction, and subsequent study sessions were held on Zoom, but attendance decreased. Data was not collected in the 331 class during Spring 2019, because the course was taught by a separate instructor who did not offer these study sessions.

Results and Discussion

The homework grades of students who did and did not attend the instructor-led study sessions each week were compared with t-test analysis. The null hypothesis stated that there was no difference between the average homework grades of students who attended and did not attend that week's study session. For the t-test analysis a data point was used to represent each student each week that homework was due. To put this into perspective, for a class with 32 students, if 2 students attended that week's study session there were 30 data points that represented students who didn't attend the study session and 2 data points that represented students who did attend that week's study session). A summary of the t-test results for all students, and the race, gender, and pell-grant status categories and subcategories is provided in Table 1. For all results, categories and subcategories with insufficient data for analysis were excluded and results are not presented.

In all subcategories analyzed t-tests results show that students who attended the study session had higher homework grades by an average of 15.4%. Additionally the p-values are generally small. Including a correction for the many categories here significance levels are α= 0.001515, which

Table 1: Summary of t-test results comparing weekly homework grades for students who attended that week's study session, and students who did not attend that week's study session.

Sample (Sub)category	Attended (n)	Didn't Attend (n)	Attended - Homework Average Grades (%)	Didn't Attend - Homework Average Grades (%)	p-values
Total	179	741	91.28	75.91	2.200E-16
Men	131	543	90.83	74.25	2.392E-16
▷ Pell Grant Recipient	71	261	88.27	68.85	3.326E-09
▷ Non-Pell Grant Recipient	60	282	93.86	79.25	1.335E-11
Women	48	198	92.54	80.44	0.0016
▷ Pell Grant Recipient	19	67	89.92	71.24	0.0003755
▷ Non-Pell Grant Recipient	29	131	90.21	80.38	0.08337
Pell Grant Recipient	90	328	89.92	71.24	1.618E-11
Non-Pell Grant Recipient	89	413	92.66	79.60	2.979E-08
Caucasians	97	361	93.39	78.75	9.552E-12
▷ Men	69	265	93.22	76.27	3.898E-13
▷ Women	28	96	93.80	85.61	0.0803
▷ Pell Grant Recipient	39	125	92.86	74.58	1.212E-07
▷ Non-Pell Grant Recipient	58	236	93.75	80.96	5.786E-06
Africans	6	6	73.58	67.17	9.552E-12
Non Resident Aliens	5	31	74.50	67.52	0.7412
▷Women	4	20	70.38	72.00	0.9517
▷Non-Pell Grant Recipient	5	31	74.50	67.52	0.7412
Hispanics/Latinos	55	165	90.21	68.82	2.374E-08
▷ Men	44	136	88.94	68.10	1.490E-06
▷ Women	11	29	95.27	72.24	0.0070
▷ Pell Grant Recipient	32	102	87.78	62.99	1.088E-05
▷ Non-Pell Grant Recipient	23	63	93.59	78.27	0.0005
Asians	5	37	91.00	79.97	0.0447
▷ Men	5	25	91.00	78.56	0.0555
▷ Pell Grant Recipient	3	7	90.00	57.71	0.0310
▷ Non-Pell Grant Recipient	2	30	92.50	85.17	0.1727
Native Americans	3	21	96.00	67.90	0.0098
▷ Men	3	9	96.0 0	64.50	0.0889
▷ Pell Grant Recipient	3	21	96.00	67.90	0.0098
Two or More Ethnicities	4	38	96.50	72.89	0.0002
▷ Women	4	6	96.50	94.17	0.3640
▷ Pell Grant Recipient	4	26	96.50	75.87	0.0024

many of these fall below. This result makes sense with the structure employed in these courses, since students who attended the study session almost always spent at least some time working on their homework. While these results do not indicate causation (students individually choose to

attend or not attend the study session each week and the option is open to all students), they do anecdotally indicate that students improved their homework grades by attending.

Observationally students who attended the study sessions generally had already started the homework, but even students who were just starting at the study session were able to make good progress on their work and get quick feedback from their peers and the instructor. Additionally it was observed that students who were not yet finished with their homework at the end of the hour study session would often remain after the instructor left to continue working with their peers.

