

## Supplemental Materials – Appendix 1 (Methods)

### Detailed Course Descriptions

#### Class 1

Class 1 was a 400-level course for majors with 47 students enrolled, 25 women and 22 men (Table 1). The instructor stood at the front of the room drawing diagrams on an electronic whiteboard for most of the class and checking occasionally for questions. Per the syllabus, in-class participation was not required for points and about a third of the course's points were more subjectively graded. The instructor and teaching assistants (TAs) were all women. The TAs handled all chat questions and comments for the instructor. Registrar records indicate that one man and one woman withdrew from the course at some point, and the picture roll we received from the instructor did not have these two students on it. Thus, our participation dataset includes 45 students, 24 women and 21 men. All participation events matched a student on the picture roll, so if the two students who withdrew did attend class at some point, they never participated during our observations.

#### Class 2

Class 2 was a 400-level class for majors with 22 students enrolled, 13 women and 9 men (Table 1). The instructor implemented a flipped classroom approach. Students watched a recorded lecture before class and came to class with questions. Partway through the semester, the instructor switched from having students ask questions live to collecting questions from students beforehand and then answering them all together. Per the syllabus, in-class participation was required for points, and these points were determined subjectively by the instructor. Overall, about two-thirds of the course's points were more subjectively graded. The instructor was a man, and the TAs were women. Registrar records indicate that one woman withdrew from the course at some point, but the picture roll we received had all 22 students on it. Thus, the woman who withdrew was included in our participation analysis. Since registrar records were de-identified, we are unsure whether the woman who withdrew ever participated in class.

#### Class 3

Class 3 was a 100-level introductory course open to all students and approved for general education requirements with 48 women and 19 men enrolled (67 students total, Table 1). Some days the class was taught as a traditional lecture with some active learning activities. On other days, a flipped classroom style was implemented with students watching a video or recorded lecture and then coming to class for a discussion or group work with a worksheet. Per the syllabus, in-class participation was not required for points and about 70% of the course's points were more subjectively graded by TAs. The instructor was a man, and all TAs were women. The TAs participated actively in class by answering questions posed in the chat and assisting in breakout room discussions. While this class had a few outside, non-student attendees, only student participation was recorded for this study. Registrar records indicate that one woman withdrew from the course at some point, but the picture roll we received had all 67 students on it. Thus, the woman who withdrew was included in our participation analysis. Since registrar records were de-identified, we are unsure whether the woman who withdrew ever participated in class.

## COPUS Collapsed Codes

- Instructor:
  - *Presenting* (Lecturing, Real-time writing, or Conducting a demo/experiment)
  - *Guiding* (Follow-up feedback on question or activity, Posing non-clicker questions, Posing clicker questions, Answering student questions, Moving through class guiding student work, or One-on-one discussions with students)
  - *Administration*
  - *Other* (Waiting or Other)
- Students:
  - *Receiving* (Listening to Instructor)
  - *Sharing in front of class* (Answering questions posed by instructor, Asking question, Whole-class discussion, or Presenting to class)
  - *Working* (Individual thinking/problem solving, Discussing clicker questions in groups, Working on worksheets in groups, Other group activities, Making predictions, Taking test or quiz)
  - *Other* (Waiting or Other)

## Participation Protocol Definitions

Definitions of instructor behaviors:

**Invitation for verbal participation:** We defined invitations for verbal participation as those that were not directed to the chat box. These invitations included questions or comments to which it would have been natural to answer out loud and if students were given time to do so. Even if no one answered, we still recorded it as an invitation if we could reasonably assume that the instructor moved on because they saw heads nodding.

**Invitation to use chat feature:** These invitations included any time an instructor explicitly said to use the chat box or asked students to type something.

**Breakout Rooms:** Each time the instructor opened breakout rooms, it was recorded as one breakout room session. We also recorded the number of minutes the breakout rooms were open later and calculated the percentage of the total class session that was spent in breakout rooms. If the instructor chose to pause the recording during breakout room sessions, we could not determine the exact amount of time the rooms were open. In these cases, the time was estimated based on the overall length of the recording compared to the class period length and/or verbal cues from the instructor.

**Class poll:** We counted the number of times the instructor used a poll of some kind. This included the Zoom poll feature and times when the instructor asked the students to raise their hand on camera or use Zoom's raise hand feature to vote for a specific answer.

Definitions of Student Behaviors:

