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Observing Engineering Student Teams from the Organization Behavior Perspective using Linguistic Analysis of Student Reflections and Focus Group Interviews

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ABSTRACT

This paper investigates group/team development in computer engineering courses at a University in the Central USA from the perspective of organization behavior theory, specifically Tuckman's model of the stages of group development. The investigation, conducted through linguistic analysis of student reflection essays, and through focus group interviews, also presents STEM education researchers with a method to obtain nuanced information about interpersonal skills issues such as how groups and teams function. A third contribution of the paper is a review of the organizational behavior literature on teams and groups with a concern for its application to modern engineering education.

Key Words: Group Development, Linguistic Analysis, Reflection Essays, Tuckman's Theory

INTRODUCTION

In the last few decades, the context of engineering problems has become increasingly global and interdisciplinary. Thus, in addition to the ongoing demand for technical engineering skills, people skills such as interpersonal communication, conflict management, and group and team leadership are deemed critical for success. While teamwork has been encouraged and incorporated in the



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engineering classroom for many years (Felder 2000; Michaelson 2002; Adams 2003; Smith 2005), more complex problems require large collaborative teams, and often a deeper understanding of social contexts within which the problem needs to be solved. Engineering collaborations must “move beyond ‘divide-and-conquer’ approaches and instead operate in a dynamic, integrative mode of continuous learning and exchanges of ideas and information” (Richter and Paretto 2009, 29). Richter and Paretto summarize the proposals from various leading groups in the USA:

In the USA, recent government reports such as *Educating the Engineer of 2020* (National Academy of Engineering 2005), *Rising Above the Gathering Storm* (Committee on Science Engineering and Public Policy 2006), and *Facilitating Interdisciplinary Research* (Committee on Facilitating Interdisciplinary Research 2005) also advocate preparing engineers and scientists who can work in creative, interdisciplinary environments. US accreditation criteria now demands . . . ‘an ability to function on multidisciplinary teams’ (ABET Engineering Accreditation Commission 2005).” (Richter and Paretto 2009, 30)

The more complex work environment places colleges of engineering under increased pressure to work across interdisciplinary boundaries so that graduates may be fully prepared for a changed engineering role. While many engineering faculty members assign team projects for their students, few of these instructors are themselves trained to operate, lead or guide teams. Fewer still are aware of the nuances of work groups and teams, and the vast body of literature from the field of organizational behavior. This gap suggests a strong need to include experts from the field of organizational behavior (OB) as partners in engineering education, particularly as it relates to collaboration in the workplace. This article is a result of an interdisciplinary collaboration that includes expertise in the OB field. To provide other engineering educators an overview and the relevant details from the OB field, the article first presents a targeted and interdisciplinary review of the pertinent literature.

The review of the current literature is paired with a qualitative case study that includes data collected over the course of three academic years at a public research university in the Central USA. It specifically considers the development of groups and teams within the computer engineering classroom and laboratory environment. These data were collected as a part of a larger study on the impact on student learning of PLP, the Progressive Learning Platform (PLP 2014; Fritz, et al. 2011; Mulia et al. 2013), a hardware/software system that creates both scaffolding and authenticity in the computer engineering curriculum. As would only be appropriate for an article of this nature, the research team was interdisciplinary in both content (comprised of professionals with expertise in organizational behavior, education, engineering, and linguistics) and in research paradigm (qualitative/inductive and quantitative/deductive researchers).



INTERDISCIPLINARY REVIEW OF LITERATURE

Many in the field of education, including engineering education, have articulated the need to change traditionally taught courses toward more student-centered, collaborative approaches (Adams 2003; Edwards 2010; Hansen 2006; Livingstone and Lynch 2000; McNair et al. 2011). The educational concern for authenticity in learning, defined as an accurate replication of real life (actual authenticity) combined with students' perceptions about how closely the learning experience represents the real life (perceived authenticity) (Hannah and Venkatachary 2010), also supports the need to more closely mirror the modern workplace. Faculty at engineering schools across the nation have not only included teamwork in their classrooms, but have also studied its effectiveness in the academic environment. A recent paper (Borrego et al. 2013) cites over one hundred papers focused on teamwork in engineering classrooms published between 2007 and 2012. One of their findings was that few engineering faculty engage in the literature on industrial and organizational psychology when designing teams and team projects in their classroom. Most faculty "expertise rests in their technical specialty" (Adams 2003, 2). Most engineering faculty have little training in the design and implementation of work groups and teams and, thus, have only a surface level understanding of their value (Hansen 2006). This is not a criticism of engineering faculty but a recognition that the field of engineering (like others) has broadened to encompass expertise that resides in other knowledge areas - areas for which special terms and assumptions may be initially difficult to understand (Salas, Goodwin and Burke 2008). The lack of knowledge may contribute to the resistance of engineering faculty to incorporate collaborative experiences into their classrooms and to recognize those as important preparations for their students' entries in the workplace.