To evaluate the impact the study session had on exam grades a linear regression model was used between the attendance difference and the improvement ratio of students. This analysis was done twice for each course, once using the IR between Exam 1 and Exam 2 and the corresponding AD of study sessions attended before Exam 1 and before Exam 2. Then the same analysis was completed but using the appropriate data from Exam 2 and Exam 3. All this data is combined below. Categories and subcategories with insufficient data for analysis are excluded.

A summary of the linear regression model results is provided in Table 2 and a visual representation of the regression models for the: entire population, ethnic subcategories, gender subcategories, and the Pell grant subcategories, are depicted in Figures 1-4. The slope values in Table 2 represent the change in IR for the change in AD. To provide some context for this, if a student scored a 60% on Exam 1 after attending 0 study sessions, a slope of 0.2036 (the slope for the total population of students) indicates that if they attended 100% of the study sessions before Exam 2 their expected Exam 2 score would be 71% (assuming the average exam score remained unchanged between exams). The course results here indicate that each study session attended will increase the subsequent exam score by 2-3%.

Attendance of instructor-led study sessions positively impacted students' exam grades. As depicted in Figures 1-4, the regression lines, fitted to linearly represent the attendance differences and the improvement ratios for the entire population and the generalized subcategories had positive slopes. Therefore, as the differences in attendance increased, the exam scores increased. For ethnic identities Asians had the highest impact followed by Non Resident Aliens, Caucasians, and Hispanics/Latinos. It is important to note that the Asian and Non Resident Alien categories had the fewest students, so while there were the biggest changes in these categories they also had the fewest data points. The regression line for Pell grant recipients had a slope that was greater than that of Non-Pell grant recipients, and the regression line for women had a slope that was greater than that of men. As the range of attendance difference data points increased, the slopes increased for each subcategory. One subset of students showed a negative correlation with attending study sessions: Hispanics who did not receive Pell-grants ($p=0.972$) but this relationships was small and had a large p-value. Additionally Pell grant recipients and women saw larger improvements in exam grades compared with their Non-Pell grant and male counterparts. This suggests that this intervention can be beneficial for some under-represented students in engineering and may help reduce achievement gaps. However this result was not seen for Hispanic/Latino students.

It is useful to note that there are some outliers in the data presented here, and the small sample size can lead to outliers influencing these regressions. For example there are fewer than 10 students with Asian race/ethnicity, and all had small changes in AD. Because of this a couple of students who had large swings in IR, caused the slope of the regression to be much steeper than for other

