GROUP DYNAMIC AND ITS EFFECT ON CLASSROOM CLIMATE, ACHIEVEMENT, AND TIME IN LAB IN THE ORGANIC CHEMISTRY LABORATORY CLASSROOM

by

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ABSTRACT

Despite the many studies on the benefits of cooperative learning, there is surprising little research into how the classroom as a whole changes when these cooperative groups are reassigned. In one section of CHEM 3011 in Fall 2013, students were allowed to pick their partner and kept the same partner all semester. In another section during the same semester, students were assigned a different partner for every wet lab and were allowed to pick their partners during the computer simulation labs. The students in both sections were given the “preferred” version of the Science Laboratory Environment Inventory (SLEI) (Fraser et al., 1993) at the beginning of the semester to elicit student preferences for the class environment, and the “actual” version of the SLEI and the Class Life Instrument (Johnson et al., 1983) at the end of the semester to determine what actually occurred during the semester. The students' interactions were recorded using an observational instrument developed specifically for this project. The students' responses to surveys, interactions, grades, and time in lab were analyzed for differences between the two sections. The results of this study will be discussed.

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CHAPTER I: INTRODUCTION

Cooperative and Collaborative Learning

Students clock as many hours a week in a chemistry laboratory class as they do in lecture. How to get the maximum benefit of this learning environment is an important, if not broad question. Since lab is generally conducted in groups, cooperative learning methods lend themselves to this type of environment. In a cooperative learning environment, a group of students works together on a structured activity, and specific roles are usually assigned within the group. While there has been a good deal of research on developing cooperative learning activities, research on how to form those cooperative learning groups and how often they should be changed if at all is much more limited. The purpose of this project is to determine what effect instructor-assigned weekly-changed groups in laboratory had on classroom climate, achievement, and time in the laboratory classroom as compared to semester-long groups formed by student choice.

The superiority and benefits of cooperative learning activities in the classroom and laboratory have been reported numerous times in the literature (Johnson, Skon, & Johnson 1980; Johnson & Johnson 1981; Gabbert, Johnson, & Johnson 1986; Cooper 1995; Doughtery, Bowen, Rees, Mellon, & Pulliam 1995; Wright 1996; Felder 1996). Johnson *et al.* compared cooperative environments to competitive and individualistic environments in the classroom (Johnson, Skon, & Johnson, 1980; Johnson & Johnson, 1981; Gabbert, Johnson, & Johnson 1986). They found that after controlling for ethnicity, gender, and ability, students in the cooperative environments outperformed students in the other two environments, and that the groups of students, when compared to the individualistic condition, also tended to produce more correct answers. This phenomenon has come to be known as process gain. They also compared how each of the students did individually after the activities and demonstrated that students that were in the cooperative groups still outperformed the other students. The impact of the group on individual performance is known as group-to-individual transfer (Gabbert, Johnson, & Johnson, 1986). Cooper (1995) stated that the cooperative learning environment also could work for large enrollment courses because it increases student satisfaction and retention, promotes active learning and the development of higher-level thinking skills.

There is technically a collaborative learning environment at Middle Tennessee State University in the Organic Chemistry laboratory because there are usually only two students in a group with no specific roles assigned (Wentzel & Watkins, 2002). In cooperative learning activities, there are often four to six members, and the members tend to have clearly defined or assigned roles. In the literature, the line between cooperative and collaborative environments tends to be blurry because many articles lump any group activity under the heading of “cooperative” or “collaborative” without regard to group size or role assignment. In the cases where collaborative learning is specified, the same general goals are achieved as with cooperative learning—students benefit from collaborating with a partner, and more learning occurs than it would if the students did the activity alone (Azmitia, 1988; Gauvain & Rogoff, 1989; Tudge, 1992; Tudge & Winteroff, 1993; Fuchs, Fuchs, Bentz, Phillips & Hamlett, 1994; Brown & Blackburn, 1999; Hass, 2000; Wentzel & Watkins, 2002; Cooper *et al*., 2008).

Most of the previous work on group assignment has related to optimal group size and optimizing group performance by taking into account partner or group-member ability and/or experience (Azmitia, 1988; Gauvain & Rogoff, 1989; Heller & Hollabaugh, 1992; Tudge & Winteroff, 1993; Fuchs *et al.*, 1994; Cooper *et al.*, 2008). Cooper *et al.* (2008) studied the effects of collaborative learning on problem solving ability. First they had students individually solve five problems on the Hazmat program which is a part of IMMEX (Interactive Multimedia Excercises). In Hazmat, the goal is to determine the identity of an unknown compound using various tests performed virtually in the program. After completing five problems alone, the students were paired up to complete five more problems. The partners were assigned based on the students' responses to the GALT or Group Assessment of Logical Thinking. Based on the responses to the GALT, students are classified as being on one of Piaget's higher levels of intellectual development: concrete, pre-formal, or formal. Working in collaborative groups did increase problem-solving ability even when the student worked alone afterward for all partner sets except ones where a concrete student was paired with another concrete student (Cooper *et al.*, 2008).

Classroom Climate

Article after article states the importance of classroom climate for learning (Haertel *et al.*, 1981; Fraser & Fisher, 1983; Haertel *et al.*, 1983; Wang *et al.*, 1990; Wentzel, 1994; Battistich *et al*,. 1997; Wentzel *et al.*, 1997). Haertel *et al.* (1981) did a review of 12 studies and showed that learning gains correlated positively with the social-psychological aspects of a classroom like "cohesiveness" and negatively with "friction" and "cliqueness." Wang *et al.* (1990) did a review of variables affecting learning outcomes. They organized 228 variables related to school learning into 30 scales, organized further into 6 categories. The category they called "implementation, classroom instruction, and climate variables" was ranked the third most influential scale for learning, preceded by "program design variables" and "out-of-school contextual variables" respectively.

There have been many instruments developed to measure the classroom climate, so many that there are instruments for almost every type of classroom, some general and some specific. General ones include the Classroom Life Instrument (Johnson *et al.*, 1983) and the ClassMaps Survey (Doll *et al.*, 2010) for example. There are also surveys which compare the student's preferred learning environment to how they felt the learning environment actually was, such as the Classroom Environment Scale (Fraser & Fisher, 1983). Many of the surveys focus on science and in particular the laboratory aspect of science classes like the Science Laboratory Environment Inventory (Fraser, McRobbie, & Giddings, 1993).

In this particular study, the Classroom Life Instrument (CLI) and the Science Laboratory Environment Inventory (SLEI) were used. The CLI was chosen because it measured many of the factors of classroom climate that might change if the group dynamic changed. The SLEI was chosen for two reasons: 1) it was developed for use in the laboratory classroom specifically, and 2) it took the students' preferences into account when analyzing what actually happened in the laboratory class.

The CLI was developed by Johnson *et al.* and published in 1983. It was developed using responses of 859 students from urban and suburban Midwestern schools in grades 5 to 9. The survey asked 59 Likert-type questions about the psycho-social environment in the classroom, broken down into 12 factors: “cooperative learning, positive goal interdependence, resource interdependence, teacher academic support, teacher personal support, student academic support, student personal support, class cohesion, fairness of grading, achieving for social approval, academic self-esteem, alienation” (Example statements in Table 1; survey in Appendix B). The survey is scored by reversing the negative statements; all the responses for each factor were added, calculating a score for each factor. The correlation between cooperative learning, positive goal interdependence, and resource interdependence was calculated for each factor. From their analysis, they determined that students in a more cooperative learning environment felt as if they had more support from their peers and teachers (Johnson, Johnson, & Anderson, 1983; Johnson & Johnson, 1983).

Table 1. Example statements from each subset of the Classroom Life Instrument.

Question Subset	Example Statement
Cooperative learning	"In this class, I can learn important things from other students."
Positive goal interdependence	"When we work together in small groups, our grade depends on how much all members learn."
Resource interdependence	"When we work together in small groups, we cannot complete an assignment unless everyone contributes."
Teacher academic support	"My teacher cares about how much I learn."
Teacher personal support	"My teacher really cares about me."
Student academic support	"In this class, other students like to help me learn."
Student personal support	"In this class, other students think it's important to be my friend."
Classroom cohesion	"In this class, everybody is a friend."
Fairness of grading	"In this class, everyone has an equal chance to be successful if they do their best."
Achieving for social approval	"I do my lab work to make my teacher happy."
Academic self-esteem	"Lab work is fairly easy for me."
Alienation	"In this class, I often feel lonely."

The SLEI, as mentioned earlier, was developed specifically for use in the science laboratory class by Fraser *et al.* in 1993. They wanted their survey to be useful for measuring the different classroom-climate aspects of the laboratory classroom because that is a different learning environment compared to a normal classroom. They analyzed literature on laboratory teaching and instruments for non-laboratory settings, specifically the ones that included an "actual" and "preferred" version, to determine possible important dimensions in a lab classroom to include in their survey. The initial "actual" and "preferred" versions of the survey were given to high school students in Australia, USA, Canada, England, Israel, and Nigeria and contained 72 Likert-type questions, broken down into eight scales with nine questions each. After analyzing this original version, the questions that remained after many item and factor analyses were used on the final versions. The final "actual" and "preferred" versions of the survey contained 35 Likert-type questions, broken down into 5 scales with 7 questions each: student cohesiveness- "extent to which students know, help and are supportive of one another," open-endedness- "extent to which the laboratory activities emphasize an open-ended, divergent approach to experimentation," integration- "extent to which the laboratory activities are integrated with non-laboratory and theory classes," rule clarity- "extent to which behavior in the laboratory is guided by formal rules", and material environment- "extent to which the laboratory equipment and materials are adequate." Since its development, the SLEI has been used for many different studies involving the affective domain in the laboratory setting: biology specially (Fisher *et al.*, 1997); comparing chemistry and biology labs (Hofstein *et al.*, 1996); comparing physics, chemistry, and biology (Fisher *et al.*, 1998); and examining primary school and pre-service science teachers perceptions of the laboratory environment (Çetinkaya & Çakiroğlu, 2011).

Observational Methods

To get a good sense of what was really happening in lab, observational data was needed. However, most of the observational methods in the literature are qualitative and also not specific to any particular classroom environment. The observer records observations in his or her field notes and then using constant comparison analysis, determines the themes that arise. Then the observer can come up with a classification system for the observations and use that to quantify and make sense of the observational data collected. This process is very time-consuming and laborious, but in the end, the data is rich. Also it is very difficult to train others to do this, and the iterative process of analyzing the observational data requires an expert.

Teacher evaluations and observations are used commonly in school systems and in programs preparing people to become teachers. Many observational methods of this type focus on interactions with the teacher as the focal point, instead of the students. Additionally these instruments are generally designed for use in a normal lecture-type class where the teacher is mobile, but students are not.

There are observational methods though which are very useful in settings where movement throughout the room is integral to the class, like in an art studio or in a science laboratory. Spatial mapping involves the use of a map of the room where instruction is taking place to record movement and interactions of the person or people being observed (Susi, 1985; Susi, 1992). Van den Berg *et al.* (2012) used spatial mapping to observe elementary students and determine the effect classroom arrangement had on peer perception and victimization. They put children who did not like each other next to each other in the classroom for several weeks, and surprisingly the students ended up liking each other afterward (van den Berg *et al.*, 2012). In this examination of group dynamic and student interaction in CHEM 3011, spatial mapping is used to track student movement throughout the lab and to record student interactions.

Importance of the Laboratory Classroom

In science, the laboratory is a unique learning environment with possibilities outside of what a student experiences in a normal lecture class. In John F. Wojcik's argument for the importance of the laboratory class (1990), he wrote, "…a chemistry course taught without laboratory experience *will become solely a course in mathematics and abstract symbol manipulation.*" Many educators have tried to clearly define the goals and purposes of laboratory, and in general they have come up with four major categories: conceptual learning, laboratory technique and manipulative skills, investigative skills, and affective outcomes (Garnett, 1995). Unfortunately, the affective aspect of laboratory is often ignored, even though participation in hands-on work has been shown to increase students' positive attitudes towards science (Thompson & Soyibo, 2002; Freedman, 1997) which in turn affects enrollment in physical science courses like chemistry and physics (Milner, Ben-Zvi, & Hofstein, 1987). Hofstein and Lunetta (2004) in their review article about research in the laboratory class called for more research into attitude, classroom environment, and social interactions in the laboratory setting. The current study on group dynamic in the organic laboratory is an effort to aide in filling that gap in the research by examining the effect changes in the group dynamic has on time on task, student interactions, and grades in a laboratory class.

CHAPTER II: MATERIALS AND METHODS

Partner Selection and Time in Lab

In two sections of Organic Chemistry II Laboratory, CHEM 3021, in Spring 2013, an instrument was developed and piloted to keep track of attendance, partners, lab stations, pre-lab assignments, and time in lab. In those two sections of lab, the graduate teaching assistant responsible for the lab assigned partners and changed them weekly, and this instrument was used as the sign-in/out sheet for the class (Appendix A). This sign-in sheet was used without changes in the two Organic Chemistry I Lab (CHEM 3011) classes to collect data for this study during Fall 2013.

In one section of CHEM 3011 taught by the lead researcher in Fall 2013, the students were allowed the pick their partners and continued to have the same partner for the rest of the semester. A couple of people dropped the lab, so some minimal shuffling and re-partnering were required. In the second section of Organic Chemistry I lab also taught by the lead researcher, the students were assigned a different lab partner for each wet laboratory experiment and allowed to pick their partner for each computer-based lab.