Groups and Teams

Research on the development and activities of groups has been ongoing since the 1950s. In a review of the organizational behavior literature related to group and team development, two specific components of research emerged as highly pertinent to this study: (1) the differentiation of groups from teams, and (2) the stages of group/team development.

There is no doubt that compared to "group", "team" is the catchier (and often misused) term in modern organizations; few organizations rally their people with fist pumping and shouts of "Go group!" Indeed, the literature shows that many researchers also use the terms 'group' and 'team' interchangeably (As we also do in sports—for instance, a basketball team mimics a true team. A wrestling team, however, is functionally a group.). While the differences may not matter a great deal in some contexts, when considering the work environment, there are important implications of confusing these terms that include mismatches of leadership and rewards. Perhaps the most significant



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repercussion may be the enduring “bitter taste” that members of failed teams (that perhaps should have been groups) carry forward to the next time they are charged with being “part of a team” (a concern also noted by Livingstone and Lynch (2000), in their study of collaborative assignments in the classroom). Those grumbling voices that sarcastically respond “great, another team” may have valid reasons for their aversions. Much like a design decision that occurs early in any process, whether a group or a team is most appropriately matched to the task should be an important first consideration. That initial decision should then drive additional considerations of structure, leadership and rewards. In some ways, it is the engineering of a human process. So, we should, indeed, endeavor to clear up the muddiness around these two terms.

Katzenbach and Smith (2005) provide perhaps the most practical and understandable (translatable) differentiation of these terms, which is primarily based upon how the collective performs. In a group, individual efforts are additive; they are added together to make up the output with each piece retaining some level of individual identity. A team, on the other hand, includes “both individual results and what we call ‘collective work products.’ A collective work product is what two or more members must work on together . . . [and] reflects the joint, real contribution of team members” (p. 164).

Work groups thrive in organizations where individual accountability is of primary concern. Because human behavior tends to follow the path of rewards, organizations that emphasize individual results (through performance reviews, recognition, and pay) tend to (perhaps unknowingly) promote work groups. While the group may come together to share, discuss, and debate information, as well as make decisions, the focus remains individual. “Working-group members don’t take responsibility for results other than their own. Nor do they try to develop incremental performance contributions requiring the combined work of two or more members” (p. 164).

Teams are, arguably, more complex both in practice and in the environment required to support them. They function best when collective accountability is considered critical and when both individual and collective responsibility are clearly translated into performance reviews and rewards. They require common commitment and belief that the team will rise or fall together. Teams are about shared contributions so intertwined that the credit for their origins of their products may be impossible to discern.

In a 2003 article on building teams in the engineering classroom, Adams (2003) recognizes the differences in groups and teams. However, an underlying assumption is that it is “advantageous for faculty members to build teams in the classroom rather than groups” (p. 2). We respectfully disagree with this premise. While teams are perhaps the gold standard of instances of amazing collective action in the workplace, they are also much more difficult to build and support. And much of the work in organizations is still done (and is probably best done) by work groups. Thus, while we are well aware of the use of these terms interchangeably in both practice and in some research, when



using the specific terms, this article will endeavor to use, whenever possible, the terms as they are differently defined and applied. However, because this article presents a case study where the engineering instructors were not aware of the distinction between groups and teams (and, thus, did not set up clear reward structures that promoted teams or groups or convey these distinctions to the students), efforts that indistinctly combine elements of both teams and groups will be referred to by the general term “collaboratives.” Our observations show that even within the same course, some of the collaboratives showed group-like behavior, whereas others performed as teams. Since both teams and groups are needed in the workplace, there is value in having both in the classroom *while understanding the differences*. In other words, it is important to also characterize *a strong work group as a great success*.