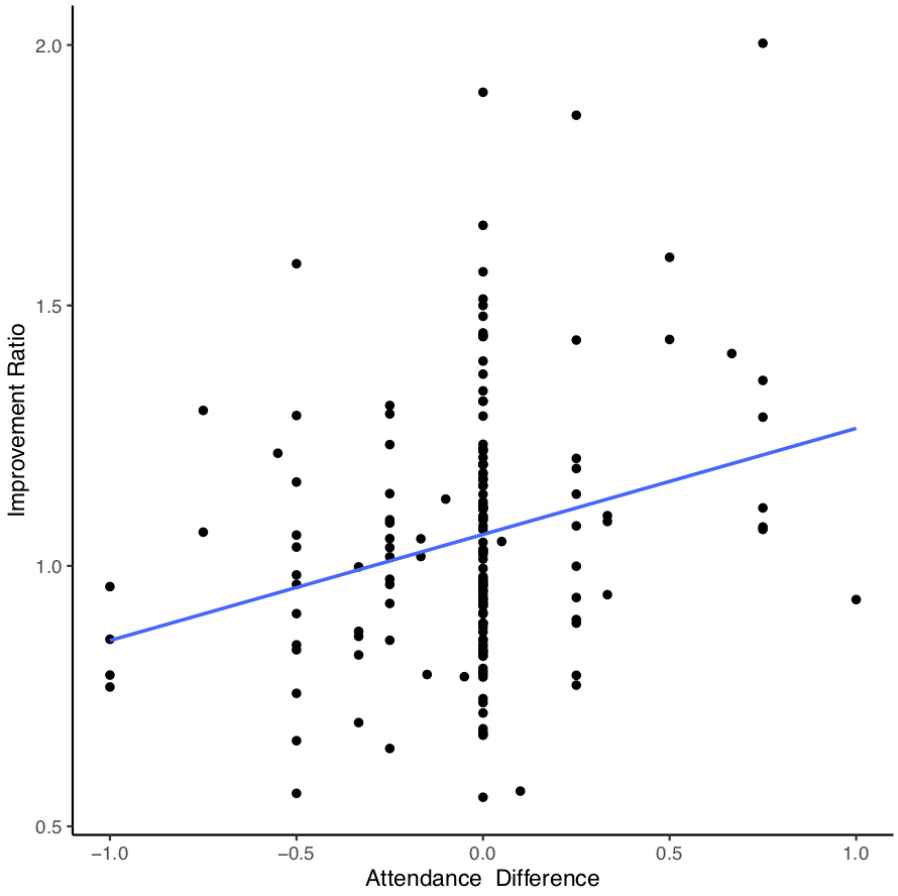

Figure 1: Plot of attendance difference for students attending study sessions before each exam and the improvement ratio on exams. Data for all students is included.

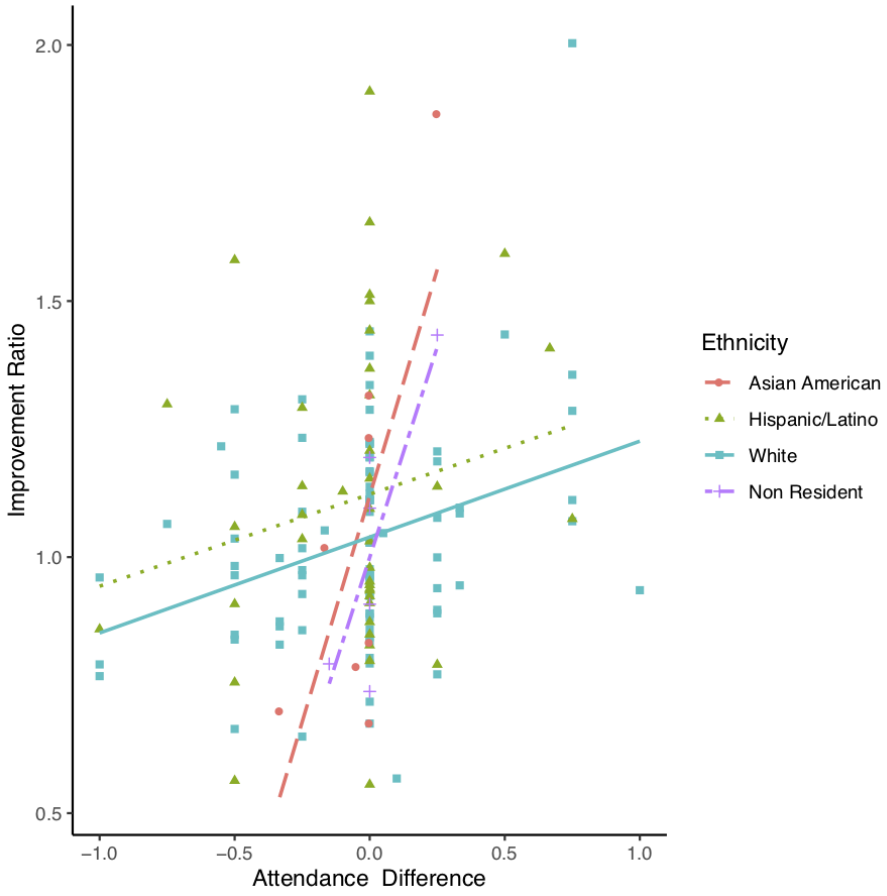

Figure 2: Plot of attendance difference for students attending study sessions before each exam and the improvement ratio on exams, with ethnic identities differentiated.

