The "Chemistry Mafia": The Social Structure of Chemistry Majors in Lab

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Abstract

A great deal of attention has been paid to the effects of group work on the performance of students enrolled in chemistry courses. However, relatively little research has been done that addresses possible explanations for the observed improvement in student performance when group work is done. In this study, a combination of field notes based on observations made during classroom laboratory courses taken by chemistry majors, individual interviews with students in the sections that were observed, and focus-group interviews with groups of students who worked together in the lab provided insight into the social interactions that occur when chemistry majors work in groups over a sequence of classroom laboratory courses. The data suggest that these social interactions set the basis for the development of a community of learners, a "Chemistry Mafia", who trust each other well enough to seek help with the content knowledge of their chemistry courses, which they might be loathe to seek from peers with whom they are less familiar. This work suggests that "off-task" interactions (e.g., socializing) in the laboratory are, in fact, valuable in developing this community of learners.

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Introduction

Group work in both K-12 and higher education has received an incredible amount of attention in recent years. Most of this work has focused on the benefits of group work, which include better performance in class, better interpersonal skills, higher retention of covered topics, and improved attitudes towards science (Bowen, 2000; Cohen, 1994; Dougherty *et al.*, 1995; Lazarowitz & Hertz-Lazarowitz, 1998; Okebukola & Ogunniyi, 1984; Tlusty *et al.*, 1993). Articles on group work that do not focus on the specific benefits of working in groups, examine the kind of group structure – such as optimal size and ability distribution – that elicits those benefits (Farrell *et al.*, 1999; Lawrenz & Munch, 1984; Lazarowitz *et al.*, 1994). There is abundant evidence that group learning consistently "works" (e.g. Felder, 1996; Gamson, 1994; Springer *et al.*, 1999); what we need to know is how.

Hamby-Towns and co-workers studied what small-group learning activities meant to students involved in an undergraduate thermodynamics class that utilized group work during "Problem-Solving Sessions" (Hamby Towns *et al.*, 2000; Kreke & Hamby Towns, 1997). This study provided useful insights into group work by using a qualitative research approach to determine the students' perspectives on group work. The authors found that group work in this class contributed to positive outcomes such as content learning and assessment performance because it built a feeling of community among the students. This feeling of community in turn fostered the development of “mutual goals centered on learning and achievement” (Hamby Towns et al., 2000, p. 115). The interplay between this feeling of community and mutual goals may ultimately lead to the improvements in learning, achievement and persistence documented in the literature.

Support for building a feeling of community is also found in the literature describing mentor programs established to encourage women and minorities to enter and stay in the fields of science. In a study of women and minority students in science, mathematics and engineering (SME) programs, Seymour (1995) found that participants were unlikely to feel that they “belong” in that field, regardless of how well prepared they were when they entered an SME program. She argued that the lack of belonging leads to shaken confidence and ultimately to a change in major to something outside of SME (Seymour, 1995). Programs across the nation purposefully build resources such as mentoring, tutoring, residential hall programs, cultural centers, and faculty support to encourage a sense of community among their women and minorities majoring in science (Bernstein, 1997; Carmichael & Sevenair, 1991; Hoyte & Collett, 1993; Johnson & Parrott, 1992; Kahveci *et al.*, 2006, 2008). Perhaps it is not surprising that historically black institutions and women’s colleges, which actively work to develop a sense of community among their students, have better track records at graduating women and minorities in the sciences than other educational institutions (Carmichael & Sevenair, 1991; Sebrechts, 1992), or that the University of Puerto Rico graduates more Hispanic students who go on for their doctorate than any of its mainland competition (Hoyte & Collett, 1993). In each of these cases, women and minorities are not targeted as isolated groups of people. Instead, they are considered part of the majority and consequently have the support of their surrounding community of peers, which sees them through the difficult times and to the completion of a degree. However, as Kahveci (2006) found, there is evidence to suggest that retention of all students, not just select sub-groups, is becoming critical.

These studies establish that group work and a sense of belonging among science students positively influences their academic achievement and retention in SME. The goal of this paper is to examine the processes involved in the construction of a self-formed community of chemistry majors. Particular attention is paid to both the academic and emotional support systems established among students within their laboratory courses at varying levels in the chemistry curriculum. This is particularly relevant in light of the fact that chemistry is often perceived as one of the more challenging science disciplines (Osborne *et al.*, 2003). The goal is not to assess the productivity of students in the laboratory, their academic accomplishments, or their longitudinal retention in the major as a result of working in groups – relationships which have been studied extensively in the past and were shown to be a positive influence as discussed earlier. Instead, the intent of this study is to focus specifically on how individuals interact both within a group and between groups to develop the sense of community so integral to higher learning and performance, and higher retention in the major. Given that group work has already been established as an effective tool in teaching and retention, the research question guiding this study is:

> What interactions occur between chemistry majors within the context of classroom laboratory group work that contribute to a sense of community between those students?

