An Investigation of the Organizational Communication Culture of an Introductory Chemical Engineering Class

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I. The Challenge

Chemical Engineering courses are often difficult for students. Among the multitude of reasons accounting for this difficulty are communication issues – what scholar I. A. Richards would call "stud[ies] of misunderstanding and its remedies[1]." That is, questions arise such as: what communication "works" for students?; what communication is ineffective in helping students learn?; and how does communication contribute to the overall learning environment in which students must operate? To answer these questions, the following study is being conducted.

This investigation seeks to use ethnographic research (study by immersion) to identify an organizational communication culture for an introductory chemical engineering classroom. Additionally, the study will identify how students and the instructor work within the culture they are constructing to achieve the syllabus goals of "develop[ing] basic skills of chemical engineering analysis," "learn[ing] the language of chemical engineering," and "hav[ing] some fun[2]." Finally, the ways that male and female students affect and are affected by the culture will be explored.

II. Literature Review

An organization can be defined as the "interlocked actions of a collectivity [a group][3]." Pettigrew[4] described culture as "the system of publicly and collectively accepted meanings operating for a given group at a given time. This system…interprets a people's own situation to themselves." Alternatively, Wood[5] defines culture as the "structures and practices that uphold a particular social order by legitimizing certain values, expectations, meanings, and patterns of behavior."

The engineering culture under examination in this study will be identified through an analysis of the rituals, passions, politics, and enculturation processes used by organization members. These elements are manifested in the stories or "symbolic actions – words and/or deeds – that have a sequence and meaning for those who live, create, or interpret them[6]." These stories will be gathered through classroom observation and through interviews with the students themselves.

Pacanowsky and O'Donnell-Trujillo[7] articulate five reasons for using an organizational culture approach to study an organization. Among these, two are: the end result will be an account of the fullness of the organizational culture, rather than a functional interpretation of problems and potential solutions, and each study can provide an overall picture of the organization for its members.

These issues are particularly relevant to the proposed study. While there is much devoted to investigating ways to improve the quality of engineering education, the majority of research tends to focus on bits and pieces of the classroom. With the exception of Tonso[8], research has not looked at the overall culture of the classroom. When they have, little has been said in terms of how all students and the instructor are working within the culture to achieve educational goals; rather, the overwhelming focus has been on how women are affected by the culture. Gaining an overall picture of the organization will serve as a valuable resource for instructors in reviewing how teaching techniques are affecting students and working to produce a classroom culture.

Also important is the concept of enculturation, defined by Louis[9] as those activities that communicate to organizational newcomers the roles and behaviors they should adopt. The introductory Material and Energy Balances (MEB) course to be studied is, in itself, an enculturation process where students learn the basic skills they will use for at least the rest of their academic career, if not for the rest of their lives. Dr. Richard Felder hypothesizes that much of the difficulty in MEB courses arises because the basic concepts are inherently simple. Students may feel at first that they need not learn the engineering approach to a problem, and, instead, use other methods learned in algebra and chemistry to solve the problems. Unfortunately, as problems become more difficult and new concepts are introduced, these students are often lost[10]. The problem them becomes one of enculturation: why do some students fail to "learn the ropes" of engineering, then become lost in the class?

Finally, many researchers[11] have argued that the engineering and engineering technology classroom cultures described above are male-dominated ones which place women in an uncomfortable educational setting. In their research of "weed-out" systems for science, math, and engineering (SME) fields, Seymour and Hewitt[12] indicated that the culture of SME disciplines, which is developed by faculty attitudes and practices, is a large contributor to SME attrition; further, the weed-out system disproportionately harms women students. In other words, an inhospitable classroom culture is responsible for higher attrition rates for female students than for male students.