Group Development

Well before there was differentiation between the terms ‘group’ and ‘team’, Bruce Tuckman (1965) wrote what was to become a seminal article on group development for the field of organizational behavior. While Tuckman used the term group, teams, too, likely go through these developmental stages (although the emphasis and outcomes may look a bit different in later stages). Tuckman’s model, induced from the literature that was available at that time, presented four stages of development. He called those stages: forming, norming, storming, and performing. Approximately ten years later, Tuckman and Jensen (1977) revisited the original stages based upon empirical research of the prior decade. This resulted in additional support of the original four stages as well as the addition of a fifth: adjourning. As evidence of its generative power in the OB community, the Harvard Business Review reprinted the original 1977 article in 2010 (2010). (For a full review of the history of the model and subsequent related studies, see Bonebright 2010.)

In the 80’s, Weber (1984) further likened groups to “complex living entities, similar in many ways to the individual” (p. 69). Weber stated that “each stage is lived by all groups that develop into cohesive, functional units... Each must be lived through... in an inevitable cycle of development” (p. 69). Weber also claimed that if the group completes the stages and continues to exist, or if there is significant change (change of members, leadership), the group will recycle through one or even all stages.

The challenge of the researcher-practitioner gap (the divide in understanding between researchers and practical application in the workplace) continues to be a great challenge, and a topic of concern, even today. The Tuckman (1965) and Tuckman and Jensen (1977) model of group development is unique in that it emerged as a conversational and practical bridge between academia and workplace practice. This was achieved partly because of its simplicity, and “the utility of providing a simple, accessible starting point for conversations about key issues of group dynamics has not diminished” (Bonebright 2010, 118–119).