As mentioned earlier, the sign-in sheets developed in a previous semester were used to keep track of multiple things; the one most relevant to this study was the time spent in lab. For the purposes of this study, time in lab was defined as the amount of time between the official class start time and when they checked out with the instructor. The instructor wrote down when each person checked out with her on the sign-in sheet and recorded the information (lab station assignment, attendance, pre-lab assignments, and time in lab) from the sheet into a workbook in Excel. The average time in lab was calculated for each student, and the two sections were compared in SPSS using simple one-way ANOVA.

SLEI, CLI, and Demographic Surveys

A survey consisting of demographic questions and the "preferred" version of the Science Laboratory Environment Inventory (SLEI) (Fraser *et al*., 1993) was given to all SS during the first lab meeting of the semester for CHEM 3011 in Fall 2013 for all sections to illicit the students' expectations of the classroom environment for the semester. Extra credit was offered to the people who completed the survey. Each student included in the study signed an informed-consent form, and the consent procedure approved by the Internal Review Board was followed (IRB approval letter attached in Appendix G). Two-hundred twelve completed surveys were turned in from all sections, but only the surveys from the two classes taught by the lead researcher were analyzed further. The information from the sixty surveys from her classes was entered into a workbook in Microsoft excel and scored.

In preparation to give the survey, other demographic surveys were read for ideas of questions to include. In Spring 2013, the first version of the demographic survey was beta tested by giving it to all sections of CHEM 3021 along with two other surveys (Classroom Life Instrument and Science Laboratory Environment Inventory) already validated and published in literature (Fraser *et al.*, 1993; Johnson, Johnson, Anderson, 1983). After the demographic survey was coded, it was obvious that some questions were unclear or did not provide useful information, so the survey was edited to clear up the unclear questions and to exclude the ones that did not provide useful information. The edited version of the demographic survey was the one used for this study.

A survey consisting of the same demographic questions, the “actual” version of the Science Laboratory Environment Inventory (SLEI), and the Classroom Life Instrument (CLI) (Fraser *et al.*, 1993; Johnson, Johnson, Anderson, 1983) were given during the last laboratory meeting of the semester for all laboratory sections to illicit information about what actually occurred in the class throughout the semester, and extra credit was once again offered for completion (Surveys and raw data contained in Appendices B, C, and D). Due to attrition, only 48 of the 60 students who completed “preferred” SLEI completed the “actual” SLEI, and only the students who completed both versions were used in the analysis of SLEI. The SLEI responses to each question subset were analyzed using an ANCOVA in SPSS. Fifty students completed the CLI, and the responses for each group of questions were analyzed in SPSS using a simple ANOVA. Effect sizes were also calculated for each question subset for both surveys. After the analysis, GPower Version 3.0.10 was used to calculate what the ideal sample size for the CLI would be to have a medium effect size (0.25) and power of 0.8 with α of 0.05.

Observations: Instrument Development and Use

Since the primary researcher was also the lab instructor, there was a need to collect observational data using research assistants. The lack of variety of observational methods in literature, required the development of a way of recording observations in the laboratory setting was developed that better fit the needs of this study. The research question required a tool which could keep track of the types of interactions in laboratory, recording both who talked to whom and the nature of the interaction. The advisor for this study came up with the idea of using a map of the laboratory classroom with each station labeled with the number and the students assigned there. Interactions could be shown with arrows drawn between students, labeled with the type of interaction (procedural, social, and conceptual). When the same type of interaction occurred more than once, tally marks could be used to indicate how many times such an interaction occurred. An interaction about what to do next or what the reaction looked, felt, smelled like, etc. was classified as a procedural interaction. A social interaction involved talking about anything unrelated to lab, like test scores or weekend plans. A conceptual interaction was an interaction about why a certain thing was being done like adding acid to a reaction or how a certain technique worked, distillation for example. Also a topic change or a change in type was considered a new interaction and would receive another tally mark on the map. A basic map of the classroom was made, and in an attempt to give plenty of space for observations, the benches and fume hoods on the edges of the room were not included in the map. This version of the map was pilot tested during the summer sessions of CHEM 3011 and 3021 in 2013 by observing a couple of times a week for an hour. Even though only an hour's worth of observation was recorded on a sheet, it very quickly became overwhelming and very difficult to extract any useful information from the map after the fact, which also brought up the need for some way of organizing and quantifying the observational data from the maps.

The decision to use multicolored pens (one pen which could write in red, blue, green, or black) and multiple pieces of paper to record the observations greatly enhanced the usefulness of the mapping recorded. The changes in color made it possible to timestamp the observations in a way because it marked out each different 10-minute period with a different color. Because the black and blue colors were not always easily discernable, each page was limited to 30 minutes per page, which better facilitated the organization of the information after the observation and allowed for depth over breadth. Also it was decided to observe the interactions of only one set of partners per lab with two observers, one for each partner to limit the number of extra people in the lab class.

A summary record sheet was devised to include the type of interaction (procedural, social, or conceptual) and with whom the student was interacting (partner, instructor, intern, observer, or other student that was not his/her partner). It was organized further into 10-minute time periods, but a structured way of recording location was still needed. It was decided to look more at why the students were interacting at a location rather than the specific location itself. Observing that a student was interacting with someone other than his/her partner at a melting-point station would not be very interesting if both people were there to take a melting point, and it would potentially be awkward if they did not interact. However, if a student were interacting with someone at a melting-point station, it would be interesting if the other student approached the station to talk to that student, not to take a melting point. The next level of organization split each type of interaction (procedural, social, or conceptual) into two parts, proximal or intentional, referring more to intent rather than the specific location. A proximal interaction was classified as an interaction with the people around the student being observed, so most interactions between partners, with neighboring stations, with the teaching assistant (TA) walking by, or between people using the same instrument station were classified as proximal. An intentional interaction was classified as one student seeking out another student, teacher, intern, or observer specifically to interact with them. There were fewer intentional interactions by far, and they were usually indicated by a long arrow leading to an entirely different area of the room. With this added level of detail, the map was expanded to include the periphery of the lab and also lab-related areas that were not necessarily a part of the lab room but were still necessary to complete the experiment, like the IR or NMR rooms (Appendix E). This is the version of the map that was used for this study, and no further modifications were made.

The two observers were trained during general chemistry, CHEM 1111, and organic, CHEM 3011, labs. Key factors in observations like what would classify an interaction, the definitions of the types of interactions, the difference between “proximal” and “intentional,” and how to fill out the sheets were described before the first observation. The trainees, along with the lead researcher, observed the same person in a general chemistry lab for an hour and then met to compare results. In the meeting, they further clarified the meaning of the definitions of the different types of interactions and what should be called a new interaction. Then all three observed another lab and yet again met to further define the interactions. After each observation, their results became more and more consistent, and after the third general chemistry observation, the classification of interactions of all 3 observers matched at least 80%. Then all three observed the first organic lab of the semester to demonstrate the maintenance of interrater reliability of at least 80%.

There were 11 lab meetings total, but only 7 were observed because 2 were drawer check-in/out days, and two others were modeling labs carried out in the computer lab rather than performed in the regular laboratory setting. The observers recorded the interactions of a set of partners, one partner for each observer, for the duration of the lab for both sections taught by the lead researcher. A couple of times the advisor on the project substituted for one of the observers because they could not be there. After the observations, the record sheets were filled out and handed to the lead researcher who compiled all the interaction data into multiple spreadsheets in Excel. The frequency data for the interactions were normalized by dividing the number of 10-minute periods observed. Because the unit of analysis is the partnership, a score was calculated for each type of interaction (conceptual_intentional_otherstudent, conceptual_intentional_teacher, etc.) by adding the normalized amount for each observer for non-partner interactions, and averaging the two for partner interactions. The scores were analyzed using 2x3x2x3 (section x type x intent x person) 4-way repeated-measures MANOVA in SPSS. To analyze the significant interactions further, the analysis was broken down into smaller MANOVAs. After the analysis, GPower Version 3.0.10 was used to determine the ideal number of partner sets that ought to be observed for a medium effect size (0.25), power of 0.8, and a correlation of 0.3 with α at 0.05.

Grades

It was assumed that the students in the two labs were randomly assigned, but to insure that the data were not biased by an initial difference in ability, the lecture professors provided the grade of the first lecture exam. This was used as a covariate in the ANCOVA in SPSS analyzing the differences in final laboratory grade between the sections to determine if the treatment had any effect on their grade. The distributions of grades in the classes were compared using a Chi-squared test of independence.

From an administrative perspective, the retention in a class or in a major is very important because it affects the funding the university receives from the state. A common measure of lack of retention is the DWF rate, so to determine if the partner shuffling affected retention, the DWF rate was calculated. The DWF rate is the frequency of students who received either a D or F in the course or dropped the class with a W. For the purposes of this study, all the students that dropped were included in the calculation of the DWF rate. The frequencies were compared in SPSS using a Chi-Square test of independence. Effect sizes were calculated for both analyses. Power analysis in GPower was used to determine the ideal sample size for both Chi-Square analyses with a medium effect size (0.3), power of 0.8, and α at 0.05.

CHAPTER III: RESULTS AND DISCUSSION

Surveys

The students were 22.13 ± 4.04 years old on average. Most were sophomores and biology or biochemistry majors on some kind of pre-professional-school track (Table 2, Table 3). There were also about twice as many women as men in both sections (Table 4).

Table 2. Year in school of each student surveyed

Year	Frequency
Freshman	1
Sophomore	21
Junior	11
Senior	13
Post-bac	4
Total	50

Table 3. Major of the students surveyed

Major	Frequency
Chemistry	3
Chemistry, pre-prof	4
Biochemistry	11
Biochem., pre-prof	1
Biology	10
Bio, pre-prof	3
Pre-prof	8
Animal Science	2
Animal Sci., pre-prof	1
General Science	4
Forensic Science	1
Other	2
Total	50

Table 4. Frequency of each gender in the students included in the study

Gender	Frequency
Female	34
Male	16
Total	50

Using the "preferred" subset scores as the covariate, there was no statically significant differences between the sections for any of the "actual" subsets of the SLEI in the ANCOVA (Tables 5-6). Effect sizes were calculated and compared. According to Cohen (1992), all of the calculated effect sizes for the between sections analyses were small or trivial. The effect size for cohesion between the two sections was the largest, and this indicates that the switched-partner section perceived more cohesion in the classroom than did the students in the non-switched section.

The section "materials" was not one where differences were expected, but a small effect size was found. Once again, the class with switched partners had a lower average post score for "materials." There are a few possible explanations for this. Since they had a different partner and were talking to a different person every week, it might be the case that negativity breeds negativity, and that the students are having small talk, like humans usually do when conversing with strangers, about negative issues every week. It might be that some feel like there are subpar conditions in the laboratory and that keeps coming up and keeps having attention drawn to it, reinforcing that idea. It is also possible that like with most sensory information, the more something continues to happen, the more likely it will start to go unnoticed. It is very likely that in the class where the students had the same partners and worked at the same station all semester, the conditions of the lab station were what was normal to them, and these conditions were not thought about much after the first couple of weeks. In the other class though, they were in a new position in the room every week, which means a new view and new surroundings, a new bit of sensory information to file away. This tour of the room may have affected how they view the facilities. Also in Fall 2013, the school was continuing construction on the new science building, set to open and hold classes in Fall 2014.

Table 5. SLEI subset scores, comparing sections with partners by student choice or by teacher assignment

SLEI	Partner Selection	N	$\bar{x}$	S^2
"Preferred" Cohesion	Teacher	26	3.81	0.62
	Student	22	3.77	0.62
"Actual" Cohesion	Teacher	26	3.73	0.51
	Student	22	3.42	0.75
"Preferred" Integration	Teacher	26	3.90	0.37
	Student	22	3.63	0.60
"Actual" Integration	Teacher	26	3.82	0.82
	Student	22	3.81	0.90
"Preferred" Rule Clarity	Teacher	26	4.40	0.39
	Student	22	4.43	0.43
"Actual" Rule Clarity	Teacher	26	4.05	0.54
	Student	22	4.18	0.66
"Preferred" Materials	Teacher	26	3.82	0.71
	Student	22	3.66	0.69
"Actual" Materials	Teacher	26	2.97	0.92
	Student	22	3.20	0.70
"Preferred" Open-endedness	Teacher	26	2.58	0.80
	Student	22	2.43	0.68
"Actual" Open-endedness	Teacher	26	2.65	0.69
	Student	22	2.48	0.81

1= Almost never, 5=Very often

Table 6. ANCOVA of student SLEI responses

Subset	Statistic	Wilk's *F*	*p*	η^2	Adjusted effect size**	Class†
Cohesion	pre-score	10.147	0.003*	0.184	0.225	medium
	section	3.092	0.085	0.064	0.068	small
Integration	pre-score	9.188	0.004*	0.17	0.205	medium
	section	0.563	0.457	0.012	0.012	trivial
Rule Clarity	pre-score	9.36	0.004*	0.172	0.208	medium
	section	0.422	0.519	0.009	0.009	trivial
Materials	pre-score	13.012	0.001*	0.224	0.289	medium
	section	2.159	0.149	0.046	0.048	small
Open-endedness	pre-score	3.276	0.077	0.068	0.073	small
	section	0.428	0.517	0.009	0.009	trivial

*significance at $p<0.05$; **adjusted according to Cohen (1992), $\eta^2/(1-\eta^2)$; †Class according to Cohen (1992)

The other SLEI measures had trivial effect sizes between sections. This indicates that the perception of rule clarity, integration, and open-endedness did not differ significantly between sections. This means that the students did not perceive the class design or the role or guidance of the instructor as significantly different.