Theoretical Framework

The theoretical framework chosen to shape this work is symbolic interactionism. Traditionally grounded in elements of social psychology, symbolic interactionism attempts to answer the question: "What common set of symbols and understandings have emerged to give meaning to people's interactions?" (Patton, 1990, p 75). These meanings are of central importance in symbolic interactionism and are governed by three assumptions (Blumer, 1969; Patton, 1990; Schwandt, 1997):

- Humans act toward the objects and people in their environments on the basis of the meanings these objects and people have for them.
- These meanings derive from the social interaction (communication, broadly understood) between and among individuals.
- Meanings are established and modified through an interpretive process undertaken by the individual actor.

These assumptions imply that meaning is only established through social communication and is "objective or behavioral" (Gallant & Kleinman, 1983). In other words, meanings are not held in individuals' minds; they are a social entity and are consequently contextualized in the social environment. Therefore, a particular meaning is not determined by an individual's experiences, but by the social interactions (communications) the individual has with his/her peers. It is these constantly evolving meanings that determine people's actions.

Methodologically speaking, the main goal of an interactionist is to use observable interactions to identify implied symbolic behavior (Denzin, 1969). This goal indicates that certain research practices need to be followed. First, both behavioral analyses and analysis of personally held meanings and definitions must be examined. This means data must consist of both observations of actions – or interactions such as those that occur in a laboratory environment – and in-depth interviews to uncover individual meanings. One without the other would only allow the researcher to gain insight into either the observable or the implied; not both.

Second, both individual and interactional meanings must be examined and analyzed. As the data are examined, the researcher seeks existing associations between the observed behaviors and the meanings that students possess and acquire through the laboratory experience. In the context of this study, behaviors observed in the lab setting were compared to the meanings drawn from interviews in search of connections between the two realms.

Third, the researcher must view things through the perspective of participants involved in the study in order to adequately understand human action. The best way to achieve this is for the researcher to enter the participants' setting or situation. Participant observation becomes a key method here (Patton, 2002); it allows the researcher to contextualize the data being collected and participate in the interactions of the participants. The researcher, in this case a student of science herself – with experience in both the classroom laboratory and research laboratory settings – was allowed a unique insight into the domain under study.

Fourth, meanings are tied to social situations – or contextualized – and therefore the situation or setting itself becomes an element of analysis. Here, one must address the role of the researcher and how his/her presence affects the interaction process. This becomes a particularly important point for participant observation where the researcher's presence in a lab potentially alters the behaviors exhibited by the students and will be discussed in detail later.

Finally, the methodological approach must be pliable, to reflect both the stability and constant change of a social group. This is most commonly handled by triangulation, which involves the use of more than one data collection technique (Patton, 1990, 2002). The multiple methodologies deemed appropriate for this work included a combination of laboratory observations, individual interviews, and group interviews.

Methodology

The methodological design of this study included three parts: individual semi-structured interviews, focus-group interviews, and observations in a chemistry classroom laboratory setting. Each aspect of the study design allowed for a different but complimentary insight into students' ideas about social behavior in a lab setting. One course at each level of a 4-year, chemistry-major curriculum was chosen to study students' perceptions of their experiences as science students. Observations were conducted throughout an entire, 16-week, Fall semester at a large, state funded, Midwestern institution in four courses, three of which were designed for and taken only by chemistry majors — a 100-level general chemistry course taken by first-year students, a 200-level inorganic course taken by second- or third-year students, a 300-level analytical course taken by third-year students, and a 400-level instrumental analysis course taken by fourth- or fifth- year students seeking the ACS certified degree. The only course that included students who were not chemistry majors was the 300-level course, in which 7 of the 18 students were pre-pharmacy majors. Since the courses were spread out over the entire four year sequence leading to a B.S. degree in chemistry, students ranged in age from 18-23 years old. All courses had a mandatory laboratory component and built upon previous courses. The 400-level course, for example, assumed that the students would have had laboratory experiences in all three previous courses. While the same students likely progress through the sequence of courses together, the size of the program – approximately 60-80 chemistry graduates per year – requires several sections of a particular lab course to be offered during any given semester. Therefore, groups of students do not necessarily enroll in the same laboratory sections from year to year, despite the fact that they are in the same lecture and frequently see one another during that time.

These specific courses and their individual sections were selected so that the researcher could fit all four lab sections into her schedule. Each course met once a week and the observer attended every 3-hour laboratory session until all students had left the room (see Table I for additional information).