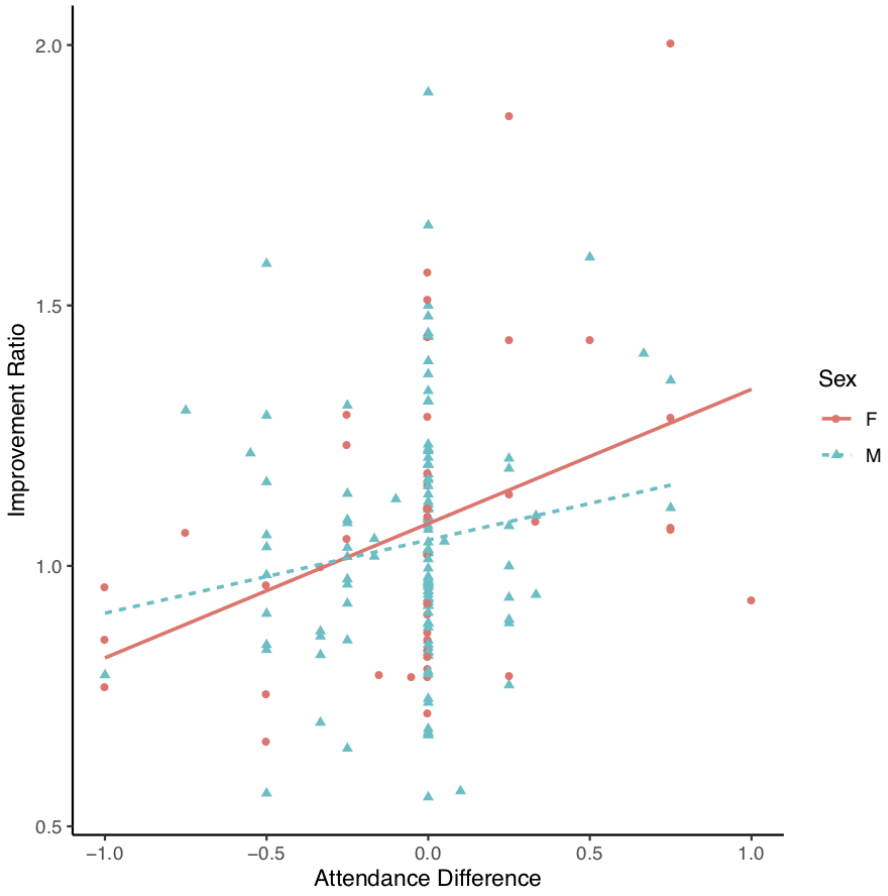

Figure 3: Plot of attendance difference for students attending study sessions before each exam and the improvement ratio on exams, with gender differentiated.

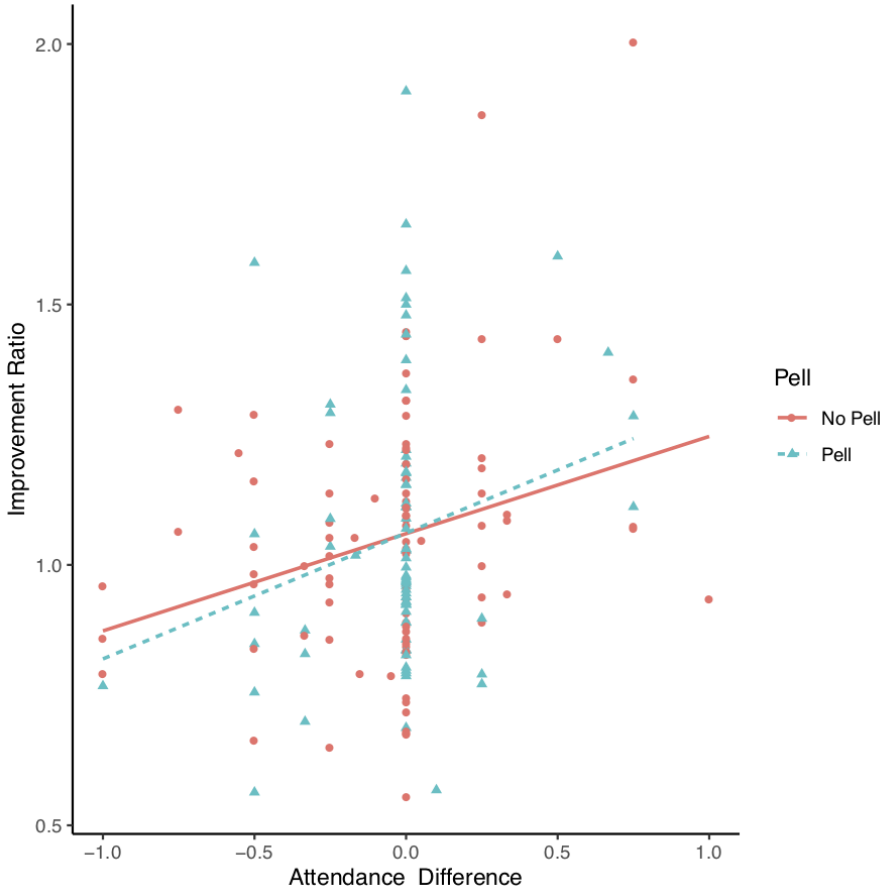

Figure 4: Plot of attendance difference for students attending study sessions before each exam and the improvement ratio on exams, differentiated for Pell grant status. Where 'No Pell' are students who did not receive Pell Grants and 'Pell' are students who did receive Pell Grants.