Of all the CLI measures, the only one that had a significant difference between sections was classroom cohesion (F=5.722, p=0.021, Refer to Tables 7-8), which is the measure of how well students know each other and get along. The cohesion score also had the highest adjusted effect size, 0.120, and "student personal support" had the next highest adjusted effect size of 0.060. Also most of the other sections that indicate some kind of community building in a classroom had small effect sizes: positive goal interdependence, student academic support, academic self-esteem, and alienation. This indicates that the classroom with partners which were switched weekly perceived more familiarity with and support from their classmates. From the power analysis in GPower, the ideal sample size for this analysis to have power of 0.8 and a medium effect size would be 128. To increase the power of this analysis, this study should be completed again, this time surveying more students.

"Fairness of grading" and "academic self-esteem" were not initially expected to have effect sizes but did have small ones. The two measures are likely related. The class with switched partners had a higher academic self-esteem (3.11 compared to 2.90) and a lower perceived fairness of grading (3.22 compared to 3.60), and they also ended up with higher first lecture-exam grades and higher final lab grades. They may have felt they deserved a higher grade than they received, and that dissatisfaction is showing in their survey responses as perceived unfairness.

There was also a small effect size for "achieving for social approval." The questions in that subset ask students to rate from 1 to 5 how much they agree with statements like, "I do my work so that my teacher will happy with me," or, "I do my work so that my classmates will be happy with me" (Appendix B). The class with switched partners had a higher score for that subset of questions, 2.62 compared to 2.29. One possible explanation for this is that now there is a community in the class and everyone knows everyone, they want to do well and not have the embarrassment of getting a bad grade and having everyone know about it.

Table 7. CLI subset scores of students surveyed

CLI measures	Partner Selection	N	$\bar{x}$	S^2
Cooperative learning	Teacher	28	3.98	0.59
	Student	22	3.92	0.77
Positive goal interdependence	Teacher	28	3.24	0.60
	Student	22	2.99	0.84
Resource interdependence	Teacher	28	3.14	0.60
	Student	22	3.17	0.72
Teacher personal support	Teacher	28	3.34	0.66
	Student	22	3.26	0.76
Teacher academic support	Teacher	28	3.82	0.82
	Student	22	3.82	0.69
Student academic support	Teacher	28	3.33	0.77
	Student	22	3.11	0.76
Student personal support	Teacher	28	3.20	0.66
	Student	22	2.89	0.60
Classroom cohesion	Teacher	28	3.39	0.65
	Student	22	2.93	0.72
Fairness of grading	Teacher	28	3.22	0.97
	Student	22	3.60	0.89
Achieving for social approval	Teacher	28	2.62	0.72
	Student	22	2.29	0.69
Academic self-esteem	Teacher	28	3.11	0.74
	Student	22	2.90	0.66
Alienation	Teacher	28	2.69	0.65
	Student	22	2.93	0.72

1=Strongly disagree, 5= Strongly agree

Table 8. ANOVA of student CLI-subset scores, comparing sections with different methods of partner selection, either student choice or teacher assignment

Measure	F	p	η^2	Adjusted effect size**	Class†
Cooperative learning	0.110	0.742	0.002	0.002	Trivial
Positive goal interdependence	1.445	0.235	0.029	0.030	Small
Resource interdependence	0.039	0.844	0.001	0.001	Trivial
Teacher personal support	0.175	0.678	0.004	0.004	Trivial
Teacher academic support	0.000	0.988	0.000	0.000	Trivial
Student academic support	0.989	0.325	0.020	0.020	Small
Student personal support	2.909	0.095	0.057	0.060	Small
Classroom cohesion	5.722	0.021*	0.107	0.120	Small
Fairness of grading	2.024	0.161	0.040	0.042	Small
Achieving for social approval	2.632	0.111	0.052	0.055	Small
Academic self-esteem	1.146	0.290	0.023	0.024	Small
Alienation	1.522	0.223	0.031	0.032	Small

*significance at $p<0.05$; **adjusted according to Cohen (1992), $\eta^2/(1-\eta^2)$; †Class according to Cohen (1992)

The remaining CLI measures had trivial effect sizes. This indicates that the perception of cooperative learning, resource interdependence, teacher personal support and teacher academic support were similar between sections. This means that the treatment did not negatively impact the students' view of the instructor. Interestingly, the students also did not perceive a different level of cooperative learning, which indicates that the class who did not switch partners still recognized that collaborative learning was occurring. The students also thought they had the same level of resource interdependence. This suggests that the setup of the classes was only different in the method and frequency of partner assignment, and that differences in the sections are a result of the differing partner assignment practices.

Time in Lab

The students in the section of organic lab where the partners were assigned by student choice spent significantly less time in lab than the partners by teacher assignment that were changed weekly, F=17.500, p<0.001 (Table 9). It seems there is a certain efficiency lost by having a new partner every week. There are several possible explanations for this. Working with a new person means getting acquainted with a new person every week which also means interactions not necessarily relevant to the lab. Additionally within established partner sets, the partners tend to fall into certain roles, and after a few weeks, less time is devoted to discussing task division. With weekly shuffling of partners, the partners within a set do not have time to fall into roles, and time has to be devoted to task division each week.

Table 9. Comparison of time in lab between sections with different methods of partner selection, either teacher assigned or student chosen

Measure	Partner Selection	N	$\bar{x}$	S^2	F	p
Time in lab (minutes)	Teacher	28	170.30	9.88	17.500	<0.001
	Student	22	155.73	15.04		

Significance at p<0.05

Observations

While there was no significant difference in interactions between the sections (F=0.046, p=0.833), there were significant main effects and interaction effects for the other variables: type (F=31.946, p<0.001), intent (F=212.355, p<0.001), person (F=9.786, p=.004), type by intent interaction (F=51.773, p<0.001), and intent by person interaction (F=16.336, p=0.001) using the multivariate approach (Tables 10-11).

The lack of statistical difference between sections may be a problem of lack of statistical power. There was a lot of variation in some of the measures from lab to lab, sometimes giving a standard deviation larger than the average measure (Table 10). Some labs required more interacting than others (Raw data in Appendix E). Just from a visual analysis of the graphs below, it is easy to see that there is a good deal of variability from week to week (Graphs 1-3), and that high degree of variability may have affected the analysis. Power analysis in GPower indicated that the necessary sample size for this analysis with a medium effect size was 30, but the sample size was only 14. To increase power, this study would need to be repeated but observing twice as many partner sets. The other significant effects suggest differences in type, intention and person.

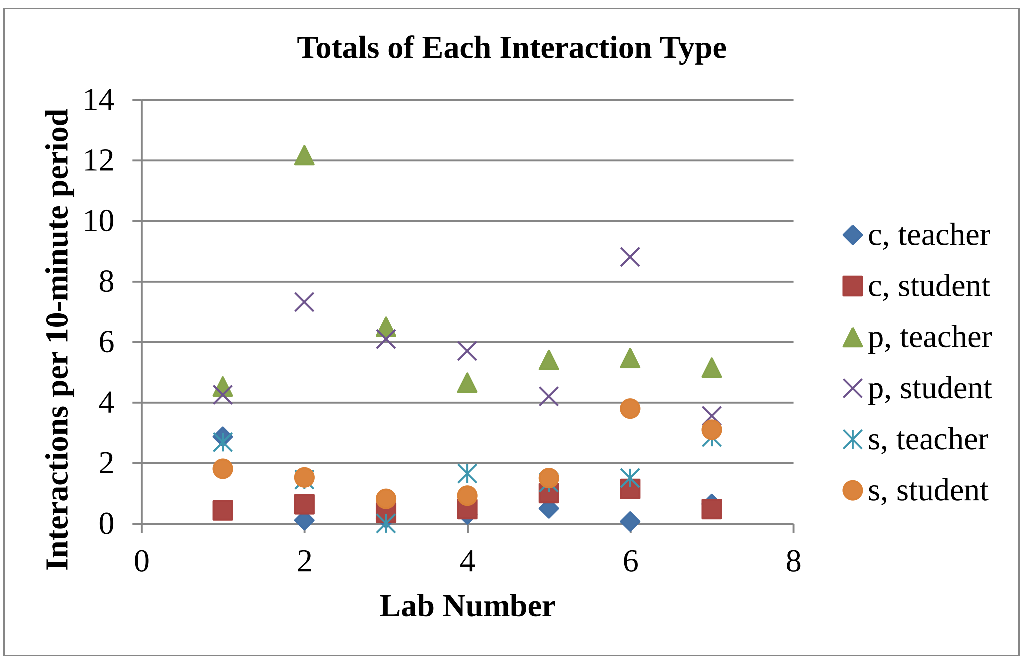
Table 10. Average number of each type of interaction per 10-minute period observed

Interaction Type	Partner Selection	N	$\bar{x}$	S^2
conceptual, proximal, other student	Teacher	7	0.09	0.11
	Student	7	0.23	0.44
conceptual, proximal, teacher	Teacher	7	0.05	0.10
	Student	7	0.14	0.26
conceptual, proximal, partner	Teacher	7	0.50	0.33
	Student	7	0.24	0.23
conceptual, intentional, other student	Teacher	7	0.00	0.00
	Student	7	0.00	0.00
conceptual, intentional, teacher	Teacher	7	0.00	0.00
	Student	7	0.05	0.10
conceptual, intentional, partner	Teacher	7	0.00	0.00
	Student	7	0.00	0.00
procedural, proximal, other student	Teacher	7	1.45	1.07
	Student	7	1.68	0.86
procedural, proximal, teacher	Teacher	7	0.94	0.61
	Student	7	1.25	1.10
procedural, proximal, partner	Teacher	7	2.68	0.60
	Student	7	2.48	1.38
procedural, intentional, other student	Teacher	7	0.23	0.41
	Student	7	0.16	0.40
procedural, intentional, teacher	Teacher	7	0.40	0.26
	Student	7	0.68	0.70
procedural, intentional, partner	Teacher	7	0.00	0.00
	Student	7	0.00	0.01
social, proximal, other student	Teacher	7	0.65	0.54
	Student	7	0.64	0.58
social, proximal, teacher	Teacher	7	0.16	0.15
	Student	7	0.37	0.47
social, proximal, partner	Teacher	7	0.98	0.58
	Student	7	0.61	0.41
social, intentional, other student	Teacher	7	0.11	0.12
	Student	7	0.01	0.02
social, intentional, teacher	Teacher	7	0.02	0.03
	Student	7	0.01	0.02
social, intentional, partner	Teacher	7	0.00	0.01
	Student	7	0.00	0.00

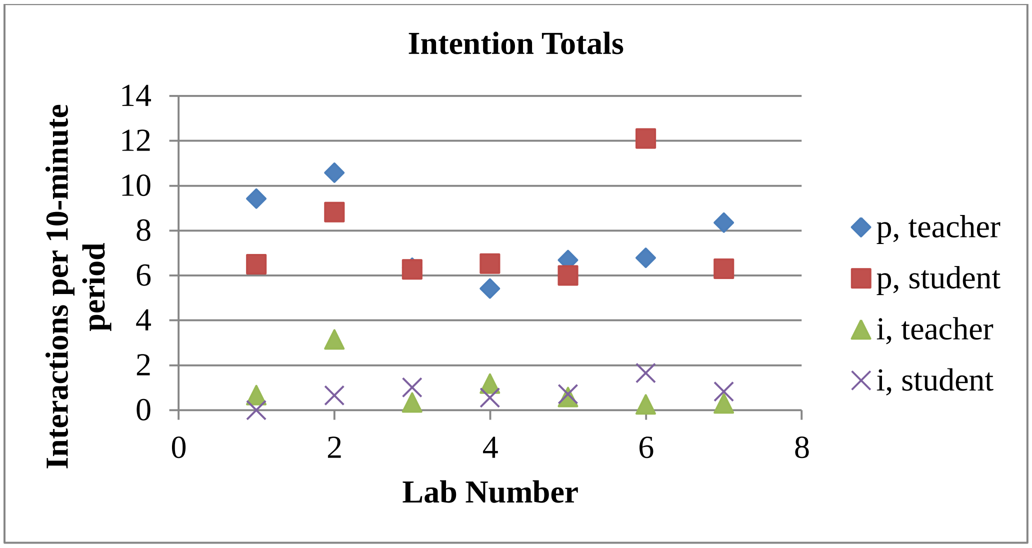
Table 11. 4-way repeated-measures MANOVA comparing the interactions of a class with partners by student choice to one by teacher assignment

Effect	Wilk's *F*	*p*
Type	31.946	<0.001*
type*section	0.283	0.759
Intent	212.355	<0.001*
intent*section	0.000	0.997
Person	9.786	0.004*
person*section	2.428	0.134
type*intent	51.773	<0.001*
type*intent*section	0.040	0.961
type*person	2.916	0.084
type*person*section	0.261	0.896
intent*person	16.336	0.001*
intent*person*section	1.246	0.325
type*intent*person	3.335	0.062
type*intent*person*section	0.343	0.843

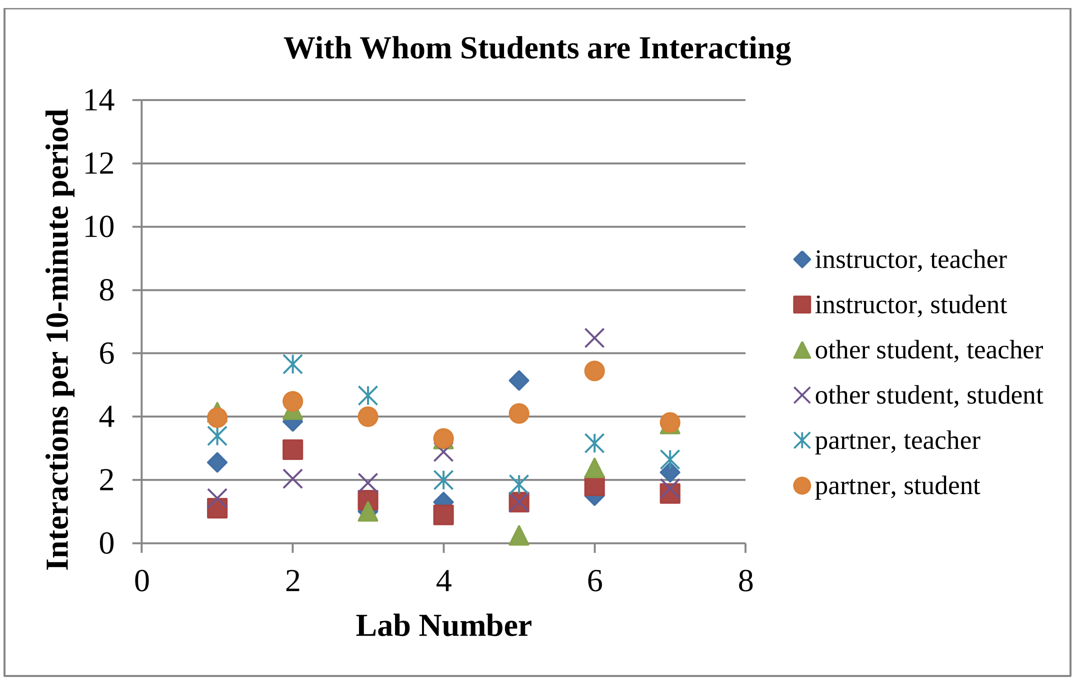
*significance at $p<0.05$



Graph 1: Total interactions per 10-minute period observed in each wet lab for each type of interaction (conceptual, procedural, and social) for both methods of partner selection (student choice or teacher assigned).