Table I:
Breakdown of the enrollment of the observed sections, number of lab sessions that met during the Fall 2000 semester, and typical lab group size for each observed course

	100-level	*200-level*	*300-level*	*400-level*
Enrollment	37 (split into 2 adjoining rooms)	16	18	13
Sessions	13	14	9	12
Group Size	2-3	2-4	4-5	2-5

Detailed field notes were taken with pen and paper, then transcribed and elaborated on within 24 hours of the lab meeting. Notes included descriptions of accounts of interactions students had with each other, the equipment used in the lab, the teaching assistant, or the researcher, and even included comments students made to themselves. In line with the theoretical framework and participant observation, the researcher interacted with the students, answering questions about the lab when she could, getting involved in conversations between students, and discussing the details of her research when asked. While it is conceivable that the researcher's presence altered the behavior of the students, the role the researcher attempted to play was that of someone between "student" and "knowledgeable expert". This allowed her to fit in to the laboratory setting with as little intrusion as possible since students were accustomed to the presence of each other and teaching assistants. Observations collected during the labs played a crucial role in determining the content and structure of both the individual and focus group interviews.

Half-way through the semester, volunteers were asked to participate in group and individual interviews. All students who volunteered were scheduled for interviews. Students who could not meet during group times were slotted as individual interview participants. Two focus groups from each class were organized (for a total of eight group interviews) and ranged in size from three to six students. With the exception of one student, no one who participated in the group interviews participated in an individual interview. Groups were also organized such that only students from the same lab sections were involved in a single group, allowing the group to discuss issues specific to their course and section. Unlike the individual interviews, the focus-group interviews supplemented the discussion by adding the social aspect of the classroom laboratory. In line with the symbolic interactionism framework, focus group interviews were able to contextualize the topic of conversation – which was often an event from lab – with the same people involved in the laboratory. This also allowed the researcher to probe for meaning behind the particular event without students being distracted by their lab responsibilities. As with any group setting this may have intimidated some, but it inspired others and usually instigated a lively discourse that allowed for social interaction and was welcomed as part of the discourse.

The key characteristic of focus groups is "the explicit use of the group interaction to produce data and insights that would be less accessible without the interaction found in a group" (Morgan, 1988, p. 12). Focus groups were useful here because they allowed the social aspect of chemistry to emerge and be observed as well as discussed. As Morgan notes, focus groups can reveal attitudes and cognitions in the same way as individual interviews, but they can also reveal social roles and organizations similar to participant observations. Consequently, the focus group interviews served as a connective bridge between the observations and the individual interviews. Although the focus-group interviews did not take place in a laboratory setting, the participants in a given focus group were always from the same laboratory section and therefore had common laboratory experiences to bring to the discussion.

Two individuals from each course volunteered to participate in interviews but could not arrange to meet with the group. These eight individuals instead participated in individual interviews ranging in length from approximately 45-120 minutes. These interviews were conducted within the same time frame as the group interviews but at a time more convenient to the student than the group interview. Individual interviews allowed for a detailed account of what each participant believed and experienced. There were minimal peer-related social constraints and influences on the students in these interviews because only the researcher and the participant were present. The researcher was therefore able to ask probing questions pertaining to issues at hand and uncover the implied meanings that events had for the participants.

All interviews were unstructured and started with the question: "What do you think of [course number] lab?" Where the conversation went from there was determined by the student(s). The researcher asked an occasional question to either get the conversation going, direct the conversation back on track, or probe a particular issue further. Certain topics that became apparent from the observations and were specifically addressed by the interviewer included the social aspect of lab, the time constraints of lab, and students' attitudes toward lab. Interviews allowed participants to clarify and explain specific observations and validate the researcher's interpretation of those observations. The interviews were audio-taped and transcribed in full by the researcher for analysis.

Analysis

Inductive analysis was performed with the aid of the "Atlas.ti" software package (Muhr, 1997) and was ongoing throughout data collection. Transcripts and observation notes were read and coded by the researcher based on the predominant themes that emerged from individual text units[1] with the data. The field notes and observations, individual interviews, and group interviews were coded separately with the analysis of

[1] For the purpose of this analysis, the term "text unit" is defined as a segment of transcribed text which falls under a particular code that can vary in length from a few lines to a paragraph or more.

the field notes and observations taking place first simply because they were collected before interviews were conducted.

One of the most recurrent themes from the classroom observations was how frequently students entered into social interactions among themselves, with the researcher, and/or with the teaching assistant. During the first phase of the analysis, the codes “social talk” and “social including researcher” were created to identify occurrences of behavior and conversation that were “off-task” — not directly related to the laboratory task at hand. On-task activities were coded separately because group work has already been shown to be effective in improving performance (Lazarowitz & Hertz-Lazarowitz, 1998), and given our research question our focus here is on the social interaction within the laboratory, not the quality of laboratory performance. Therefore, on-task activities will not be discussed this paper, and happened concurrently with – rather than instead of – off-task activities and conversations with the exception of one type of activity titled “killing time.” Table II lists the distribution of text units coded for each class in the original categories of “social talk” – social conversations between any number of students – and “social including researcher” – social conversations between students and the researcher.

Table II:
Number of “social talk” and “social including researcher” text units per class over the course of the entire semester. Numbers in parenthesis indicate the average number of text units per session.

