Supplemental Material

CBE—Life Sciences Education

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Supplemental data

Contents:

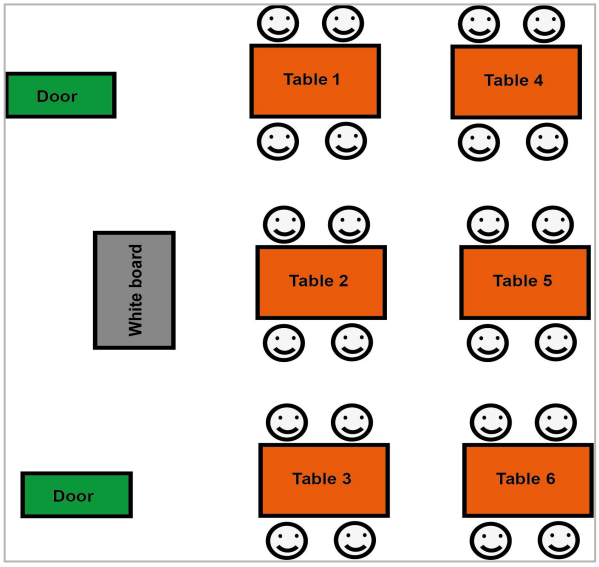

Figure S1: Laboratory layout for BIOL1108L

Each section had a maximum of 24 students and one GLA/instructor.

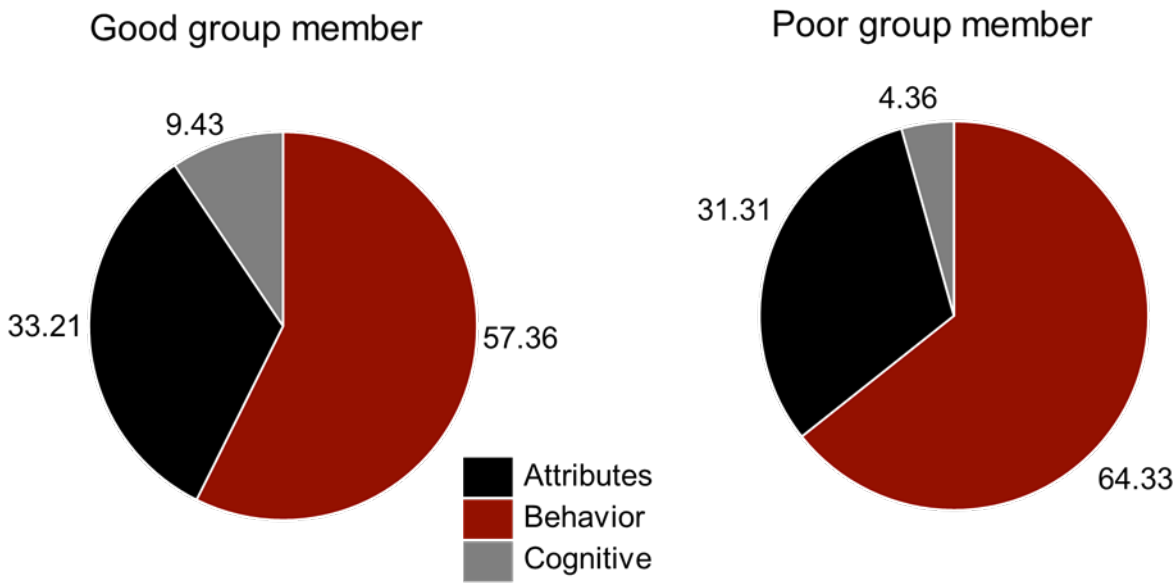

Figure S2: Analysis of preliminary qualitative data from Summer 2018 to understand students' perceptions of good and poor group members. Students defined "good" and "poor" as they perceived them without any definition or specification provided in the survey questions asked. The completion rate for all of the surveys was 84.8 %. Good group member codes (n=530) and Poor group member codes (n=527) were calculated as the frequency of responses per code over the total number of responses for all four surveys (%).

Table S1 - Demographics of students- Details of Ethnic/Racial distribution			
Ethnicity/Race		Number of students in Structured Labs	Number of students in Unstructured Labs
White (non-URM)		194	200
Asian (non-URM)	Asian Indian	41	20
	Chinese	6	10
	Korean	4	8
	Vietnamese	8	12
	Filipino	2	4
	Japanese	1	0
URM	African American/Black	32	44
	Hispanic/Latinx	17	19
	Native American/Pacific Islanders/ Alaska Natives	0	1