Graph 2: Total intentional and proximal interactions per 10-minute period observed for each wet lab



Graph 3: Interactions by with whom the students are interacting and by partner selection, either teacher assigned or student chosen.

Further analysis of the significant interactions among variables demonstrated that the effect of intent differed significantly between conceptual and procedural (*F*=96.691, *p*<0.001), conceptual and social (*F*=18.384, *p*=0.001), and procedural and social interactions (*F*=39.173, *p*<0.001) (Tables 12-13). For this analysis, α was adjusted by dividing it by the number of two-way MANOVAs into which the analysis was broken down. This analysis required three two-way MANOVAs, so α became 0.02. The effect of intent was largest for procedural interactions than for conceptual interactions, 4.5 compared to 0.6 (Refer to Graph 4). The effect of intent was also larger for procedural interactions than for social interactions, 4.5 compared to 1.6 (Refer to Graph 5). The effect of intent was larger for social than for conceptual interactions, 1.6 compared to 0.6 (Refer to Graph 6).

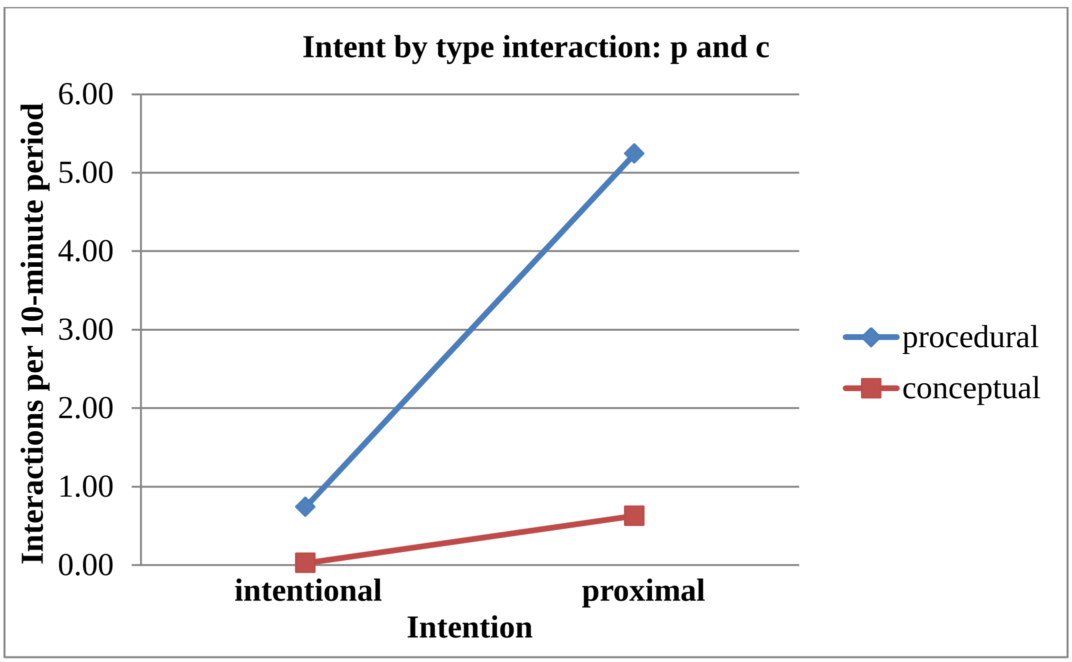
Table 12. Average number of interactions of each type and intent per 10-minute period

Measure	Partner Selection	N	$\bar{x}$	S^2
conceptual, intentional	Teacher	7	0.00	0.00
	Student	7	0.05	0.10
procedural, intentional	Teacher	7	0.63	0.52
	Student	7	0.85	1.06
social, intentional	Teacher	7	0.13	0.14
	Student	7	0.02	0.04
conceptual, proximal	Teacher	7	0.65	0.30
	Student	7	0.61	0.91
procedural, proximal	Teacher	7	5.07	1.52
	Student	7	5.42	1.79
social, proximal	Teacher	7	1.79	1.10
	Student	7	1.62	0.93

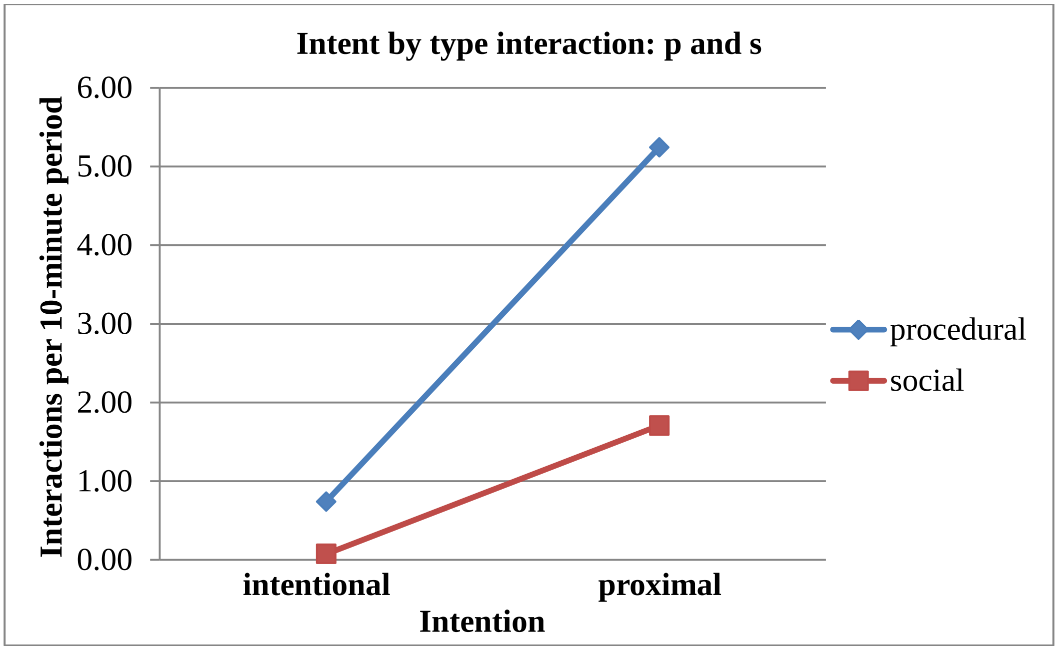
Table 13. Ignoring person, analysis of significant interactions using 2-way MANOVAs

Interaction	Comparing	Wilk's *F*	*P*
type*intent	Conceptual, procedural	96.691	<0.001*
type*intent	Conceptual, social	18.384	0.001*
type*intent	Procedural, social	39.173	<0.001*

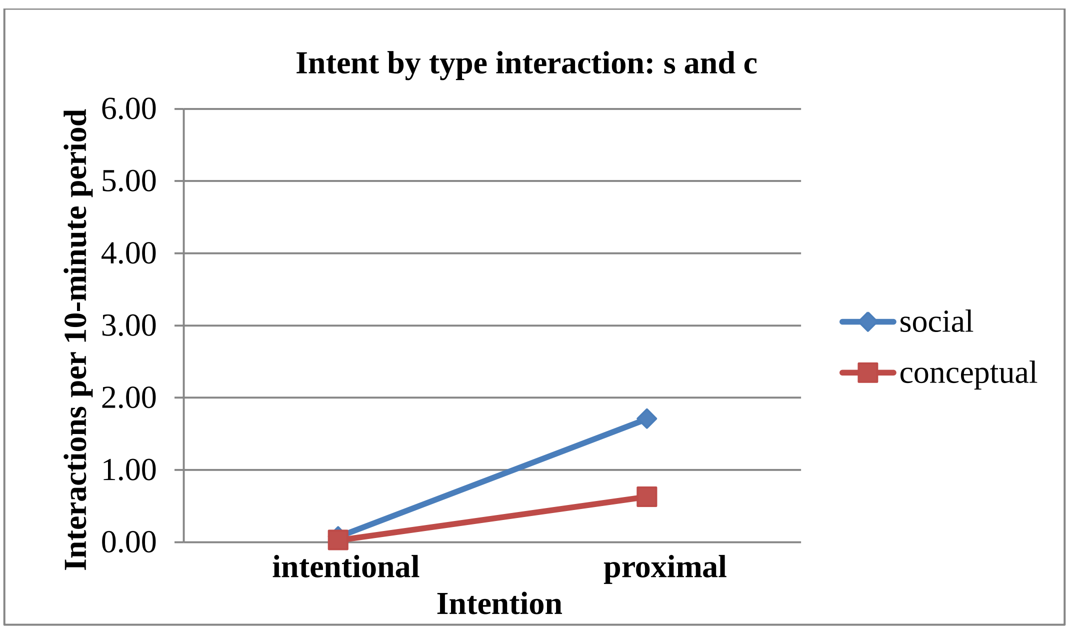
*significance at $p<0.02$



Graph 4. Average number of conceptual and procedural interactions per 10-minute period observed that were intentional and proximal



Graph 5. Average number of procedural and social interactions that were intentional and proximal per 10-minute period observed



Graph 6. Average number of social and conceptual interactions per 10-minute period observed that were intentional and proximal

The effect of intent differed significantly between other-student and partner (F=13.202, p=0.003) and also teacher and partner interactions (F=31.369, p<0.001), but non-significantly between teacher and other student interactions (F=4.738, p=0.050) (Tables 14-15). For this analysis, α was adjusted in the same manner as the previous analysis, so α became 0.02. The effect of intent for interactions with another student was smaller than interactions with a partner, 2.1 compared to 3.7 (Refer to Graph 7). The effect of intent was larger for interactions with a partner than interactions with a teacher, 3.7 compared to 0.9 (Refer to Graph 8). With the adjusted α, the effect of intent on other-student and teacher interactions was not significantly different (Refer to Graph 9).

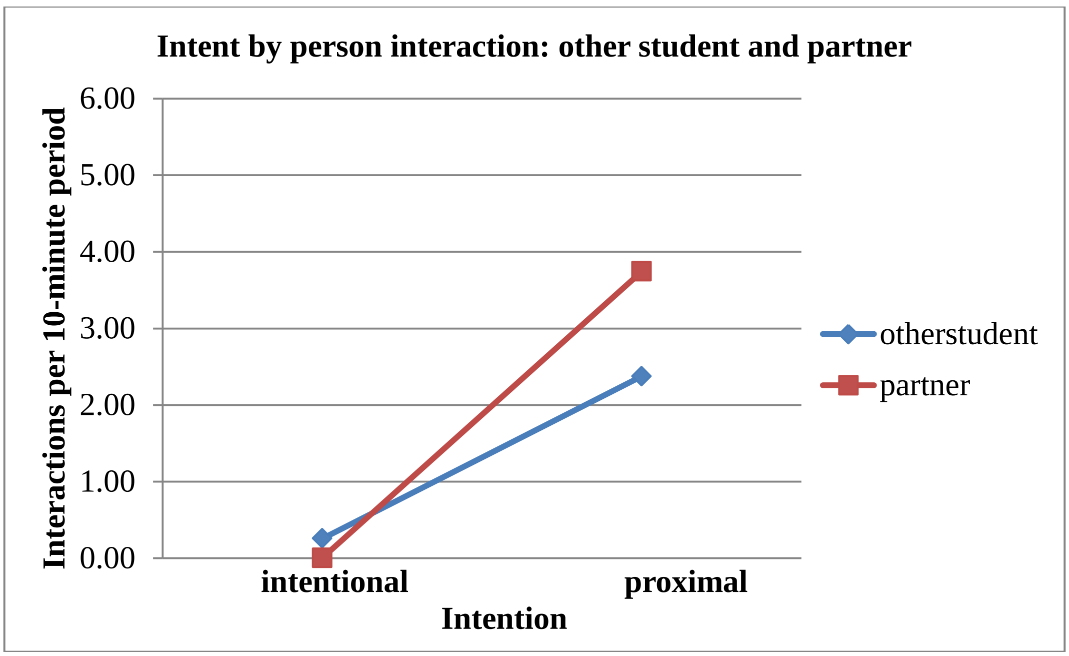
Table 14. Average number of each type of interaction per ten minute period observed for both methods of partner assignment, student choice and teacher assignment.