Code	*100-level*	*200-level*	*300-level*	*400-level*
social talk	24 (1.85)	51 (3.64)	28 (3.11)	45 (3.75)
social including researcher	20 (1.54)	22 (1.57)	20 (2.22)	27 (2.25)

During the second phase of the analysis of observations, the “social talk” and “social including researcher” categories were divided into a number of sub-codes, listed alphabetically and defined in Table III. The total number of text units in Table III is larger than in Table II because many of the text units fell under multiple sub-codes.

While qualitative research does not typically involve numerical counts, such as those in Table III, they are informative in this case, especially when averaged over the number of lab sessions, as represented by the values listed in parentheses.

Table III
Breakdown of text units from "social talk" and "social including researcher" categories over the course of the entire semester. Numbers in parenthesis indicate the average number of text units per session.

Code	*100-level*	*200-level*	*300-level*	*400-level*	*Definition*
anti-social	2 (0.15)	1 (0.071)	1 (0.11)	11 (0.92)	Occurrences where students specifically avoided social interaction either by focusing on the experiment or walking away.
background talk	10 (0.77)	6 (0.43)	1 (0.11)	1 (0.083)	Conversation about hometowns, personal hobbies and interests, academic minors (since they are all chemistry majors), and general getting-to-know-you topics.
chem classes	5 (0.38)	12 (0.86)	10 (1.11)	14 (1.17)	Discussion pertaining to chemistry classes; either the lecture component of the observed class or other classes such as organic and p-chem.
Joking / goofing off	8 (0.62)	10 (0.71)	12 (1.33)	3 (0.25)	Cracking of jokes, participating in horseplay, and just plain being silly.
killing time	0	20 (1.43)	13 (1.44)	24 (2.00)	Activity or conversation that occurred during the time between experimental runs, while a reaction was running, or while samples were drying.
non-chem class talk	4 (0.31)	4 (0.29)	3 (0.33)	1 (0.083)	Discussion pertaining to classes other than chemistry including languages, physics, math, computer science, and geo-science.
personal conflicts	3 (0.23)	1 (0.071)	2 (0.22)	0	Miscommunications between lab partners and confrontational discussions.
research/job talk	1 (0.077)	6 (0.43)	4 (0.44)	11 (0.92)	Discussion over internship, research or job opportunities and experiences.
romance	3 (0.23)	3 (0.21)	0	0	Overtly flirtatious behavior between students.
social commentary	13 (1.00)	20 (1.43)	15 (1.67)	25 (2.08)	Conversations of a personal nature about society, men, women, sex, politics, and day- to-day issues of college life.

The amount of social talk per laboratory session, for example, is roughly the same for each of the observed classes. The exception being the 100-level course in which students generally finished early and left, reducing the amount of time for social interaction and consequently the total number of social text units given the larger enrollment. Due to the fact that group composition – and therefore, total number of groups – in all but the 300-level class varied from session to session, an average number of text units per group could not be calculated. Another trend worth noting is the fact that the amount of interaction with the researcher increases slightly in the upper level classes due to the fact that several students had the researcher as a teaching assistant in the past and were already comfortable around her. The rationale behind the frequency of each sub-code can be found in Table IV but only a few of particular interest will be explained further in the results section.

Table IV
Frequency explanation for sub-codes from "social talk" and social including researcher"

Code	*Rationale*
anti-social	Not used very frequently however the unusually large number in the 400-level course reflects one particular student who was very withdrawn from her group throughout the semester.
background talk	Most frequent in lower-level classes where students were less familiar with each other.
chem classes	Smaller number of text units at the 100-level where students only have experience with the course in which they are currently enrolled. However, students in the other courses were either concurrently enrolled or had previously taken several other chemistry classes and so their numbers are higher.
joking/goofing off	Lower number of text units in the 100 and 400 level classes which is reflective of the overall tone of the students in the class. Might be attributed to the fact that these sections met at 7:30 am.
killing time	No occurrences in 100-level class, because experiments in this course were relatively short and students left once they finished.
non-chem class talk	Low number in the 400-level course may be due to the fact that most courses taken by this level are related to chem. This is supported by the slightly larger number in “chem classes”
personal conflicts	Also not used very frequently and simply illustrates some of the natural frustrations that arise from working with other people.
research/job talk	Most frequent in the 400-level class which contained seniors preparing to graduate.

Code	*Rationale*
romance	Text units pertain to two sets of students (one each in the 100- and 200-level courses). One set was in fact dating at the time, however, the other set of students never defined their relationship to the researcher.
social commentary	Overall largest number of text units with an increasing number of text units per lab session as the level of course increases indicating the development of social structure.

Once interview data was collected, the codes generated from the observations were used to begin to analyze the transcripts. This process of triangulation across the three sources (Patton, 1990) is in line with the theoretical framework by allowing the researcher to determine similarities and differences between the data sources (getting at the required pliability of the approach), as well as ascertain the meanings associated with the social situations observed. Text units from codes which existed in multiple sources were examined through the lens of the research question for commonalities to determine what types of interactions contributed to a sense of community among chemistry majors.