Table S2: Qualitative analysis of the lab sections for homophily observed with respect to Race/Ethnicity in week 5				
Lab ID	Total number of URM students	Total number of Asian students	Number of groups with URM students working together with no pre-class friend status (at least two students in a group)	Number of groups with Asian students working together with no pre-class friend status (at least two students in a group)
Unstructured lab sections				
11	4	1	1	0
21	7	3	2	0
31	5	2	1	0
41	2	3	0	1
61	5	5	1	1
91	6	2	1	1

101	6	4	0	0
121	5	3	0	0
131	4	2	1	0
141	5	2	0	0
151	1	3	0	0
171	4	7	1	2
181	4	3	0	0
Structured lab sections				
12	3	4	0	0
22	3	3	1	1
32	0	3	0	0
42	1	4	0	0
62	3	7	0	1

Table S3: Qualitative analysis of the lab sections with differential homophily observed with respect to pre-class friend status and biological sex in week 5

Lab ID	Total number of students (Female/Male ratio)	Number of groups with pre-class friends (Out of a total of 6)	Number of groups where 2 students were pre-class friends and were		
			All females	All males	Different biological sexes
Unstructured lab sections					
11	22 (1.63)	3	2	1	-
21	19 (2.8)	2	1	-	1
31	24 (3.8)	3	2	-	1
41	19 (5.33)	4	2	-	2
61	22 (1.44)	2	1	-	1

91	22 (2.14)	1	-	-	1
101	24 (5)	4	2	-	2
121	24 (1.6)	4	2	-	2
141	22(2.14)	2	1	-	1
151	23 (1.55)	3	1	-	2
171	24 (2)	4	1	-	3
181	20(1.86)	2	2	-	-
Structured lab sections					
12	21 (0.91)	2	1	-	1
22	20 (3)	2	-	-	2
32	22(2.14)	4	1	-	3
42	23(2.14)	2	1	-	1
62	20 (1.71)	2	-	-	2
92	22 (2.14)	4	2	-	2
102	19 (1.71)	2	1	1	-
122	22 (3.2)	3	1	-	3
132	18 (5)	4	2	-	2
142	24 (1.67)	3	1	-	2
152	23 (1.88)	2	1	1	-
182	21 (1.63)	3	2	1	-

Table S4: Model selection for examining the effect of fixed and random variables as a predictor for positive or negative outcomes for groups

Model Description	**Outcomes- Week 5-7 (AIC values)**					
Variables Fixed effects + (Random effects)	df	Satisfaction	Task conflict	Relationship conflict	Process Conflict	Communication frequency
Treatment + Sex + Ethnicity + GPA + Year + Week	8	3667	3068	1988	3120	4223
Treatment + Sex + Ethnicity + GPA + Year + Week + (StudentID) + (Lab-section)	10	3476	2745	1725	2970	3855
Treatment + Sex + Ethnicity + GPA + Year + Week + (Lab-section)	9	3660	3071	1988	3128	4203
Treatment + Sex + Ethnicity + GPA + Year + Week + (StudentID)	9	3487	2749	1732	2975	3865
Selected the model with the lowest AIC from above 4 models as a parsimonious model						
Removed the fixed effects in a backward fashion starting with the factor with the smallest effect from the above model						
If the AIC value decreased, the effect was removed from the model						
If the AIC value increased, the effect was added back into the model						

Outcome	**Final mixed effect model description**
Satisfaction	Week + GPA + (StudentID) + (Lab-section)
Task Conflict	Sex +Week + GPA + (StudentID) + (Lab-section)
Relationship Conflict	Week + GPA + (StudentID) + (Lab-section)
Process Conflict	Ethnicity + GPA + (StudentID) + (Lab-section)
Communication Frequency	GPA + (StudentID) + (Lab-section)

Note: Treatment is Structured/Unstructured labs

Note: Please refer to Theobald (2018) for a detailed description of model selection method

Table S5: Linear mixed model fit examining the effect of fixed and random variables on the satisfaction, conflict, and communication frequency scores.					
Satisfaction score					
Random effect		**Fixed Effects**			
Variance	**Std.Dev**		**Estimate**	**Std. Error**	**t -value**
Student ID		Intercept	3.62	0.32	11.30
0.28	0.53	Week	0.08	0.02	3.95
Lab sections		GPA	0.06	0.08	0.81
0.03	0.17				
Task Conflict score					
Student ID		Intercept	2.30	0.27	8.5
0.24	0.49	Biological Sex	0.11	0.05	2.11
Lab sections		Week	-0.11	0.01	-7.32
0.01	0.12	GPA	0.03	0.07	0.05
Relationship Conflict score					
Student ID		Intercept	1.15	0.18	6.30
0.10	0.31	Week	0.03	0.01	2.94
Lab sections		GPA	-0.04	0.04	-1.00
0.008	0.09				
Process Conflict score					
Student ID		Intercept	1.30	0.24	5.25
0.18	0.42	Ethnicity	0.06	0.02	2.50
Lab sections		GPA	-0.02	0.07	0.27
0.015	0.12				
Communication frequency					
Student ID		Intercept	10.32	0.38	26.67
0.57	0.75	GPA	0.02	0.11	0.17
Lab sections					
0.05	0.23				

t-tests use Satterthwaite's method

Table S6 - Mean, SD, and median values for satisfaction, discussion, conflict scores, and final grades in structured and unstructured labs