Measure	Partner Selection	N	$\bar{x}$	S^2
proximal, other student	teacher	7	2.20	1.53
	student	7	2.55	1.43
proximal, teacher	teacher	7	1.15	0.70
	student	7	1.76	1.42
proximal, partner	teacher	7	4.16	0.67
	student	7	3.33	1.39
intentional, other student	teacher	7	0.34	0.40
	student	7	0.17	0.40
intentional, teacher	teacher	7	0.42	0.26
	student	7	0.75	0.67
intentional, other student	teacher	7	0.00	0.01
	student	7	0.00	0.01

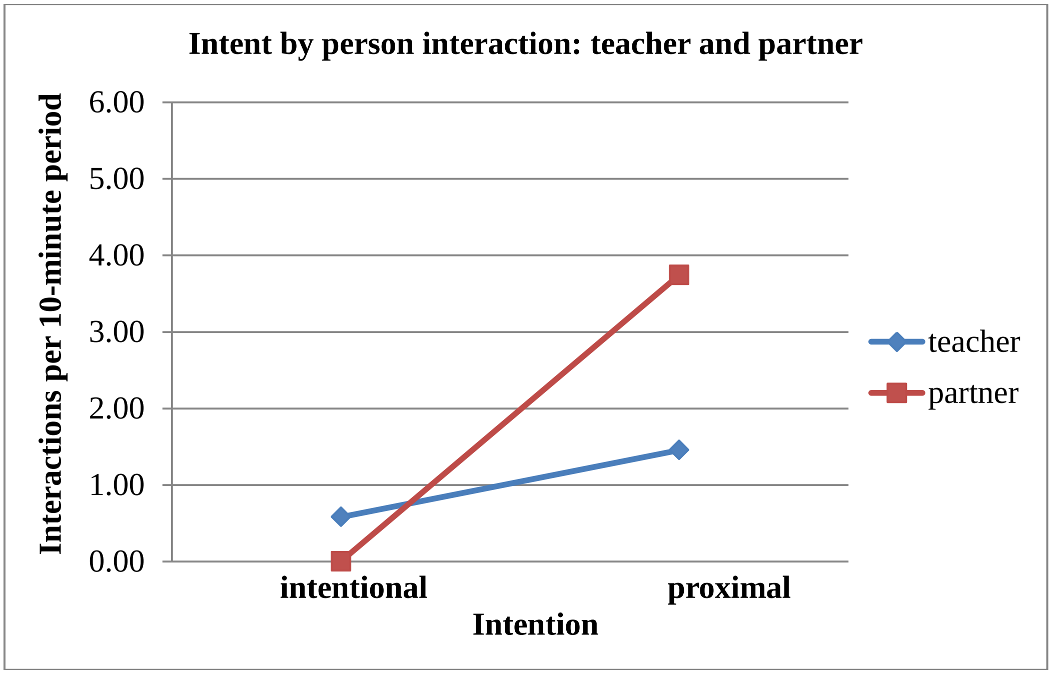
Table 15. Summary of 2-way MANOVA interaction results examining the effect on intent on interaction type.

Interaction	Comparing	Wilk's *F*	*p*
type*intent	Partner, other student	13.202	0.003*
type*intent	Partner, teacher	31.369	<0.001*
type*intent	Other student, teacher	4.738	0.050

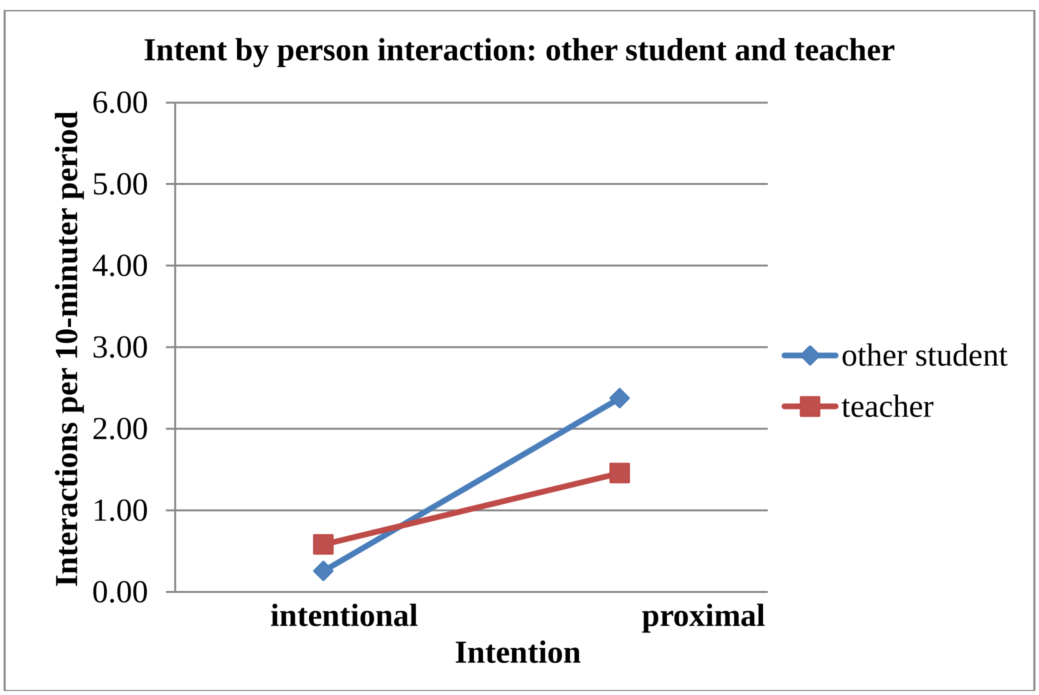
*significance at $p<0.02$



Graph 7. Average number of interactions per 10-minute period with another student and a partner broken-down by intention of interaction



Graph 8. Intention of interactions per 10-minute period with a teacher or with a partner



Graph 9. Average number intentional and proximal interactions per 10-minute period with another student and with a teacher.

Part of these differences in effects comes down to numbers. There are just so many more procedural interactions in general than there are the other two types, and the average number of conceptual interactions per 10-minute period observed over the course of the semester is less than one. Also there are so few intentional interactions in general. There are a few explanations for this. Most of the procedural interactions occur with partners, which also means that because of the setup of the instrument, that most procedural interactions are proximal interactions. The times when students have sought out another person are when they needed to know something that their partner did not, which explains the non-significant difference on the effect of intent between interactions with a teacher or with another student besides the partner.

Also the overshadowing of procedural interactions over the other interaction types may be an artifact of the type of labs performed in CHEM 3011 and the attitude of the students in the class. The majority of the labs performed in CHEM 3011 are cookbook-type or illustration labs that teach a technique or demonstrate a concept or reaction learned in the lecture class and really do not require much higher-level thinking to successfully complete, which also means that it is not necessarily important to have conceptual interactions because there is not much need to fully understand the reaction or method. Additionally, despite having signed up for a lab that has three hours budgeted for it, students rarely are willing to be in lab for the entire three-hour period. They generally try to complete the experiment as quickly as possible, which means a lot of procedural questions and interactions so they can move on to the next step with shortcuts and without really having to think about what the procedure says.

Grades

The partners by student-choice did not receive a significantly different grade in lab than the partners by teacher-assignment (Tables 16-17). Also the grade distributions for each section were compared using a χ^2 test of independence (Tables 18-19). There was not a significant difference in the grade distribution. An effect size was calculated for the Chi-Square value, and it was small (0.279). This indicated that there is some difference between sections in grade distribution. Power analysis indicated that the ideal sample size for medium effect size and power of 0.8 for the grade distribution analysis is 143, so the sample size should have been almost three times bigger than it was.

It seemed as though there might be a difference in the DWF rate between the sections because more students dropped in the partners-by-student-choice class. For the purposes of this study, the DWF rate was used as a measure of successful retention. A student has been successfully retained if he or she receives an A, B, or C in the class, and not if they receive a D, F or drop/withdraw from the class before they complete it. Both classes started out with 30 students each. In the class with partners by teacher-assignment 24 students were retained, while in the student-choice class, only 18 were retained. (Table 20). However this difference is not statistically significant (Table 21). An effect size was calculated for the Chi-square value, and it was small (0.218). This indicated that there is some difference between sections in DWF rate. Power analysis indicated that the sample size for a medium effect size with power of 0.8 should be 88.

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Table 16. First lecture test and lab total grades for both sections

Grades	Partner Selection	*N*	$\bar{x}$	S^2
first lecture test	Teacher	28	75.25	16.21
	Student	22	66.05	16.06
lab total	Teacher	28	81.25	11.27
	Student	22	76.65	15.69

Table 17. Comparison of lab grades between sections using first lecture test as a covariate

Statistic	*F*	*p*
test 1	29.862	<0.001*
section	0.002	0.961

*significance at $p<0.05$

Table 18. Grade Distribution

Partner Selection		A	B	C	D	F	dropped
teacher	count	6	11	7	2	2	2
	residual	0.5	2	0.5	0	0	-3
student	count	5	7	6	2	2	8
	residual	-0.5	-2	-0.5	0	0	3

Table 19. Chi-Squared test of independence on grade distribution

	Value	df	*N*	*p*
Pearson Chi-Square	4.657	5	60	0.459
Likelihood Ratio	4.919	5	60	0.426

Table 20. DWF Rate

Partner Selection	DWF Frequency	DWF %
teacher	6	20
student	12	40

Table 21. Chi-squared test on DWF rate

	Value	df	*N*	*p*
Pearson Chi-Square	2.857	1	60	0.091
Likelihood Ratio	2.899	1	60	0.089

Further Qualitative Observations

Often these observations assist in understanding the quantitative data or lead to new research questions. The observations of there labs were no different (Appendix F). There were many interesting things that were observed but not measured directly. For example, during the computer simulation labs, students were allowed to pick their partner. In the class that switched partners weekly during wet labs, interestingly students often times would still work with someone they had not worked with before, this time by their own choosing. They would usually just end up working with whomever they happened to sit next to when they arrived to the computer lab, and usually the computer assignment ended up more like a whole class assignment because they would all end up helping each other with the procedure, questions, and calculations. This likely occurred because of their familiarity with one another.

The same person taught both labs, but after a while the two labs had a different atmosphere. The first time that the lead researcher began to notice a difference in the feel of the two classes was the first reaction day in organic chemistry I laboratory, wet lab 5, synthesis of bromobutane from butanol using HBr. There is a step where sulfuric acid is added to the reaction, and the reaction vessel gets very warm very quickly. Usually when there are unexpected changes, at least from the student perspective, in temperature or color, they ask the teacher if that is right or what is supposed to happen. In the switched class though, one of the students went up to almost every partner set in the room to ask them if their reaction did the same thing, and then they proceeded to talk about what they thought was happening that would make the flask so warm. Again the whole class was involved in a discussion and not so dependent on the teacher for confirmation.

That whole-class discussion was not always the case in the switched class. In the first few weeks of lab, the students in that class actually seemed to rely more on the instructor and intern when compared to the class that chose their partners. It took a few labs for them to get to know each other and realize that there were resources in the classroom besides the instructor.

The weekly change in scenery in the switched class also seemed to make the students in that class have a different view of the observers than the other class had. In the class where partners and thus lab stations were changed weekly, the students seemed less aware that the observers were observing and treated them more like the intern or another resource in the class. However in the other section, the students were more aware of the observers and less apt to talk to the observers, and the students treated them more like intruders than resources.

CHAPTER IV: CONCLUSION

Implications

Changing partners weekly contributes to the formation of a community in the classroom. The survey responses on both the Classroom Life Instrument and the Science Laboratory Environment Inventory indicate that the students in the class where a new partner was assigned every week perceived a greater degree of community in the class environment. While the students did take longer on average to complete the experiment, that time may have been invested in community building which means that it was not really wasted at all.

While there was some degree of discomfort with the treatment, there was not so much that the students' responses were overwhelmingly negative on the surveys or in their conversations with the observers, interns, or instructor. Also the treatment or frustration with it did not cause them to perform poorly in the class. Being uncomfortable on some level is a necessary step in the learning process according to constructivist theory. Managing frustration so that it does not become counterproductive is an important job of a teacher. Based on student responses and class scores, these two things seem to be in balance.

To have more confidence in our results and increase our statistical power, the experiment needs to be repeated with a larger sample size. This would hopefully increase the clarity of the survey responses, retention measures, and the observational data, and it would paint a better picture of the differences in group dynamic in classrooms with the different types of partner assignment.

Future Research Questions and Directions

The observational instrument met the needs of this study and aided in the collection of meaningful data. All that being said, the instrument needs to be further refined to increase its utility. There are still a few aspects that are not as clearly defined as they really ought to be. For instance, there may need to be another type of interaction listed because all of the things that were not lab related were lumped under "social" when maybe some of them could be put under another heading. Perhaps "managerial" could be used for the conversations about lab grades or the interactions that involved giving back lab reports. Perhaps "miscellaneous" could be used for the other interactions that are more difficult to classify and do not fit under an already established type and for the sake of economy on the record sheet and map will be classified together.