Results

Classroom Observations

Interesting results are associated with the sub-code "killing time." This code was used to indicate activity or conversation that occurred during the time between experimental runs, while a reaction was running, or samples were drying. Examples of observation notes include:

200-level: After students take their spectra and put their samples in the oven several students go out into the hall to play cards since the samples need to dry for an hour.

300-level: There's lot of conversation in Amy's[2] group while the titration is going on…Once they get everything set up all they have to do is switch samples and let the computer do the rest. Each run takes about 15-20 minutes so there's a lot of down time.

400-level: UV/VIS group strikes up a conversation with their TA. Jenna is apparently going to visit upstate New York. Aire is from there and Anna also seems familiar with it. They're all waiting for the reaction to come to equilibrium before doing the run.

There were no recorded occurrences of "killing time" in the 100-level class, which is in accordance with the fact that the experiments in this course were relatively short and students were allowed to leave once they had finished. The other three courses

[2] Pseudonyms were assigned to all participants.

had about the same amount of social interaction while “killing time” per lab session indicating similar types of experiments and classroom structure.

Closely related to “killing time” is “joking/goofing off”, which was used to indicate when students did anything from crack jokes to dismantling the backside of a lab bench to see what was inside:

100-level: John and Eric get into a dialogue conversation that only consists of the word "dude" which they chuckle about after its completion.

200-level: Don, Jessica, and Peter get four model kits together in an attempt to figure out their nearest neighbor’s problem. They are briefly distracted when they realize that the Styrofoam balls stick to Don's fleece jacket so they start throwing them at him.

300-level: Amy's group gets the idea from the other section to unscrew the back panel off of the lab bench. For no other [apparent] reason than to see what's behind it. They're using spatulas from their drawers and Swiss Army knives to undo the screws…Once they are able to get it off and look inside they try to get a pipet that is stuck under the drawer. They realize that it won't come out without breaking it and decide to put the panel back on…Amy can't get the panel lined up right to fit the screws back in. They struggle with it for a good ten minutes before Lynn has to get on the floor on her back and push the panel up with her feet while Amy puts the screws back in.

400-level: The rest of the group talks about how Sissy wanted to use a "scary font" on her lab report for today since it was Halloween.

These antics are similar to those found in “killing time” but were not the consequence of downtime that occurred within an experiment, and were actually performed while they or their group members continued to work on the laboratory task at hand. These were not distractions due to a lack of things to do, but intentional sidebars to interject “fun” into “work.” Consequently, these activities and conversations did not sacrifice the completion of the on-task activities, and in fact happened concurrently. For example, the conversation illustrated above which only consisted of the word “dude” was performed as the two group members walked to the hood, measured the chemicals needed, and added them to their flask before moving on to the next part of the experiment, illustrating that many “off-task” interactions happen even while “on-task” activities are being performed.

The code “Background talk,” which refers to conversation about hometowns, personal hobbies and interests, academic minors (since they are all chemistry majors), and general getting-to-know-you topics, was most frequent in the lower-level classes where students were less familiar with each other.

100-level: As they are cleaning up Lori and Kathy talk about their high school experiences and what stupid things their teachers did. One thing was the fact that they used glass burets with "stoppers" that fell out. Another teacher put Na metal into water and not the other way around so flames end up scorching the ceiling.

200-level: Tammy says that there is a certain order to adding reactants but Bonnie says it all goes into solution anyway so just mix it, it doesn't matter. [The researcher] asked her if she was the type of person who mixed her peas and carrots on her plate. She says "oh, yeah and I add them to my mashed potatoes". At this point Jeremy steps in and says "how can you do that?”

As can be seen by the gradual decrease in text units per session with increasing course level (Table III) and the fact that “background talk” is not merely limited to pre-college experiences, the data in this category suggest the evolution of a community of students who become more familiar with each other as the students progress through their academic careers. If a community were not established and progressing, and students were unfamiliar with one another at each stage of the program, one would expect to see “background talk” prominently in all of the courses regardless of level.

The code containing the largest total number of examples is “social commentary”, which encompasses conversations of a personal nature about society, men, women, sex, politics, and the day- to-day issues of life — college life in particular. Students discussed issues ranging from marriage to the fact that they overslept because the power went out in the residence halls.

100-level: Becky, Katie, and [the researcher] started talking about lack of sleep and having to get up for a 7:30 [lab] and Becky mentions how she was so proud of herself for not going out to a frat party last night because she knew she had to be up for lab.

200-level: [One group] talk[s] about parking tickets. Apparently Lizzie got one a few weeks ago but couldn't find her checkbook. Once she found her checkbook she lost the ticket. She now found the ticket and has to pay for it.

300-level: Amy, Jerome, Lynn, and [the researcher] get to talking at the beginning of lab about babies (Jerome's roommate is a father and Jerome missed seeing the baby the other night since he wasn't home). Eventually the conversation led to birth weights and how the average is so much higher than it used to be.