Lab	Week 5			Week 6			Week 7		
	Mean	SD	Median	Mean	SD	Median	Mean	SD	Median
(a) Satisfaction score									
Structured	4.28	1.06	5	4.38	0.94	5	4.44	0.93	5
Unstructured	4.31	1.04	5	4.38	0.91	5	4.49	0.77	5
(b) Task conflict score									
Structured	1.74	0.79	2	1.72	0.78	2	1.45	0.69	1
Unstructured	1.73	0.78	2	1.78	0.87	2	1.56	0.77	1
(c) Relationship conflict score									
Structured	1.14	0.49	1	1.21	0.56	1	1.2	0.58	1
Unstructured	1.12	0.41	1	1.23	0.59	1	1.19	0.59	1
(d) Process conflict score									
Structured	1.40	0.68	1	1.41	0.65	1	1.28	0.56	1
Unstructured	1.38	0.66	1	1.54	0.83	1	1.42	0.81	1

(f) Final grades

Lab	Group grades			Individual grades		
	Mean	SD	Median	Mean	SD	Median
Structured	0.94	0.03	0.95	0.94	0.05	0.95
Unstructured	0.90	0.10	0.93	0.90	0.11	0.92

Table S7: Model selection for the effect of structure and unstructured lab settings as a predictor for communication frequency and shared workload during weeks 1 to 4

Model Description	Outcomes- Week 1-4 (AIC values)		
Variables Fixed effects + (Random effects)	df	Shared workload score	Communication frequency
Treatment + Week	4	3437	7045
Treatment + Week + (StudentID) + (Lab-section)	6	3229	6839

Treatment + Week + (Lab-section)	5	3277	7021
Treatment + Week + (StudentID)	5	3372	6858
Selected the model with the lowest AIC as a parsimonious model			
Removed the fixed effects in a backward fashion starting with the factor with the smallest effect from the above model			
Selected a parsimonious model			
Final model: Outcome ~ Week+ (StudentID) + (Lab-section)			

Table S8: Mixed Level model examining the effect of structure and unstructured lab settings on the communication frequency and shared workload during weeks 1 to 4

Communication frequency					
Random effects		**Fixed Effects**			
Variance	**Std.Dev**		**Estimate**	**Std. Error**	**t -value**
StudentID		Intercept	9.68	0.08	119.6
0.48	0.69	Week	0.11	0.02	5.48
Lab sections					
0.05	0.24				
Shared workload score					
StudentID		Intercept	4.58	0.03	130.6
0.05	0.23	Week	0.01	0.008	1.98
Lab sections					
0.01	0.12				

Table S9 - Mean, SD and median values for communication frequencies in structured and unstructured labs

Weeks	Structured Labs			Unstructured labs		
	Mean	SD	Median	Mean	SD	Median
Week 1	9.88	1.33	10	9.77	1.42	10
Week 2	9.79	1.30	10	9.98	1.28	10
Week 3	10.03	1.24	10	10.02	1.32	10
Week 4	10.07	1.25	11	10.30	1.11	11
Week 5	10.38	1.12	11	10.36	1.09	11
Week 6	10.40	1.20	11	10.40	0.99	11
Week 7	10.41	1.12	11	10.42	0.94	11

Table S10 - Mean, SD, and median values for shared workload in structured and unstructured labs over the period of the first four weeks

Weeks	Structured Labs			Unstructured labs		
	Mean	SD	Median	Mean	SD	Median
Week 1	4.61	0.46	4.66	4.62	0.44	4.67
Week 2	4.57	0.58	4.67	4.63	0.57	5.00
Week 3	4.60	0.55	4.67	4.66	0.47	5.00
Week 4	4.61	0.59	5.00	4.72 *	0.45	5.00

Appendix 1- Survey items

A) Demographics Questions as a part of the survey in week 1

In order to understand the different characteristics that you use to form groups, please provide some details about yourself in the questions below.