Also the beginning of a new interaction needs to be further refined. It has already been defined as a change in type of interaction or an interaction with a different person, but it has been difficult to draw the line between when one interaction ends and a new interaction begins of the same type with the same person during the same conversation. The observers and lead researcher had many talks during the course of the experiment about what classified a new interaction, and despite this, the clarity of this definition is still not optimal. The best way to fix this may lie in better and more training for the observers, so they can make that call and so that they are consistent in what they count as a new interaction. Also as the instrument becomes more established, the training will too, and the kinks in the training process can be further worked out, along with the kinks in the instrument.

The potential uses for the observational instrument are interesting to consider. With all the interest in how lab should be structured, it could be used to examine the interaction differences in chemistry labs of different types. For example in an inquiry-based lab, one might expect more conceptual interactions, so it would be interesting to see if that is really the case using an instrument that would track interaction types. The instrument could also be used to probe the interaction differences between classes with linked lab and lecture and those without. One might expect the interactions to be different because the students would have a higher degree of familiarity with each other in the linked class and also would have interactions outside of the laboratory class. These are both reform efforts discussed to increase learning and retention, and the observations instrument would allow those questions to be explored more intentionally and from a different perspective.

Take-Home Lesson

Just from a cost-benefit analysis perspective, switching partners or group members often is worth it. There are no major drawbacks for the students: even though they took more time when they switched partners weekly, they did not take more time than the time allotted on average, and their grades were not negatively affected. They did have a huge plus though-- they felt more connected and supported in the class. The biggest (but still not very big) downside from the instructor point of view is that he or she will have to come up with those new groups often. Other than that, there is no modification to instructor style, no increase in grading, no additional student testing, and no increase in time spent preparing for class, assuming that the teacher already uses some cooperative or collaborative activities in his or her classroom. Overall what the student gains from having a community in class—increased support from peers and teachers and increased positive learning outcomes—far outweighs the five minutes of extra work it requires to setup the groups.

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APPENDICES

APPENDIX A:

Sign-in Sheet

Experiment: Section #:

Date:

#1: Intro: Rxn: Table: Procedure: Time Out:	#2: Intro: Rxn: Table: Procedure: Time Out:
Intro: Rxn: Table: Procedure: Time Out:	Intro: Rxn: Table: Procedure: Time Out:
#3: Intro: Rxn: Table: Procedure: Time Out:	#4: Intro: Rxn: Table: Procedure: Time Out:
Intro: Rxn: Table: Procedure: Time Out:	Intro: Rxn: Table: Procedure: Time Out:
#5: Intro: Rxn: Table: Procedure: Time Out:	#6: Intro: Rxn: Table: Procedure: Time Out:
Intro: Rxn: Table: Procedure: Time Out:	Intro: Rxn: Table: Procedure: Time Out:
#7: Intro: Rxn: Table: Procedure: Time Out:	#8: Intro: Rxn: Table: Procedure: Time Out:
Intro: Rxn: Table: Procedure: Time Out:	Intro: Rxn: Table: Procedure: Time Out:
#9: Intro: Rxn: Table: Procedure: Time Out:	#10: Intro: Rxn: Table: Procedure: Time Out:
Intro: Rxn: Table: Procedure: Time Out:	Intro: Rxn: Table: Procedure: Time Out:
#11: Intro: Rxn: Table: Procedure: Time Out:	#12: Intro: Rxn: Table: Procedure: Time Out:
Intro: Rxn: Table: Procedure: Time Out:	Intro: Rxn: Table: Procedure: Time Out:
#13: Intro: Rxn: Table: Procedure: Time Out:	#14: Intro: Rxn: Table: Procedure: Time Out:
Intro: Rxn: Table: Procedure: Time Out:	Intro: Rxn: Table: Procedure: Time Out:

APPENDIX B

Classroom Life Instrument

Item	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1. In this class other students want me to do my best lab work.	1	2	3	4	5
2. In this class are my best friends.	1	2	3	4	5
3. I am not doing as well in lab as I would like to.	1	2	3	4	5
4. I find it hard to speak my thoughts clearly in class.	1	2	3	4	5
5. In this class other students like to help me learn.	1	2	3	4	5
6. Lab work is fairly easy for me.	1	2	3	4	5
7. In this class other students think it is important to be my friend.	1	2	3	4	5
8. When we work in small groups we try to make sure that everyone in our group learns the assigned material.	1	2	3	4	5
9. I do lab work to make my teacher happy.	1	2	3	4	5
10. In this class I like to work with others.	1	2	3	4	5
11. I should get along with other students better than I do.	1	2	3	4	5
12. I do lab work because my classmates expect it of me.	1	2	3	4	5
13. My teacher really cares about me.	1	2	3	4	5
14. When we work together in small groups our job is not done until everyone in our group has finished the assignment.	1	2	3	4	5
15. My teacher thinks it is important to be my friend.	1	2	3	4	5
16. In this class everyone has an equal chance to be successful if they do their best.	1	2	3	4	5
17. In this class other students care about how much I learn.	1	2	3	4	5
18. Whenever I take a test I’m afraid I will fail.	1	2	3	4	5

Item	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
19. I am doing a good job of learning in this class.	1	2	3	4	5
20. In this class other students like me the way I am.	1	2	3	4	5
21. When we work together in small groups we all receive the same grade.	1	2	3	4	5
22. My teacher cares about how much I learn.	1	2	3	4	5
23. I do school work to make my parents happy.	1	2	3	4	5
24. In this class everybody is a friend.	1	2	3	4	5
25. In this class other students want me to come to class every day.	1	2	3	4	5
26. I do lab work to keep my teacher from getting mad at me.	1	2	3	4	5
27. When we work together in small groups our grade depends on how much all members learn.	1	2	3	4	5
28. My teacher likes to see my work.	1	2	3	4	5
29. In this class other students care about my feelings.	1	2	3	4	5
30. I often get discouraged in school.	1	2	3	4	5
31. In this class other students like me as much as they like others.	1	2	3	4	5
32. In this class if a student works hard, he/she can definitely succeed.	1	2	3	4	5
33. My teacher likes to help me learn.	1	2	3	4	5
34. When we work together in small groups I have to make sure that the other members learn if I want to do well on the assignment.	1	2	3	4	5
35. In this class other students really care about me.	1	2	3	4	5
36. I have lots of questions I never get the chance to ask in class.	1	2	3	4	5
37. I do lab work to be liked by other students.	1	2	3	4	5

Item	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
38. My teacher wants me to do my best in lab work.	1	2	3	4	5
39. When we work together in small groups we cannot complete an assignment unless everyone contributes.	1	2	3	4	5
40. My teacher likes me as much as he/she like other students.	1	2	3	4	5
41. In this class I am often lonely.	1	2	3	4	5
42. In this class students get the scores they deserve, no more and no less.	1	2	3	4	5
43. My teacher cares about my feelings.	1	2	3	4	5
44. In this class all of the students know each other well.	1	2	3	4	5
45. I deserve the scores I get.	1	2	3	4	5
46. I am a good student.	1	2	3	4	5
47. When we work together in small groups the teacher divides up the material so that everyone has a part and everyone has a share.	1	2	3	4	5
48. I often feel upset in lab.	1	2	3	4	5
49. Sometimes I think the scoring system in this class is not fair.	1	2	3	4	5
50. When we work together in small groups we have to share materials in order to complete the assignment.	1	2	3	4	5
51. In this class I like to share my ideas and materials with other students.	1	2	3	4	5
52. When we work together in small groups everyone's ideas are needed if we are going to be successful.	1	2	3	4	5
53. In this class I can learn important things from other students.	1	2	3	4	5
54. In this class I like to help other students learn.	1	2	3	4	5
55. In this class I try to share my ideas and materials with other students when I think it will help them.	1	2	3	4	5

Item	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
56. When we work together in small groups, I have to find out what everyone else knows if I am going to be able to do the assignment.	1	2	3	4	5
57. In this class it is a good idea for students to help each other learn.	1	2	3	4	5
58. In this class I like to cooperate with other students.	1	2	3	4	5
59. In this class students learn lots of important things from each other.	1	2	3	4	5

Breakdown of Questions by subset

Subset	Question #
cooperative learning	51, 53, 54, 55, 57, 58, 59
positive goal interdependence	8, 14, 21, 27, 34
resource interdependence	39, 47, 50, 52, 56
teacher academic support	22, 28, 33, 38
teacher personal support	13, 15, 40, 43
student academic support	1, 5, 17, 25
student personal support	7, 20, 29, 31, 35
classroom cohesion	2, 10, 24, 41*,44
fairness of grading	16, 32, 42, 45, 49*
achieving for social approval	9, 12, 23, 26, 37
academic self-esteem	3*, 6, 18*, 19, 46
alienation	3, 4, 6*, 11, 18, 30, 36, 41, 46*, 48, 49

*indicates scoring was reversed

Student scores on CLI Measures from the class with partners by student choice

Subject	cooperative learning	positive goal interdependence	resource interdependence	teacher personal support
69	1.571	1.000	2.200	3.250
70	4.286	2.400	1.800	3.250
71	4.000	3.200	3.800	3.000
74	4.000	4.600	3.800	3.250
75	3.571	2.200	2.400	1.250
77	3.571	3.600	3.600	4.000
78	5.000	3.800	4.400	4.375
79	4.000	3.000	3.000	3.000
80	4.286	2.800	2.600	2.500
81	5.000	2.800	3.000	2.750
83	3.429	4.000	4.200	4.500
84	3.000	3.200	3.000	3.750
85	3.286	1.800	3.000	2.250
87	3.857	3.600	2.800	4.000
88	3.571	2.200	3.000	3.750
89	4.143	3.600	3.000	3.750
90	3.286	2.600	3.200	2.750
91	4.857	3.600	3.400	3.750
92	4.143	3.200	4.400	3.000
93	4.429	3.800	4.000	3.250
219	4.000	2.000	2.200	2.500

Subject	teacher academic support	student academic support	student personal support	classroom cohesion
69	4.000	1.250	1.000	1.000
70	4.250	4.000	3.200	3.200
71	3.250	3.500	2.800	3.000
74	3.250	3.250	3.400	3.400
75	2.500	2.250	2.000	2.200
77	4.250	3.000	2.800	3.000
78	4.750	4.500	3.800	4.600
79	3.000	2.500	3.000	3.000
80	3.000	2.250	2.800	2.600
81	4.250	3.250	3.200	2.600
83	4.750	2.250	2.600	2.800
84	3.750	3.250	2.600	3.000
85	2.750	2.500	2.800	2.600
87	4.500	3.750	3.200	2.200
88	3.750	3.500	2.800	2.800
89	4.750	3.250	2.800	3.200
90	3.250	2.750	2.600	2.400
91	4.500	3.750	4.000	3.600
92	3.750	4.000	3.000	2.600
93	3.750	2.750	3.200	4.200
219	3.500	3.000	2.800	3.200

Subject	fairness of grading	achieving for social approval	academic self-esteem	alienation
69	3.200	2.800	3.000	3.091
70	4.200	1.400	3.600	1.909
71	3.400	2.600	3.200	3.091
74	4.200	2.600	2.400	3.636
75	1.800	2.200	2.200	3.818
77	4.600	2.000	3.600	1.545
78	4.800	2.600	3.000	2.455
79	3.600	3.000	2.800	2.909
80	3.200	1.800	2.400	3.182
81	5.000	1.000	3.600	2.000
83	3.400	3.000	2.800	3.636
84	3.000	3.800	2.800	3.273
85	2.800	2.200	3.200	3.182
87	3.600	2.400	3.800	2.273
88	2.000	1.200	1.800	3.909
89	4.600	2.600	2.600	3.273
90	3.600	2.800	1.800	3.455
91	3.400	1.400	2.800	3.182
92	2.800	3.000	2.600	3.455
93	4.000	2.400	3.600	2.273
219	3.000	2.000	2.000	3.364

Student scores on CLI subsets from the class with weekly assigned partners

Subject	cooperative learning	positive goal interdependence	resource interdependence	teacher personal support
160	4.857	3.600	2.800	4.250
161	4.857	4.000	4.800	3.250
162	4.143	3.800	3.800	3.500
163	4.429	3.600	3.800	3.750
164	4.714	3.600	3.800	4.000
165	3.286	2.200	2.600	2.250
166	4.714	3.200	3.600	3.250
167	3.000	2.400	3.000	3.250
168	3.857	3.000	2.800	3.500
169	4.429	2.400	3.200	2.500
170	4.429	3.400	2.800	3.000
171	4.000	3.800	3.400	3.250
172	3.857	3.200	2.400	4.500
173	3.429	3.000	3.200	2.750
174	4.000	3.800	3.800	3.000
175	4.429	3.800	3.000	3.750
176	3.286	3.200	3.000	3.250
177	4.286	2.600	2.200	3.000
178	3.857	2.800	2.800	4.000
179	3.429	3.000	2.800	2.750
180	3.571	3.200	2.600	3.250
181	3.857	3.000	2.800	3.000
182	5.000	4.800	3.800	5.000
185	2.857	2.600	3.000	3.000
186	3.571	2.200	2.400	2.000
187	4.143	3.200	2.400	3.250
224	4.000	3.600	4.000	4.000
225	3.143	3.600	3.200	3.250