400-level: One particular conversation [in the group] revolved around a friend of Sissy's from high school who apparently is going to be married or was married recently and how Sissy keeps hoping that she will wait to have children until after she graduates 2 years from now.

> She also wants her friend to have a career since she will be the bread winner in the marriage (her husband is a social work major).

These conversions were unrelated to chemistry, and resembled the topics that groups of individuals at this age might discuss while going out to lunch, or at a party. As one would expect, the number of text units per session increased with the level of course. This illustrates a shift in social interaction from primarily “background talk” in the lower level courses, to a more personal nature in “social commentary”. When the text units from these codes were compared with the interviews, it was clear that the students considered the classroom laboratory an environment in which they can interact and behave on a social level. Inasmuch as the primary goals of the laboratory are traditionally thought to focus on academic issues, the social aspect of the laboratory classroom that was apparent from the field notes was explicitly addressed in both the individual and focus group interviews.

Student Interviews

Two predominant themes emerged from the interviews and supported the findings from the observations. First, the students were social in the laboratory as a means of making the best of a forced situation. Although these students were chemistry majors, they were not particularly interested in spending their time in the classroom laboratory environment. They therefore entered into social interactions while simultaneously performing on-task activities in order to make the situation tolerable. Bonnie, for example, who was a 200-level student, stated in her individual interview:

> So I look at it as teamwork, and you have to get along with the people around you ... I think it's social because you, I mean you have to do [group work]…why not have a good time while you're there? You know, I mean if you're gonna just be biting your nails and you know, getting all mad for three hours isn't going to make the three hours go any easier. So you know, why not have fun while you're there. I mean … what we're doing isn't really hard.

Bonnie felt the tasks at hand in the classroom laboratory were not particularly challenging and she was required to work with other people in her lab section, so the only way to make it bearable was to joke around and have fun. This attitude was shared by Ed and Amy, 300-level students:

> Amy: I think that's why people are really social in lab, it's because like in a lab you can, having to cook something for like an hour. Well ok, so you either sit there...doing nothing, read the paper or you go talk to people … I don't know like, if you just sat there and did nothing I would be upset with myself, but it's a lot better if I have my buddies there because at least we can talk.
>
> Ed: Yeah, I just think … it's characteristic of everything, that it's more bearable if you're having fun, you know and, sitting there just starting and watching things boil, you know that's not fun for anyone, not even me. And uh, I would say it,

> wouldn't that be characteristic of every lab that you, you start talking to people when there's nothing else to do?

Similar comments from the other classes provided insight into reasons for the social atmosphere evident in the observation data. The social aspects of interactions in the laboratory classroom, however, go beyond simple boredom. Once students acknowledged in their interviews that the lab was social, they went on to note that the social atmosphere developed in the classroom laboratory extends beyond the lab courses and evolves over the course of their academic careers.

> *100-level:* And the situation with [my one partner] has been really good with me, because like, we became lab partners and we started dating, so it's kind of a nice situation for me.

> *200-level:* When comparing to taking classes at [the local 2-year college] you couldn't become like, friends with anybody in your class because…these weren't the people that you were going to call up later on that night and try to get help from or anything like that. Or, call them up and be like, hey let's go watch a movie or something like that, or see them everyday because you know, they live an hour away from where you lived…[It was] completely different, not as much fun.

> *300-level:* I made my friends my freshman year in freshman chemistry you know, and it's just so much easier to go talk to people…it seemed like they were always a lot more willing to help [than professors]…it was just, I don't know, a lot more social and open.

> *400-level:* Like I know with my group we've been lab partners since like, forever you know. And it was like we'd said before, when you start out as a freshman…and we all know each other and we all get along and there's like little groups you know, friends that have developed from these classes and you know you're just, when you're in a group with these people you're social with them.

The second major theme that emerged from the individual interviews stems from the extended social interaction between students, and was termed the "chemistry mafia". This term originated from Ed, a student in the 300-level class, to describe a group within his particular graduating class of chemistry majors:

> I think the group, like the chemistry mafia kind of hangs out. There's like a core group and I go and do p-chem with them, and I'm friends with all of them but like, we don't hang out and stuff.

"Chemistry mafia" was used by the students to refer to a specific, tight-knit group of students who, through their interactions in shared courses, developed relationships based not only on academic assistance but social companionship and emotional support fostering a better work and learning environment. This idea is developed further by Bonnie who, while not in the 300-level class at the time, was taking physical chemistry with the group of students Ed labeled as the mafia:

> We're in a pack. I mean, there's 20 of us in [this] pack. Ed put it best, we're the chemistry mafia, we are!...I feel, I have a lot more gusto to go up to a TA or a prof and say, "hey I [don't understand]", and if I didn't have a group backing me up I probably wouldn't do that. And I know that if I have a thought like that, I have a whole bunch of people to ask and say hey, what do you guys think about it? You know, give me some feedback; tell me how you would do this.