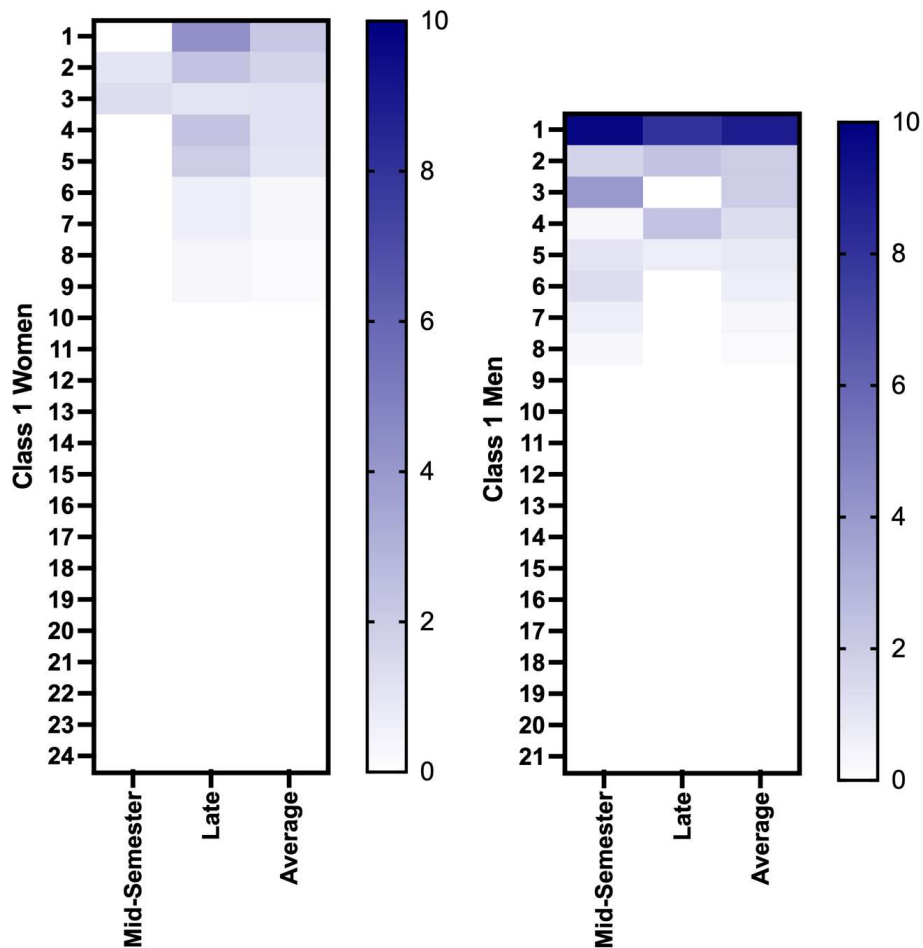
**Chat box participation:** Any time a student typed in the chat box, we counted it as a chat participation event regardless of whether it was on topic. If the professor asked students to send them a private message in the chat box, this was not counted as a participation event. We treated it as the equivalent of a professor asking students to come to office hours or email them rather than a participation event in front of the class.

**Verbal participation:** Any time a student unmuted themselves and spoke verbally, we counted this as a verbal participation event.

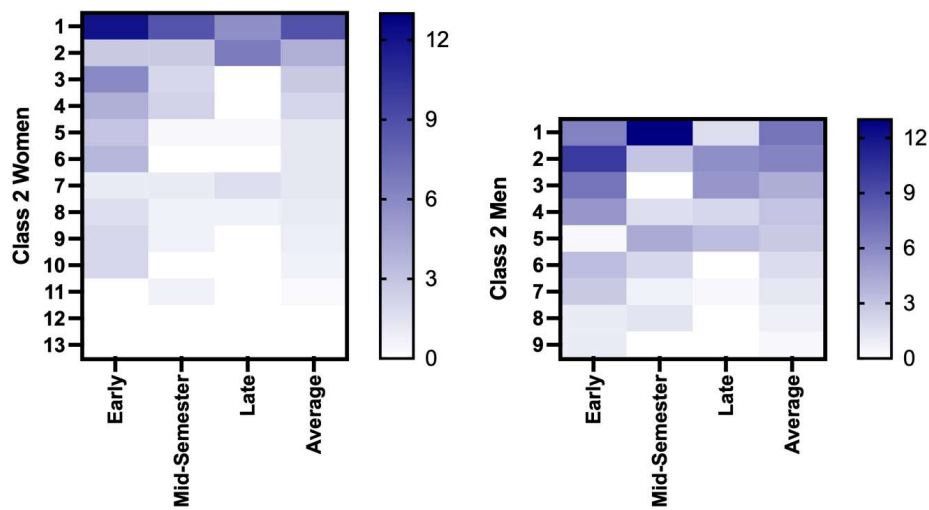
**Chat acknowledged by instructor:** Any time the main course instructor or a TA referred to a student's chat comment, we marked the student's chat comment as acknowledged by an instructor. This acknowledgement could have been verbal or could have been in the form of a chat comment. If both the instructor and a TA acknowledged a comment (e.g., the instructor verbally read it out loud and the TA typed a response in chat), that student's chat would be marked as acknowledged twice. Thus, the number of acknowledgements could be greater than one if multiple instructors acknowledge it.

**Chat acknowledged by peer:** Any time a student referred to another student's chat comment in their own chat comment or answered another student's chat question, we marked the first student's chat comment as acknowledged by a peer. (Note: The second student's chat would also be marked as a chat box participation event.) We recorded each time a chat was acknowledged by a peer, so the number of acknowledgements per chat could be greater than one.