Subject	teacher academic support	student academic support	student personal support	classroom cohesion
160	5.000	4.250	3.600	4.000
161	5.000	3.250	2.200	2.000
162	4.000	3.500	4.200	4.200
163	4.250	3.250	3.000	4.000
164	5.000	1.750	2.200	3.400
165	2.750	3.000	2.400	2.400
166	4.250	3.500	2.400	3.600
167	3.000	3.250	3.000	3.200
168	4.000	3.250	3.800	3.600
169	4.000	2.750	2.400	2.800
170	5.000	3.000	3.400	2.800
171	3.500	3.500	3.400	3.600
172	4.250	3.750	4.000	3.000
173	3.000	2.250	2.600	3.800
174	2.750	2.750	3.200	3.000
175	4.250	5.000	4.200	3.800
176	3.250	3.000	3.200	3.600
177	2.750	4.500	3.600	4.200
178	4.250	3.500	3.400	3.000
179	3.500	2.750	2.800	3.400
180	4.000	3.500	3.200	3.800
181	4.250	3.500	2.800	3.200
182	4.750	5.000	5.000	4.600
185	2.500	3.250	3.000	3.000
186	2.000	1.750	2.600	2.000
187	4.250	3.250	3.200	4.400
224	4.000	3.500	3.600	3.200
225	3.500	3.750	3.200	3.400

Subject	fairness of grading	achieving for social approval	academic self-esteem	alienation
160	4.600	4.400	4.800	1.364
161	2.800	2.200	2.200	3.273
162	4.200	1.600	3.600	1.909
163	4.200	1.800	3.800	2.000
164	3.600	2.000	3.200	2.727
165	4.000	3.000	3.200	3.364
166	4.000	2.800	3.400	2.000
167	1.800	2.000	1.400	3.273
168	3.800	2.800	2.800	3.182
169	3.200	2.600	3.200	2.727
170	2.600	2.600	3.400	2.545
171	3.600	3.000	3.000	3.273
172	2.600	2.800	3.400	2.545
173	2.800	2.800	2.200	3.273
174	1.600	3.600	3.200	2.364
175	4.200	2.800	3.000	3.182
176	2.400	2.800	2.400	3.273
177	2.800	2.900	2.800	3.000
178	4.600	1.200	4.200	1.455
179	3.400	2.600	3.000	2.636
180	3.800	2.400	4.400	1.727
181	2.200	1.200	2.600	2.909
182	3.400	4.000	3.200	2.636
185	1.600	2.800	2.000	3.455
186	1.200	2.200	2.600	3.273
187	4.600	2.400	4.000	1.636
224	3.600	3.200	3.200	3.273
225	3.000	2.800	3.000	3.091

APPENDIX C: Science Laboratory Environment Inventory

Item	Almost never	Seldom	Sometimes	Often	Very often
1. Students in this laboratory class get along well as a group.	1	2	3	4	5
2. What we do in our regular science class is unrelated to our laboratory work.	1	2	3	4	5
3. Our laboratory class has clear rules to guide student activities	1	2	3	4	5
4. The laboratory is crowded when we are doing experiments.	1	2	3	4	5
5. Students have little chance to get to know each other in this laboratory class.	1	2	3	4	5
6. The laboratory work is unrelated to the topics that we are studying in our science class.	1	2	3	4	5
7. This laboratory is rather informal and few rules are imposed.	1	2	3	4	5
8. The equipment and materials that students need for laboratory activities are readily available.	1	2	3	4	5
9. Members of this laboratory class help one another.	1	2	3	4	5
10. Our regular science class work is integrated with laboratory activities.	1	2	3	4	5
11. Students are required to follow certain rules in the laboratory.	1	2	3	4	5
12. Students are ashamed of the appearance of this laboratory.	1	2	3	4	5
13. Students in this laboratory class get to know each other well.	1	2	3	4	5
14. We use the theory from our regular science class sessions during laboratory activities.	1	2	3	4	5
15. There is a recognized way of doing things safely in this laboratory.	1	2	3	4	5
16. Laboratory equipment is in poor working order.	1	2	3	4	5
17. Students are able to depend on each other for help during laboratory classes.	1	2	3	4	5
18. The topics covered in regular science class work are quite different from topics dealt with in laboratory sessions.	1	2	3	4	5

Item	Almost never	Seldom	Sometimes	Often	Very often
19. There are few fixed rules for students to follow in laboratory sessions.	1	2	3	4	5
20. The laboratory is hot and stuffy.	1	2	3	4	5
21. It takes a long time to get to know everybody by his/her first name in this laboratory class.	1	2	3	4	5
22. In our laboratory sessions, the teacher/instructor decides the best way to carry out the laboratory experiments..	1	2	3	4	5
23. What we do in laboratory sessions helps us to understand the theory covered in regular science classes.	1	2	3	4	5
24. The teacher/instructor outlines safety precautions before laboratory sessions commence.	1	2	3	4	5
25. The laboratory is an attractive place in which to work.	1	2	3	4	5
26. Students work cooperatively in laboratory sessions.	1	2	3	4	5
27. Students decide the best way to proceed during laboratory experiments.	1	2	3	4	5
28. Laboratory work and regular science class work are unrelated.	1	2	3	4	5
29. This laboratory class is run under clearer rules than other classes.	1	2	3	4	5
30. The laboratory has enough room for individual or group work.	1	2	3	4	5

The same surveys were given for the “actual” and “preferred” versions. Only the directions were different. The directions for the “preferred” version said to answer based on your expectations for the semester, and for the “actual” version to answer based on what actually happened over the course of the semester. The original version also contained more “openendedness” questions, but because they were not relevant to our study, they were eliminated for economy.

Breakdown for Questions of SLEI

Subset	Question
cohesion	1, 5*, 9, 13, 17, 21*, 26
integration	2*, 6*, 10, 14, 18*, 23, 28*
rule clarity	3, 7*, 11, 15, 19*, 24, 29
materials	4*, 8, 12*,16*, 20*, 25, 30
openendedness	22*, 27

*indicates scoring was reversed

Pre-Scores for each SLEI question subset

Subject	Partner Selection	Cohesion	Integration	Rule clarity	Materials	Open-endedness
68	student	3.857	3.714	4.286	3.429	3.500
69	student	3.571	2.429	4.857	2.571	1.500
70	student	4.714	4.429	4.857	3.714	1.000
71	student	3.429	3.143	4.143	4.429	3.000
72	student	4.000	3.143	4.714	3.000	2.000
74	student	3.857	3.286	3.714	4.143	3.500
75	student	2.857	4.286	4.286	2.857	2.000
77	student	4.571	4.429	4.714	5.000	2.000
78	student	4.143	3.286	4.286	4.429	2.500
79	student	3.714	2.571	4.286	3.143	2.500
80	student	4.714	4.429	5.000	4.857	3.000
81	student	4.714	4.000	5.000	3.857	1.500
83	student	3.286	3.000	4.286	3.143	2.000
84	student	2.286	3.429	4.714	3.000	1.500
85	student	3.143	3.429	3.429	3.286	3.000
87	student	3.714	3.714	4.286	4.571	3.000
88	student	3.857	3.571	4.286	3.571	2.500
89	student	4.429	4.143	5.000	3.429	3.000
90	student	3.429	3.143	4.286	3.286	2.500
91	student	3.286	3.714	3.857	2.857	2.500
92	student	3.857	4.429	4.857	4.000	3.000
93	student	3.571	4.143	4.286	4.000	2.500

Subject	Partner Selection	Cohesion	Integration	Rule clarity	Materials	Open-endedness
160	teacher	3.286	3.714	4.571	3.857	2.000
161	teacher	3.714	3.571	4.000	4.000	3.500
162	teacher	5.000	4.429	4.857	5.000	2.500
163	teacher	4.286	4.000	4.857	4.143	2.500
164	teacher	4.000	4.429	4.857	4.429	3.000
165	teacher	3.143	3.714	3.714	3.000	3.500
166	teacher	4.000	3.429	4.571	3.857	3.000
167	teacher	4.714	3.857	4.143	4.286	2.500
168	teacher	3.429	3.714	4.000	3.286	2.500
169	teacher	4.429	4.429	4.714	4.571	2.000
170	teacher	3.714	4.000	4.714	2.714	3.500
171	teacher	3.429	4.143	4.143	3.143	2.500
172	teacher	3.571	3.857	4.714	3.286	2.000
173	teacher	3.000	3.857	3.857	3.143	3.000
174	teacher	3.714	2.857	4.143	2.714	5.000
175	teacher	4.429	3.571	4.143	3.429	1.500
176	teacher	4.714	3.857	4.571	4.714	1.500
177	teacher	3.714	4.000	4.857	2.857	2.500
178	teacher	2.429	3.857	4.857	4.857	2.000
179	teacher	2.857	4.286	4.000	4.143	2.000
180	teacher	4.000	3.714	4.857	4.714	2.000
181	teacher	4.000	4.429	4.286	4.143	3.500
182	teacher	4.429	4.143	3.857	4.571	3.000
185	teacher	4.143	4.143	4.571	3.714	2.000
186	teacher	3.143	3.429	3.857	2.857	2.500
187	teacher	3.857	3.857	4.714	3.857	1.500

Post scores for each SLEI question subset

Subject	Partner Selection	Cohesion	Integration	Rule clarity	Materials	Open-endedness
68	student	4.143	4.857	4.286	3.857	3.000
69	student	2.000	1.429	4.714	1.857	1.000
70	student	4.143	4.857	4.714	2.714	1.000
71	student	4.286	4.286	3.429	4.143	2.500
72	student	4.000	3.000	4.429	2.714	2.000
74	student	3.429	2.857	3.286	4.000	3.500
75	student	2.571	4.143	4.286	2.857	3.500
77	student	3.143	3.429	3.000	2.714	3.000
78	student	4.429	5.000	4.429	4.143	2.500
79	student	3.286	3.000	4.000	3.571	2.000
80	student	2.714	2.714	4.000	4.429	3.500
81	student	5.000	4.286	4.429	3.143	2.500
83	student	3.143	3.286	3.857	2.143	3.000
84	student	2.429	4.857	5.000	3.143	1.500
85	student	3.143	3.143	3.143	3.000	3.000
87	student	4.143	4.286	4.857	3.000	3.500
88	student	2.714	3.714	4.857	3.286	2.500
89	student	3.143	4.857	5.000	3.429	3.000
90	student	3.143	4.286	3.571	3.714	2.500
91	student	3.000	4.143	4.857	2.571	2.000
92	student	3.286	3.429	3.143	2.286	1.000
93	student	3.857	3.857	4.571	3.714	2.500

Subject	Partner Selection	Cohesion	Integration	Rule clarity	Materials	Open-endedness
160	teacher	3.571	4.286	4.857	3.714	2.000
161	teacher	3.286	3.714	4.714	4.714	2.500
162	teacher	4.143	4.286	4.571	3.571	3.000
163	teacher	4.000	4.571	4.143	3.714	3.500
164	teacher	3.000	3.714	4.286	1.286	4.000
165	teacher	2.714	4.286	3.429	3.143	2.500
166	teacher	3.286	4.143	3.714	3.571	2.500
167	teacher	4.000	4.286	3.857	4.286	3.000
168	teacher	3.857	4.143	4.571	2.429	2.500
169	teacher	3.714	4.571	4.571	2.571	3.500
170	teacher	3.286	4.714	4.571	1.714	2.500
171	teacher	3.857	3.714	3.286	2.143	3.000
172	teacher	3.429	3.000	4.286	3.000	2.500
173	teacher	3.429	2.429	3.286	2.143	4.000
174	teacher	3.571	2.286	4.286	2.286	2.000
175	teacher	3.857	3.714	3.286	2.143	3.000
176	teacher	4.143	2.000	3.571	2.000	2.500
177	teacher	4.714	5.000	3.714	2.000	3.000
178	teacher	3.429	4.143	4.857	4.143	2.500
179	teacher	3.714	4.143	4.000	2.714	2.000
180	teacher	3.429	3.000	4.429	3.429	3.500
181	teacher	3.571	4.286	4.000	3.000	2.500
182	teacher	4.857	4.857	3.571	4.286	2.000
185	teacher	3.857	3.714	3.714	4.000	2.000
186	teacher	3.429	2.429	3.143	2.000	2.000
187	teacher	4.714	3.857	4.714	3.286	1.000