Table 2: Summary of linear regression analysis results between study session attendance difference (AD) and exam improvement ratio (IR). Subcategories with two or fewer participants or with no change in their attendance difference were excluded from the regression analysis because their linear regression results were undefined.

Sample (Sub)category	n	Slope	p-value
Total	170	0.2036	8.35E-04
Men	124	0.1405	0.093
▷ Pell Grant Recipient	61	0.2367	0.111
▷ Non-Pell Grant Recipient	63	0.0693	0.468
Women	46	0.2578	7.73E-03
▷Pell Grant Recipient	16	0.2485	0.216
▷ Non-Pell Grant Recipient	30	0.2569	0.0257
Pell Grant Recipient	77	0.2417	0.0379
Non-Pell Grant Recipient	93	0.1867	8.04E-03
Caucasians	86	0.1872	2.13E-03
▷Men	62	0.1042	0.176
▷Women	24	0.2503	0.0224
▷Pell Grant Recipient	30	0.1683	0.151
▷Non-Pell Grant Recipient	56	0.1979	6.56E-03
Non Resident Aliens	6	1.644	0.0557
▷Women	4	1.623	0.0400
▷Non-Pell Grant Recipient	6	1.643	0.557
Hispanics/Latinos	40	0.1795	0.225
▷Men	32	0.2302	0.272
▷Women	8	0.1252	0.553
▷Pell Grant Recipient	25	0.3661	0.126
▷Non-Pell Grant Recipient	15	-0.005541	0.972
Asians	8	1.767	0.0424
▷Men	6	0.8099	0.412
▷Non-Pell Grant Recipient	6	3.483	0.0350

ethnicity categories.

All results presented here, especially for sub-categories, should be taken in the context of low sample size (86 students total) and large p-values. However, the large number of students who attended these study-sessions, and overall improvement, indicate that it is an approach to office hours that is beneficial to students and encourages faculty-student interaction without being a burden on faculty members. Additionally, the improvements seen in this study were encouraging for some under-represented students. Women and Pell grant recipients who attended study sessions saw a larger improvement in exam score than their male and Non-Pell grant peers.

Data were not collected on normal office hour attendance, but anecdotally there were typically only zero to three students who attended office hours each week for each of these courses compared with an average of 8 students per week in the study sessions or 17% of the students in the course.

While improvements for attending standard office hours are not available for this study it was observed that the study sessions were more dynamic and students were engaged for longer periods of time.

Conclusion

The instructor-led study sessions that are examined here, are an easy strategy for faculty to help provide time and space for students to complete coursework and ask questions. The time commitment from the faculty member to conduct this was to organize a room and advertise the sessions, the hour each week was counted as part of the mandated office hours required of the faculty member. Anecdotally these study-sessions were better attended than more traditional office hours, so the faculty member was not able to multitask during these, however the engagement with students and connections made improved the sense of community in the classroom and the connection of the faculty member to the students.

Students who attended the instructor let study session analyzed in this study improved both their homework and exam grades. Although researchers cannot say that the attendance of study sessions are the direct source of an improvement in both homework and exam grades, there is a trend that depicts a positive impact on students that participated in the instructor-led study sessions that occurs across the analyzed populations. These study sessions were well attended by students from all demographics, and did not place extra work on the instructor (by being only a modification of an existing mandated office hour). However for exam grade analysis the p-values were large resulting in not statistically significant results, and no comparisons were made to traditional office hours.

Future work on this topic could:

- Gather data on students office hour attendance to extend the analysis to account for the effects of office hour attendance.
- Tracking the grades of students who attended study sessions in future courses and identifying students who completed the Environmental Resource Engineering degree.
- Collecting more data to better represent all categories of students.
- Hold instructor led study sessions in an informal location to compare the effect the room has on the attendance of these sessions.

These additions will benefit the analysis used to determine if the transformation of office hours to instructor led study sessions positively impact the completion of STEM programs.

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