Abstract

It is unclear whether in-person and online modalities are equally effective in promoting student engagement and learning in hybrid courses. We analyzed differences in student engagement and learning among students who self-selected their modalities and discovered that students who attended class in-person had higher levels of engagement, interacted more with their peers, and achieved higher learning gains than students who attended class online. Additionally, the presence of student interactions between rounds of peer instructions were shown to have improved learning gains for students attending class in-person. This indicates that pedagogical strategies like peer instructions may also be more effective in an in-person course setting.

Objectives

We sought to understand how the self-selection of modality impacts student engagement, interaction, and learning outcomes in an undergraduate data science course (CS216).

Our research questions are as follows:
1. How accurate are students at remembering their modality rates?
2. What is the relationship between students’ self-reported actual behavior and their perceptions of the class?
3. How do students’ modalities relate with their interactions during peer instructions?
4. How do students’ modalities and interactions relate to learning gains (as determined by PI correctness)?

Methods

I. Class Setting and Participants:
• The course is split into 10 modules, each of which is covered across 2 class meetings within a single week.
• Classes were offered in a hybrid format in Fall 2022 (FA22) and Spring 2023 (SP23). Students were allowed to attend class in-person or synchronously online and could alternate their modality between each class meeting.
• Peer instruction sets (PIs) were utilized in class. Each PI contained 1-4 questions (PIQs).

II. Data Collection
• Starting in the second half of the FA22 semester, students were asked to (1) self-report their modality (in-person, online, or neither) within the first PI of each class meeting, and (2) indicate whether they had recently interacted with other students within the second round of each PI.
• Zoomlogs were used to infer modality for class meetings that took place in the first half of the FA22 semester.
• Students filled out a mid-semester survey during weeks 7–8, where they were asked to (1) report the percentage of classes they attended in-person, online, or neither, and (2) to evaluate their experience attending class in their chosen modality.

III. Data Wrangling and Metrics
• We excluded (1) questions where no modality data was present and (2) students who indicated that they attended class neither online nor in-person from our calculations.
• We calculated an in-person modality proportion for each student using the following formula:

\[
\text{Proportion} = \frac{\text{Number of classes in-person}}{\text{Total number of classes attended}}
\]

• Normalized learning gains (NLG) were calculated for each PI using the following formula from Simon et al. (2010):  

\[
\text{NLG} = \frac{C_2 - C_1}{(C_2 - C_1) - 1 - C_1}
\]

• Cliff’s delta test was used to determine the distribution of NLG for each modality for PIQs.

Limitations

• Potential inaccuracies in student self-reported data
• Analyses on student interactions and engagement were limited to data from a single semester because the presence of interactions between students could not be inferred for prior semesters → would be beneficial to re-run the tests in future semesters to confirm results.

Additional Course Development

We created a dashboard that:
• provides statistics on student Sakai quiz submissions for each module
• visualizes the distribution of answer selections for each quiz question

Results

1. Differences in Students’ Self-Reported and Actual Modality Mix

50.33% of students self-reported an in-person modality proportion that was within 10% of their actual in-person modality proportion, as determined by PI responses.

2. Differences in Students’ Self-reported/Actual behavior and their Perceptions of the Class

Discovered a positive correlation between the frequency of students’ in-person interactions and their agreement with the notion that their modality mix supports a sense of community:
• Kruskal-Wallis Test: p-value = 0.006
• Cliff’s delta test: post-hoc pairwise comparison between those who agree and disagree (p-value = 0.004, with a medium effect size).

3. Differences in Student Interactions based on Modality

There was a statistically significant difference in the percentage of students who interacted with others while attending class in person and the percentage of students who interacted while attending class online on both a semester and PIQ level.
• (Semester) Chi-Square Test: p-value = 17.75 * 10^-9
• (PIQ) Wilcoxon signed-rank test: p-value = 4.547 * 10^-13

4. Impact of Modality and Interaction on Learning Gains

We conducted Wilcoxon tests on data from both the FA22 and SP23 semesters to investigate the relationship between students’ modalities and learning gains. Both tests yielded significant differences (p-value = 1.224 * 10^-6 for FA22 and p-value = 1.969 * 10^-4 for SP23). The following graphs show the distribution of NLG for each modality for PIQs in FA22 (left) and SP23 (right).

Additional Course Development

We noted significant differences in the engagement levels and learning gains of students who attend class in-person and students who attend class online. It may thus be worth it to reexamine the value of hybrid courses in the post-pandemic era, starting with CS216 itself.

Conclusion

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References