APPENDIX D: Demographic Survey

Name: ______________________________ Section #:____

Gender: ________

Age: ____

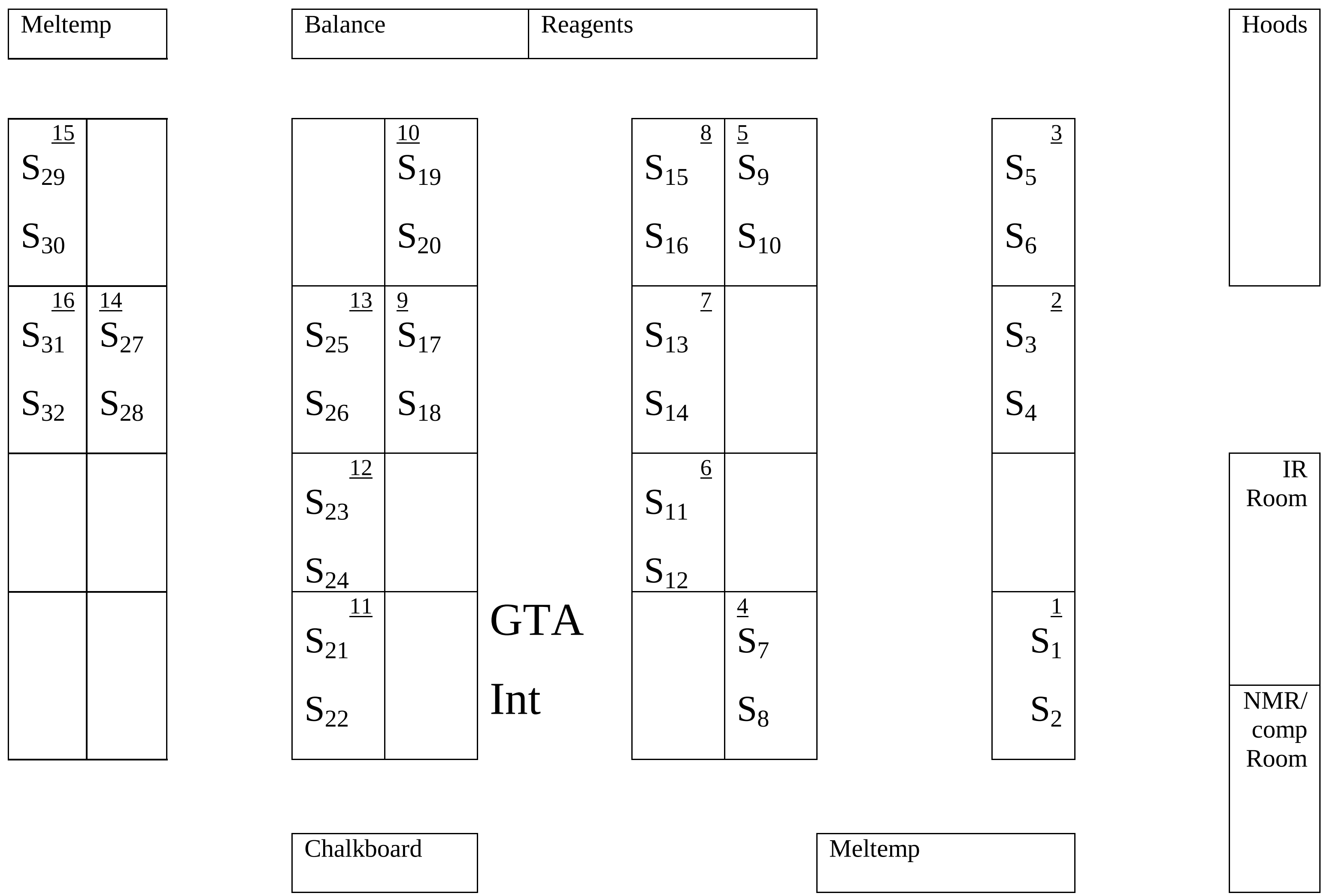
Year in school:
- ☐ Freshman
- ☐ Sophomore
- ☐ Junior
- ☐ Senior
- ☐ Post-bac

Major (check all that apply):
- ☐ Chemistry
- ☐ Biochemistry
- ☐ Biology
- ☐ Pre-professional
- ☐ General Science
- ☐ Animal Science
- ☐ Forensic Science
- ☐ Other:_______________

Minor (check all that apply):
- ☐ Biology
- ☐ Chemistry
- ☐ Physics
- ☐ Math
- ☐ None
- ☐ Other:_______________

Expected Lecture Grade:
- ☐ A
- ☐ B
- ☐ C
- ☐ D
- ☐ F

Expected Lab Grade:
- ☐ A
- ☐ B
- ☐ C
- ☐ D
- ☐ F


Meltemp
Balance
Reagents
Hoods
15
S29
S30
10
S19
S20
8
S15
S16
5
S9
S10
3
S5
S6
16
S31
S32
14
S27
S28
13
S25
S26
9
S17
S18
7
S13
S14
2
S3
S4
12
S23
S24
6
S11
S12
IR Room
11
S21
S22
GTA
Int
4
S7
S8
1
S1
S2
NMR/ comp Room
Chalkboard
Meltemp

	10						20						30					
	P/O		S		C		P/O		S		C		P/O		S		C	
Interacting w/	P	I	P	I	P	I	P	I	P	I	P	I	P	I	P	I	P	I
Partner																		
Instructor																		
Intern																		
Observers																		
student______________																		
student______________																		
student______________																		
student______________																		
student______________																		

	40						50						60					
	P/O		S		C		P/O		S		C		P/O		S		C	
Interacting w/	P	I	P	I	P	I	P	I	P	I	P	I	P	I	P	I	P	I
Partner																		
Instructor																		
Intern																		
Observers																		
student______________																		
student______________																		
student______________																		
student______________																		
student______________																		
student______________																		

	70						80						90					
	P/O		S		C		P/O		S		C		P/O		S		C	
Interacting w/	P	I	P	I	P	I	P	I	P	I	P	I	P	I	P	I	P	I
Partner																		
Instructor																		
Intern																		
Observers																		
student_______________																		
student_______________																		
student_______________																		
student_______________																		

	100						110						120					
	P/O		S		C		P/O		S		C		P/O		S		C	
Interacting w/	P	I	P	I	P	I	P	I	P	I	P	I	P	I	P	I	P	I
Partner																		
Instructor																		
Intern																		
Observers																		
student_______________																		
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student_______________																		
student_______________																		
student_																		

	130						140						150					
	P/O		S		C		P/O		S		C		P/O		S		C	
Interacting w/	P	I	P	I	P	I	P	I	P	I	P	I	P	I	P	I	P	I
Partner																		
Instructor																		
Intern																		
Observers																		
student_______________																		
student_______________																		
student_______________																		
student_______________																		
student_______________																		

	160						170						180					
	P/O		S		C		P/O		S		C		P/O		S		C	
Interacting w/	P	I	P	I	P	I	P	I	P	I	P	I	P	I	P	I	P	I
Partner																		
Instructor																		
Intern																		
Observers																		
student_______________																		
student_______________																		
student_______________																		
student_______________																		
student________________																		

	190						200						210					
	P/O		S		C		P/O		S		C		P/O		S		C	
Interacting w/	P	I	P	I	P	I	P	I	P	I	P	I	P	I	P	I	P	I
Partner																		
Instructor																		
Intern																		
Observers																		
student_______________																		
student_______________																		
student_______________																		
student_______________																		
student_______________																		

	220						230						240					
	P/O		S		C		P/O		S		C		P/O		S		C	
Interacting w/	P	I	P	I	P	I	P	I	P	I	P	I	P	I	P	I	P	I
Partner																		
Instructor																		
Intern																		
Observers																		
student_______________																		
student_______________																		
student_______________																		
student_______________																		
student_______________																		
student_______________																		

Calculated interaction totals for each lab

Conceptual, proximal interactions

Partner Selection	wet lab	10-minute periods	c_p_otherstudent	c_p_teacher	c_p_partner
teacher	1	14.5	0.133	0.000	0.302
student		17	1.188	0.722	0.722
teacher	2	17	0.056	0.250	0.326
student		17	0.053	0.000	0.053
teacher	3	11	0.000	0.000	0.364
student		6	0.000	0.000	0.167
teacher	4	18	0.278	0.000	0.194
student		17.5	0.000	0.000	0.294
teacher	5	7.5	0.000	0.000	1.000
student		7.5	0.000	0.143	0.214
teacher	6	15.5	0.192	0.000	0.950
student		16	0.000	0.000	0.063
teacher	7	17	0.000	0.111	0.361
student		17	0.353	0.118	0.176

Conceptual, intentional interactions

section	wet lab	10-minute periods	c_i_otherstudent	c_i_teacher	c_i_partner
teacher	1	14.5	0.000	0.000	0.000
student		17	0.000	0.236	0.000
teacher	2	17	0.000	0.000	0.000
student		17	0.000	0.000	0.000
teacher	3	11	0.000	0.000	0.000
student		6	0.000	0.000	0.000
teacher	4	18	0.000	0.000	0.000
student		17.5	0.000	0.000	0.000
teacher	5	7.5	0.000	0.000	0.000
student		7.5	0.000	0.143	0.000
teacher	6	15.5	0.000	0.000	0.000
student		16	0.000	0.000	0.000
teacher	7	17	0.000	0.000	0.000
student		17	0.000	0.000	0.000

Procedural, proximal interactions

section	wet lab	10-minute periods	p_p_otherstudent	p_p_teacher	p_p_partner
teacher	1	14.5	0.824	0.895	2.531
student		17	1.785	0.694	1.736
teacher	2	17	1.333	2.181	3.347
student		17	2.940	1.716	4.363
teacher	3	11	1.364	0.364	3.455
student		6	1.000	0.667	4.500
teacher	4	18	2.056	0.333	2.806
student		17.5	2.000	0.118	1.353
teacher	5	7.5	0.900	1.000	1.800
student		7.5	0.250	3.482	1.241
teacher	6	15.5	3.500	0.975	2.688
student		16	1.625	1.250	2.344
teacher	7	17	0.174	0.819	2.135
student		17	2.176	0.824	1.853

Procedural, intentional interactions

section	wet lab	10-minute periods	p_i_otherstudent	p_i_teacher	p_i_partner
teacher	1	14.5	0.000	0.000	0.000
student		17	0.000	0.278	0.028
teacher	2	17	0.000	0.458	0.000
student		17	1.067	2.077	0.000
teacher	3	11	0.091	0.818	0.000
student		6	0.000	0.333	0.000
teacher	4	18	0.000	0.500	0.000
student		17.5	0.000	1.176	0.000
teacher	5	7.5	0.200	0.300	0.000
student		7.5	0.000	0.429	0.000
teacher	6	15.5	1.133	0.513	0.000
student		16	0.000	0.250	0.000
teacher	7	17	0.188	0.236	0.000
student		17	0.059	0.235	0.000

Social, proximal interactions

section	wet lab	10-minute periods	s_p_otherstudent	s_p_teacher	s_p_partner
teacher	1	14.5	0.467	0.210	1.136
student		17	1.111	0.556	0.903
teacher	2	17	0.458	0.063	0.809
student		17	0.158	0.053	1.242
teacher	3	11	0.364	0.182	0.182
student		6	0.000	0.000	0.000
teacher	4	18	0.556	0.000	0.306
student		17.5	1.294	0.000	0.353
teacher	5	7.5	0.000	0.000	1.300
student		7.5	0.000	0.946	0.402
teacher	6	15.5	1.658	0.329	1.806
student		16	0.750	0.000	0.750
teacher	7	17	1.063	0.347	1.288
student		17	1.176	1.059	0.618

Social, intentional interactions

section	wet lab	10-minute periods	s_i_otherstudent	s_i_teacher	s_i_partner
teacher	1	14.5	0.000	0.000	0.000
student		17	0.056	0.063	0.000
teacher	2	17	0.188	0.000	0.000
student		17	0.000	0.000	0.000
teacher	3	11	0.091	0.000	0.000
student		6	0.000	0.000	0.000
teacher	4	18	0.000	0.056	0.000
student		17.5	0.000	0.000	0.000
teacher	5	7.5	0.200	0.000	0.000
student		7.5	0.000	0.000	0.000
teacher	6	15.5	0.000	0.000	0.000
student		16	0.000	0.000	0.000
teacher	7	17	0.313	0.056	0.031
student		17	0.000	0.000	0.000

APPENDIX F: Other Qualitative Observations

Interesting observations:

-At the end of the lab, in the section where the partners were switched weekly, one partner thanked the other for good work during the lab.

-The students tended to ask the intern basic procedural questions and where to dispose of waste.

-In the class where students picked their partners, the minorities in the classroom tended to segregate themselves. African Americans in the class tended to work together and in one specific section of the lab. Also the Middle-Eastern students also tended to work together and in one specific section of the lab. In the class where partners were changed weekly, they were limited a little by with whom they were assigned to work, but generally when it came to with whom the students chose to interact, the minorities once again tended to only interact with each other.

-In the class where students picked their partners, the observers were noticed more as observers. The students tended to observe the observers and treat them like people who did not belong in the class. In the class where students were assigned a different partner every week, the observers were seen more as resources and treated similarly to how the students treated the intern.

-In the class where students picked their partners, some of the partners did not interact. There was a partner set that actually physically turned their bodies away from one another and did not interact for long periods of time.

-in the beginning, the class where the partners were changed weekly seemed to interact a lot more with the instructor. It may be that the students did not know yet who was a resource so they asked the teacher more for help initially.

APPENDIX G: IRB Approval

August 23, 2013

Rachael Suzette Hall
CC: Dr. Amy Phelps
Protocol Title: **Group assignment and its relation to classroom climate, time on task, and achievement in the organic chemistry lab**
Protocol Number: 14-022

Dear Investigator(s),

The MTSU Institutional Review Board or its representative has reviewed the research proposal identified above. The MTSU IRB or its representative has determined that the study meets the criteria for approval under 45 CFR 46.110 and 21 CFR 56.110, and you have satisfactorily addressed all of the points brought up during the review.

Approval is granted for one (1) year from the date of this letter for **250** participants. Please use the version of the consent form with the compliance office stamp on it that will be emailed to you shortly.

Please note that any unanticipated harms to participants or adverse events must be reported to the Office of Compliance at (615) 494-8918. Any change to the protocol must be submitted to the IRB before implementing this change.

You will need to submit an end-of-project report to the Office of Compliance upon completion of your research. Complete research means that you have finished collecting and analyzing data. Should you not finish your research within the one (1) year period, you must submit a Progress Report and request a continuation prior to the expiration date. Please allow time for review and requested revisions. Failure to submit a Progress Report and request for continuation will automatically result in cancellation of your research study. Therefore, you will NOT be able to use any data and/or collect any data.

According to MTSU Policy, a researcher is defined as anyone who works with data or has contact with participants. Anyone meeting this definition needs to be listed on the protocol and needs to complete training (there is no need to include training certificates in your correspondence with the IRB). If you add researchers to an approved project, please forward an updated list of researchers to the Office of Compliance (compliance@mtsu.edu) before they begin to work on the project.

All paperwork, including consent forms, needs to be given to the faculty advisor for storage. All research materials must be retained by the PI or faculty advisor (if the PI is a student) for at least three (3) years after study completion and then destroyed in a manner that maintains confidentiality and anonymity.

Sincerely,

William Langston
Chair, MTSU Institutional Review Board