The key element to this group clearly stems from the social interactions between students as they progress through their coursework. A good example of this is a discussion Sandi, a 300-level student had in her interview:

> I guess it's just started from like, my freshman chemistry. We've all been together since then and we all pretty much know what's going on in each other's lives…[and] the more people we meet in lab the more people, our group expands out.

Theodore, a 300-level student, emphasizes the importance of the social aspect in his group interview:

> Well, I think it's, it's helpful to be social because I mean, if you know you have to get something done then of course you're not just going to be talking, talking about things that aren't relevant to lab. And then you know like, if you're friendly with the people that are in your group and other groups then you can ask them and see what's going on, things like that. So that's actually very helpful. 'Cause if you're in a situation where you feel kind of like, almost scared to talk to somebody else and you need help or you want to do this, you might not actually do that and, and that's not really helpful to yourself. So I think it's good.

Theodore admitted that the students in his class of chemistry majors talked about chemistry issues as well as social issues, but he felt this group of students was more at ease asking each other for needed help on academic issues because the social issues that lead to the formation of a community of learners had already been established. For many students this academic help was crucial to their success in chemistry, but they noted they would rather not reveal their academic weaknesses unless they felt they had the support of those around them. Seeking academic help becomes an issue of trust within a community of peers. These students developed their own community of learners, in which they felt secure and could trust other students. Another 300-level student sums this up in a group interview by saying:

> Yeah it's more like people are just, everybody's comfortable ... [the other student's] group is especially comfortable with each other … they're all friends or whatever. I mean and then our group like, some of us are friends, some of us just know each other and then it just kind of rubs off 'cause they're standing right in

> front of us. I mean so everybody pretty much is comfortable saying whatever, like you're doing this wrong, oh you need to add this.

Because the members of this group were both familiar and comfortable with each other, they had no problem asking for help or correcting their lab mates, ultimately facilitating the learning process for all members of the group. Tammy, a 200-level student discussed friends gained through lab interactions as a resource in her group interview:

> Ok, college is really you learn how to use, you realize all the resources that you have in all your friends…My favorite thing would be to be on instant messenger you know, talking to people trying to figure out some of the [chemistry] problems, being on the phone and doing the homework….It's just, it's funny. And I think it's funny how, 'cause really if you didn't network in college you wouldn't survive.

Bonnie in her individual interview, also discusses the support offered as being part of the group, how it consequently overlaps into the social realm outside of class and relates to survival:

> It's seriously, It's my way of surviving to be in the group. Like if I didn't have study groups like that, I, I don't think I could have made it. [My lab partner] and I are attached at the hip now, because, without you know, to be able to have somebody to go through these class with you. Because chemistry does demand a lot out of you…but my roommate and I were talking about it; she's a management, an accounting major. She's just kind of amazed at how close I am to all my chemistry friends. 'Cause she said, "Yeah we're kind of cut throat, and one wants to beat the other, every man for himself", and I said, we could take that approach but we're wanting to help each other out, 'cause we all want to make it through here. And the fact that we can work together is just trying to help each other out.

The "Chemistry Mafia" was so pronounced that students who were not involved in the group recognized they were not part of that "crowd" and typically worked on their own outside of class. Charlie, a 300-level student, falls in this category:

> Interviewer: So do you think you would have fit in better with the back groups [of chemistry majors]?
>
> Charlie: I don't know. Well I mean, I don't, I don't really know them guys that well, so I can't say if I would or not. It's hard to say ... See, uh, I started out in chemical engineering, a few years and then I switched to chemistry education and so uh, I guess maybe I, I've seen them in a couple of my classes before but not like, the whole way through.
>
> Interviewer: So has there been a group that you've kind of migrated through your classes with?

> Charlie: Um, yeah, well I don't know. There's, I mean nobody that made the switch [from engineering to education].

This conversation with Charlie originally started with a discussion of his particular lab group, in which he was the only chemistry major. He recognized that the other chemistry majors in the class regularly worked together and were therefore more proficient at getting the experiment done. Because Charlie did not start out in the same classes as the rest of the community of chemistry majors, he felt he was not a part of the "chemistry mafia." He knew that he was on the outside of this social circle and was not sure he would fit in, even if he tried, due to his lack of common experiences with the rest of the group.

Similarly, Anna, a 400-level student who worked with the same partner all semester, confessed in her group interview that she did not learn any more in her class than if she were to have worked alone:

> Anna: I worked with [one guy] the whole time, but we just worked. So we did our, we knew what we were doing going into it, so did it and left. So it would have been the same for me if I did it myself or if he was there.
>
> Interviewer: So it wasn't helpful to have someone working with you on it?
>
> Anna: No, the only way it would be helpful, or make it more interesting is if it's more like, a social group.

In fact, most recorded observations of Anna and her partner pertain to "on-task" activities. She was never observed to have any personal conflicts with her partner, nor did she complain about his level of performance or participation. However, she recognized that it would have been more helpful to her learning if she and her partner had more social interactions.