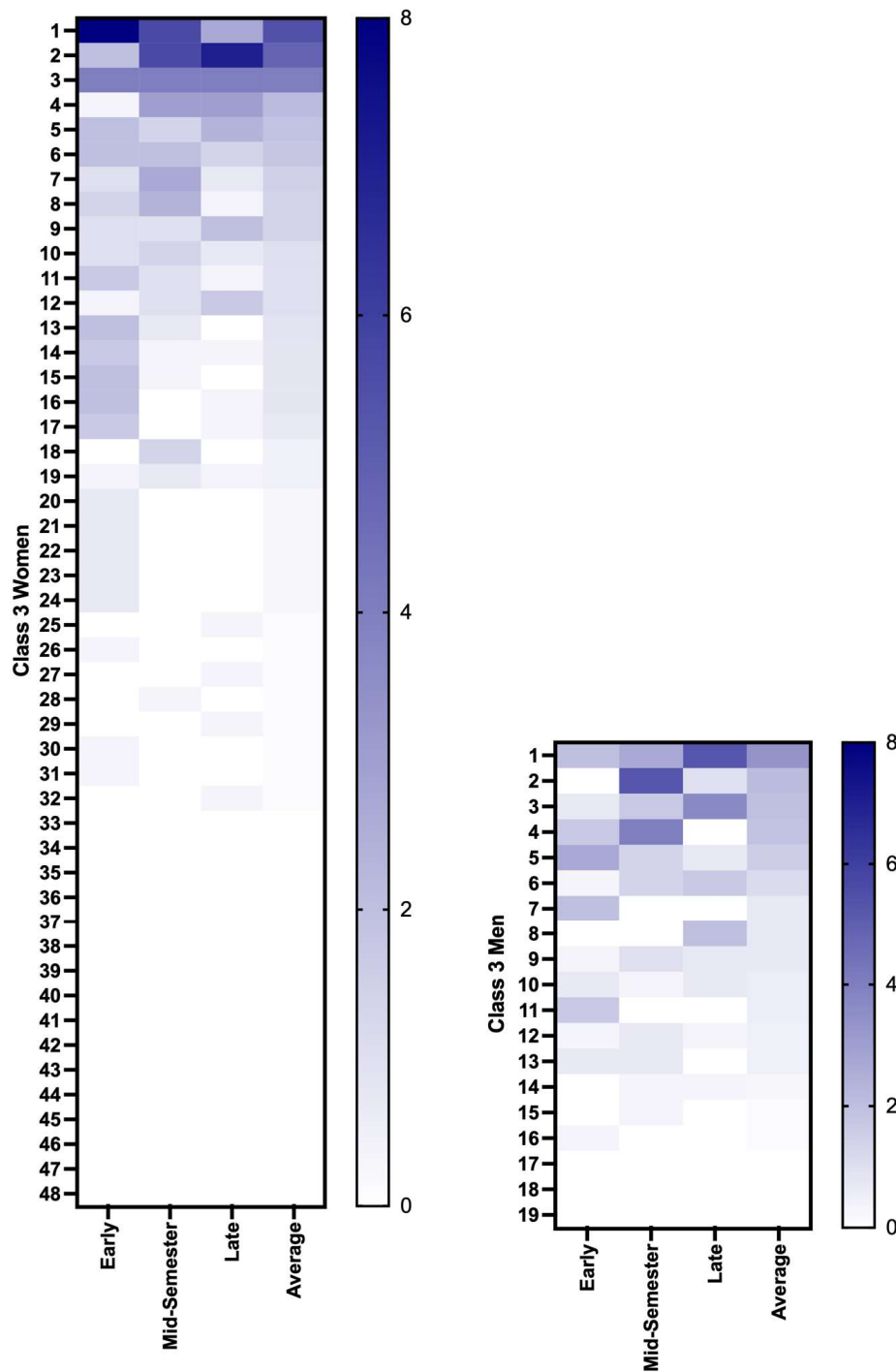
## Supplemental Materials – Appendix 2 (Figures)



**Figure S1. Heat map of average participation rates for each student in Class 1 over the course of the semester.** Each row represents one student, and each column represents point in the semester (Mid-Semester = average of three observations in the middle of the semester; Late = average of three observations near the end of the semester; Average = average of all observations). Darker colors represent more participation events (chat and verbal combined) as shown in colored legend. Women are shown on the left, and men are shown on the right. Students were sorted by average participation (far right column) with more frequent participators on top.



**Figure S2. Heat map of average participation rates for each student in Class 2 over the course of the semester.** Each row represents one student, and each column represents point in the semester (Early = average of three observations near the beginning of the semester; Mid-Semester = average of three observations in the middle of the semester; Late = average of three observations near the end of the semester; Average = average of all observations). Darker colors represent more participation events (chat and verbal combined) as shown in colored legend. Women are shown on the left, and men are shown on the right. Students were sorted by average participation (far right column) with more frequent participators on top.



**Figure S3. Heat map of average participation rates for each student in Class 3 over the course of the semester.** Each row represents one student, and each column represents point in the semester (Early = average of three observations near the beginning of the semester; Mid-Semester = average of three observations in the middle of the semester; Late = average of three observations near the end of the semester; Average = average of all observations). Darker colors represent more participation events (chat and verbal combined) as shown in colored legend. Women are shown on the left, and men are shown on the right. Students were sorted by average participation (far right column) with more frequent participators on top.