However, recent studies researching those factors affecting attrition rates for engineers have found that gender is not a significant variable in predicting persistence in engineering[13] or, at least, is dependent upon the particular institution[14]. These latter two studies have been conducted relatively recently, while the former were done as long as eighteen years ago. The changing tenor of findings, coordinated with an increased percentage of women in engineering, seems to highlight a shift either in the engineering culture or in the way female students are reacting to it. Further study in this area is merited in order to investigate these changes.

To these ends, the following research questions will be pursued in this study:
RQ1: How does instructor communication contribute to the classroom culture?
RQ2: What communication is effective in achieving enculturation of the students?
RQ3: How does gender influence the way students experience the classroom culture?

III. Method

This study's objective was to examine the development of a communication culture in an engineering classroom. Study participants were college students enrolled in an introductory chemical engineering class at a private university in Ohio.

At the selected university, as at most universities, the first true chemical engineering course a student takes is Material and Energy Balances, commonly abbreviated as MEB. Students enroll in the course in their first semester of their second year of schooling, and are exclusively chemical engineering majors. The course is taught in two sections of approximately thirty students by the same professor. By gender, the class is approximately 50% female. Tri-weekly classes are a mixture of lecture and problem solving, with students often breaking up into smaller groups to solve an assigned problem. In addition to these classes, a problem session is held each week and is administered by a post-graduate chemical engineer. Although two sections of the course are taught, only one lecture section was observed, due to time constraints and scheduling complications.

In this study, the researcher acted in the role that Bantz[15] describes as "participant-as-observer" – the researcher actively participates in the organization, but is known to be an observer. The method was chosen to allow students to build a better relationship with the researcher and to avail the researcher to comments and questions asked outside the traditional classroom setting.

Once the messages were identified through classroom observation and student interviews, they were recorded in a journal. These notes were then distilled to the recurring themes present in the course. Finally, as common themes were developed from the observations, these themes were tested for validity using what Glaser and Strauss term "theoretical sampling[16]," where these themes are tested against new observations to see if they work in answering the question "What is going on here?". Further, notes were examined for any apparent gaps in research to ensure that one particular aspect of the culture was not underrepresented in data gathering. Finally, the observed professor periodically commented on his perspective of classroom communication as a method of coordinating data gathered from inside the classroom.

IV. Experimental Results

Experimental results indicated that the wide majority of students found the class to be open, supportive, and highly interactive. Instructor communication contributed to these perceptions. The instructor was very willing to admit his mistakes to the class. Comments such as "My mistake… thanks for pointing it out," and "I don't think I'm asking this question very well," signaled to students that mistakes were okay, and helped to contribute to students' reports that they were comfortable asking and answering questions in class. Instructor responses to students who asked or answered questions were almost always supportive. If a student didn't give the correct answer, the instructor would usually ask a series of questions that would lead him or her to the correct answer, or at least would allow the students to find the mistake s/he had made in the original answer.

The instructor was also extremely careful to use plural pronouns, rather than singular ones, that is, to make statements such as "we are going to solve this problem," rather than "I'm going to have you solve this problem." Using plural pronouns helped to create the impression that everybody, including the instructor, was "in this together," and helped contribute to students' perceptions that, "Dr. Myers seems like he's available to help us, both in class and out." Also contributing to the supportive climate was frequent reiteration of office hours and comments that encouraged students to come see him for help. Almost all respondents to the survey indicated that having so many office hours, encouraging students to use them, and giving lots of help outside of class really helped them to feel that the professor cared about how well students were learning the class material.

The instructor heavily encouraged classroom participation, both in class answering questions, and in small group problem sessions. Although there was some hesitation on the part of the students to talk to each other in the small group working sessions, participation was encouraged through humorous comments like, "You can talk [in your groups] – you don't have to use sign language" and "You're allowed to talk and have fun, but I'll get suspicious if you have too much fun!" However, some students reported that they were a bit unsure of how to take the humor. Two commented that sarcastic comments made them feel intimidated about participating in the class.