Discussion

It is clear to anyone who observes a classroom — especially a classroom laboratory — that the atmosphere is social in nature. But this social interaction is not limited to the classroom environment. Latour and Woolgar (1979) suggest that scientific "facts" are constructed through social mechanisms established within the scientific community. Scientists use the approval and social discourse of their peers to shape their perceptions of reality. Consequently, what evolves is a societal understanding of the phenomena under study. In a similar fashion, in can be argued that the social interactions between students in the chemistry classroom laboratory foster their construction of facts — the ones they need to know for a given class. While this study did not specifically assess the amount of learning that occurred, previous research about the effectiveness of group work and simply the fact that students progressed through the class implies that *some* learning occurred. The point of this study was to examine the mechanism of interaction, specifically social interaction, which contributes to the learning – regardless of level – that inevitably occurs. Symbolic interactionism, which shaped this study, is based on the assumption that meanings are socially constructed. Through the use of observations of student behavior and personal conversations with the same students, this study suggests that students who work together in a series of chemistry classroom laboratory courses use their social surroundings to develop and reaffirm scientific facts, as evidenced in their discussions about studying together, in a manner similar to the way Latour and Wolgar posit that scientists construct "scientific fact" in a research laboratory. Consequently, the knowledge that students construct is situated in the participation of social interaction which becomes critical to the success of the students and is integral to the development of becoming practitioners in their field (Lave & Wenger, 1991). Because of this connection between social interaction and knowledge construction, the specific details of the interactions are critical.

Previous studies of the classroom laboratory environment that focused on measures of "time-on-task" and how "productive" students are within the group imply that time off-task is ineffective with regards to the pedagogical goals of group work (Kempa & Ayob, 1991). This study suggests that what seems to be "off-task" time in the classroom laboratory is used to gain the social means, or "social capital" necessary to accomplish all that is asked of them within the major (Coleman, 1988). Social capital is defined as consisting "of social networks, habits of cooperation, and bonds of reciprocity that serve to generate benefits for members of a community…they embody the emotional bonds of group support and trust" (Hosen & Solovey-Hosen, 2003, p. 84). This social capital is then used as a means for accomplishing goals or actions, in this case, completion of the degree in chemistry (Coleman, 1988).

Social capital is also evident in the literature on campus-based support groups for women and minorities in SME majors. These groups have growing prominence on college campuses in the effort to retain students in science and mathematics by instilling a sense of belonging to a community of practice (e.g. Kahveci *et al.*, 2008; Wenger, 2000). The social support and companionship afforded to students in these groups is similar to the support which naturally developed among the groups of chemistry majors involved in this study. Regardless of the topic of conversation among students in a laboratory environment, it is the "off-task" socialization and establishment of social capital that lays the foundation for the socially constructed knowledge we know students acquire through group work.

Conclusions and Implications

The social aspect of the classroom laboratory begins as a mode for passing time and making the best of an undesirable and forced situation. From this social interaction, however, a community of learners evolves. This community consists of students who learn to know each other in their introductory classes and stay together through all they must endure before graduation. They gain the trust of one another through non-academic social interactions, which, in part occur in the classroom laboratory. This interaction occurs concurrently with the on-task activities required of students, and despite the fact that the laboratory is usually considered by faculty to be a solely academic atmosphere. Students, on the other hand, view it additionally as an opportunity to socialize, and it is this socialization that is the basis of the community of chemistry majors which supports the eventual construction of any content knowledge. The community is used as a resource, offers support to its members, and is considered a valuable asset to its citizens; it is so much of an asset, that students who are not a part of the group feel they are at a disadvantage for not belonging as seen with Charlie and Anna.

The results of this study begin to outline the significance of understanding the social aspect of group work. Not only do members of the group work together to accomplish a specific task in the lab, they also develop interpersonal relationships which offer support and encouragement throughout their personal and academic lives. This feature of group work parallels the supportive environment of pre-established peer mentor programs. It is clear from the data in this study that the academic and social worlds of these chemistry majors are intricately entwined and consequently inseparable. Despite faculty efforts and desire to keep students "on-task", it is evident that these are not the only worthwhile behaviors. While the groups in this study were self-formulated, instructors and departments in the future might consider encouraging more social interaction among majors. Within individual classrooms, instructors should allow for a little "goofing-off" between students in lab (within safety considerations). We need to remind ourselves that simply because science is not being "discussed" does not mean that important interactions are not taking place. Allowing "off-task" activities and conversations fosters a sense of community within a group or even a classroom. Other opportunities could take the form of something as simple as having a student lounge for science (or chemistry) majors on the floor of the building where most of their classes are held. This allows for a common meeting ground across the classes and could foster a sense of community program-wide, rather than within specific classes. This, in addition to the social interactions students naturally engage in on their own may initiate the social support students require to survive an academic program.

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