1. Please indicate your gender
   - o Male
   - o Female
   - o other _____
   - o prefer not to respond
2. With which race(s) and ethnicity/ies do you most closely identify? Please choose all that apply.
   a. African American or Black
   b. American Indian or Alaskan Native
   c. Asian Indian
   d. Chinese
   e. Filipino
   f. Japanese
   g. Korean
   h. Latina / Latino or Hispanic
   i. Native Hawaiian or Other Pacific Islander
   j. Vietnamese
   k. White
   l. Other - please explain:
      ___
   m. Prefer not to respond
3. Please indicate your class standing in college.
   - o freshman (0-30 hours)
   - o sophomore (31-60 hours)
   - o junior (61-90 hours)
   - o senior (above 90 hours)
4. Please indicate your current cumulative college GPA (e.g 3.87 or 3.25).

B) Survey distributed during weeks 1-4 to collect information

1. Please select the students with whom you worked in the lab today. {List just contains the students in that lab section}
2. {Populated question with the answers from question 1}
   For each student that you worked with today, select those that you consider a pre-class

friend: A student that you would consider a friend from BEFORE the term of this class. If you have met someone in this class that you would consider a friend now but not before this class, do not select them as a pre-class friend.

3. {Populated question with the answers from question 1}
   For each student that you worked with in lab today, rank how well you felt they shared the workload as a group member: shared workload includes discussing ideas, using equipment, recording data, presenting your group's ideas, asking relevant questions, etc.

	very poor	poor	moderate	good	very good
(Group Member 1)	o	o	o	o	o
(Group Member 2)	o	o	o	o	o
(Group Member 3)	o	o	o	o	o

4. Indicate the frequency or communication between members of your group in the lab today.

   -5 indicates extremely rare communication (several members did not talk at all)
   0 indicates average level of communication.
   +5 indicates very frequent communication (all students communicated throughout lab)

5. Please provide at least two traits you used (or would use) to identify someone as a good group member.
6. Please provide at least two traits you used (or would use) to identify someone as a poor group member.
7. For each of the students that you worked with today, select only those that you would like to work with again.
8. What factored into your decision for the last question? {Populated with individual students}

   a. Positive Options:
   Well prepared for class & knows the material well in advance.
   Pays attention.
   Participates in discussion and offers meaningful suggestions.

   b. Negative Options:
   Does not come to class prepared or does not know the material in advance.
   Does not seem interested in the class.
   Does not participate in discussions / listen to others.

C) Survey distributed during weeks 5-7 to collect information

1. Select the members of the group that you will be working with for the next few lab sessions: {List just contains the students in that lab section}
2. {Populated question with the answers from question 1}
   Please indicate which of these students was a pre-class friend.
3. In general, how would you rate your previous experience working in a group?

   a. Extremely bad
   b. Bad
   c. Neutral
   d. Good
   e. Extremely Good

4. How do you feel your group worked today?
   a. Extremely well
   b. Well
   c. Neutral
   d. Poor
   e. Extremely poor

5. Indicate the frequency or communication between members of your group in the lab today

   -5 indicates extremely rare communication (several members did not talk at all)
   0 indicates average level of communication.
   +5 indicates very frequent communication (all students communicated throughout lab)

Group Satisfaction items

6. I am satisfied with my present teammates (Select one)
   o Strongly agree o Agree o Neutral o Disagree o Strongly disagree
7. I am pleased with the way my teammates and I worked together today (Select one)
   o Strongly agree o Agree o Neutral o Disagree o Strongly disagree
8. I am very satisfied working with this team (Select one)
   o Strongly agree o Agree o Neutral o Disagree o Strongly disagree
9. What is your biggest concern working in a group? Please explain.

Group Conflict items - Task Conflict

10. How much conflict of ideas is there in your work group? (Select one)
    o None/Not at all o Little/Rarely o Some o Much/Often o Very Much/Very Often
11. How often do people in your work group have conflicting opinions about the project you are working on? (Select one)
    o None/Not at all o Little/Rarely o Some o Much/Often o Very Much/Very Often

12. How often are there disagreements about who should do what in your work group? (Select one)

o None/Not at all o Little/Rarely o Some o Much/Often o Very Much/Very Often

Group Conflict items – Relationship Conflict

13. How much relationship tension is there in your work group?

o None/Not at all o Little/Rarely o Some o Much/Often o Very Much/Very Often

14. How often do people get angry while working in your group?

o None/Not at all o Little/Rarely o Some o Much/Often o Very Much/Very Often

15. How much emotional conflict is there in your work group?

o None/Not at all o Little/Rarely o Some o Much/Often o Very Much/Very Often

Group Conflict items –Process Conflict

16. How frequently do you have disagreements within your work group about the task of the project you are working on?

o None/Not at all o Little/Rarely o Some o Much/Often o Very Much/Very Often

Group Atmosphere items –Discussion of ideas

17. How often do you have open discussion about these issues in your group?

o None/Not at all o Little/Rarely o Some o Much/Often o Very Much/Very Often