There are two primary enculturation goals being achieved in the MEB classroom: teaching students how to "think like a chemical engineer," and the behavioral processes, or teaching students how to "act like a chemical engineer." In his December 13th reflection on how the class was going, the professor expressed his fears that students had not learned how "to break down a problem into smaller, more manageable parts," which is certainly a key (if not *the* key) way that chemical engineers are taught to think about the problems with which they deal. Performances on tests tended to support this statement, as the test average between the first test, where problems were very simple and required little in the way of being "broken down," and the second test, which did require such skills, fell approximately twenty-three percentage points.

In this class, almost all communication of how to work problems was given through solving example problems. On the whole, little actual "lecturing" was done. While students seemed to find the examples helpful, test results would indicate that students were unable to learn from them as much as had been expected. Most students reported that clear, step-by-step explanations of problems made learning seem easier. However, there was no explicit lecture given that explained the steps to solving a problem, which could have been a factor in how students learned or failed to learn the "engineering" approach to a problem.

Students expressed some displeasure over the lack of lecture that occurred in the class. During a feedback session on how the class was helping students led by a faculty member from another department, students were very vocal in stating that they wished that new concepts would be explained in lecture first, and then a problem applying these concepts should be attempted. This point was also addressed by several students in the Course Evaluation Survey. However, students seemed unwilling to share this opinion in interviews with the researcher. This discrepancy draws into doubt the effectiveness of answering the second research question through student interviews.

In teaching students how to "act like a chemical engineer," the primary communication route taken was the distribution of articles from *Chemical Engineering Progress* or a similar publication that explained either what chemical engineers did for a living or what chemical engineers were researching currently. The effectiveness of such communication was highly dependent upon the students actually reading the material; comments made between students in the class such as “Oh, is that what that [handout] was about? I never read them,” seemed to indicate that students were not reading the material.

In answering the third research question, “How does gender influence the way students experience classroom culture?,” some general trends were observed that are antithetical to previous research on gender and the engineering classroom. In interviews with and surveys from the students, only two responses to questions about gender indicated that students found any difference in the way the two genders experienced the classroom culture. Where responses did indicate a difference, the students’ comments – “Girls do better in chemical engineering than guys,” and “the girls tended to help each other more on the homeworks than [they helped] other guys” – seemed to indicate that females had an easier time negotiating certain elements of the classroom culture than did males. The latter comment also demonstrates a realization of the role that relationships can play in determining success in the classroom.

Another departure from literature expectations came in the results females gave to a survey question reading, “What words would you use to describe the overall atmosphere of the class?” Both male and female student responses mentioned similar terms – “hard,” “challenging,” “interactive,” “fair,” “interesting,” “open,” “a little overwhelming [course material-wise],” “fun,” relaxed,” and “supportive.” Three-fifths of female responses indicated that they found the atmosphere to be supportive and/or open, whereas literature would argue that females often find engineering classrooms to be intimidating and/or exclusionary.

Class responses were unanimous in stating that the professor contributed to the perception of a lack of gender difference by treating all the students equally. Observation indicates that this perception is true to what went on in the classroom. Responses to both male and female students answering or asking questions were the same. While, on the whole, more males participated in classroom discussion, this increase in participation was generated by the students themselves, and in only three or four instances over the course of the entire semester, did a male’s participation come at the expense of a female’s.

V. Conclusion

This study found that the engineering classroom culture under investigation was a supportive, open, and participatory one for all students. Gender made very little difference in how students experienced this classroom culture. Classroom enculturation seemed to be incomplete, judging from some students’ test performances that indicated that they had not learned “the engineering approach” to a problem.

Questions for future study include: Would a more explicit explanation of how to solve a problem (lecturing on heuristics instead of having students glean the heuristic from solving example problems) increase students’ knowledge of “how to think like an engineer”? Are student reports to the researcher of their perception of the classroom culture self-censored or not? Why is there a discrepancy between literature reports of women’s experiences in engineering classrooms and what was found in this study – is there a point at which a “critical mass” of women is reached and gender differences are not noticed?

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