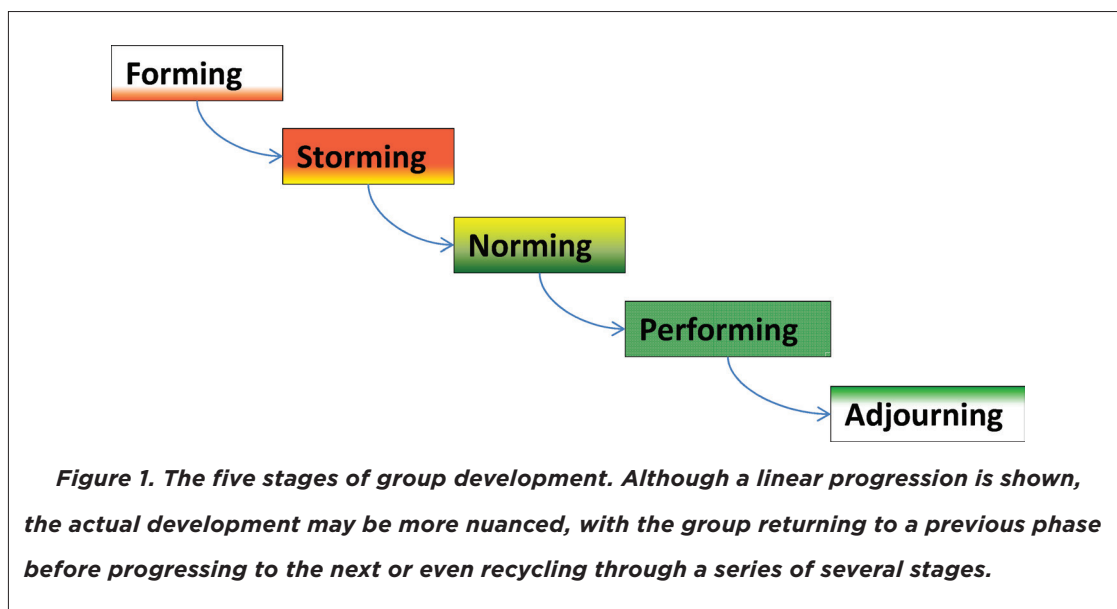


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Almost half of a century has passed since the creation of the Tuckman (1965) and Tuckman and Jensen (1977) model, and links between group stage and productivity have been established in a number of studies. “Groups that function at the higher stages of development are more productive” (Wheelan 2009, 250). Over those years some researchers have been critical of “stage models” of group development as they inherently have some of the weaknesses of stage models for any human-related phenomenon: a lack of apparent flexibility for a specific setting and/or individuals and a typically false impression that a task would occur in a wholly linear fashion. However, the widespread recognition and application of Tuckman and Jensen’s work, and recognition of it as an industry standard (Miller 2003), continues to make it the primary model in the field of organizational behavior. For these reasons and because this article intentionally draws from interdisciplinary knowledge, Tuckman’s revised model of five stages (Tuckman and Jensen 1977) was selected, *a posteriori* (after the data were collected), as a primary lens for analyzing the data. The work of later researchers, such as Weber (1984), also helped to operationalize the characteristics of the stages for the purpose of data analysis.

Stage One Forming

The first stage in the model is one of Forming, and includes group behaviors aimed at clearly understanding and structuring toward the assigned task, comprising both interpersonal and task-related efforts (Tuckman 1965). Behaviors include setting ground rules for safe patterns of interactions, matching expertise to task, and establishing initial relationships. At first, behaviors may appear polite and even superficial but “confusions and anxiety abound as different styles and





needs become evident . . . This first stage may be smooth and pleasant or intense and frustrating” (Weber 1984, 69). Groups in the Forming stage, as they orient toward the assigned task, are also commonly noted for being highly dependent upon the identified leader.

Stage Two Storming

The second stage in the model is characterized by hostility and conflict among group members, including coalescence against the leader. Labeled as “*intragroup conflict*” by Tuckman (1965), “group members become hostile toward one another . . . as a means of expressing their individuality and resisting the formation of group structure” (p. 386). Storming is generally considered the most difficult developmental stage and one which managers and members can misinterpret to mean the group is failing. In reality, group members are “dealing with power and decision making – necessary skills for the future functioning of the group . . . members are working through their own control needs, both to be in sufficient control and to have some sense of direction” (Weber 1984, 70). Tuckman notes that Storming will be most visible when the group’s goal is directed at understanding or changing itself. The stage “will be considerably less visible in groups working on impersonal, intellectual tasks” (p. 386).

Stage Three Norming

In the third stage, group members accept each other and, together, generate norms that guide the behaviors and decision making of members. Intentional efforts toward harmony are a key characteristic of this stage (Tuckman, 1965). The group “becomes a cohesive unit as it begins to negotiate roles and processes for accomplishing its task. Functional relationships are explored and established in spite of differences. The group is ready to tackle its goals, working together collaboratively” (Weber 1984, 70).

Stage Four Performing

It is the lure of the fourth stage, Performing, that makes the development of teams such a focus in the workplace. In Performing, the group becomes “a problem-solving instrument” (Tuckman 1965, 387). The relationships of members are established and members focus on the task at hand with a willingness to play the roles needed to achieve it together. “The emphasis is on constructive action . . . energy previously invested in [the tasks of developmental stages] can be devoted to the task” (p. 387). A “sense of ‘group-ness,’ a feeling of uniqueness of the group with all its strength and faults, occurs. The group now has an identity of its own” (Weber 1984, 70).

Stage Five Adjourning

As previously noted, a fifth stage of Adjourning was added to the Tuckman (1965) model by Tuckman and Jensen (1977) based upon a review of the research that occurred after the model’s



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inception. When groups must disburse, after real bonding has occurred, adjourning becomes a necessary task of closure and letting go.

As noted by Bonebright (2010), numerous researchers have since tested Tuckman's (1965) model in the classroom setting and found it to be applicable. Neither the practical application nor the usefulness of the organizationally-based model is a significant question within the general field of education, or within this article.

RESEARCH QUESTION

This qualitative case study drew from the previous review of literature to address the research question: In what ways are group/team development processes and characteristics outlined in the field of organizational behavior identifiable within an academic computer engineering lab?

DATA COLLECTION SITE AND STUDY CONTEXT

Data used in this case study was collected over three academic years (spring 2010-spring 2012) in three sections of a senior-level Computer Architecture and two sections of a junior-level Microprocessors courses. Course sections were taught in the undergraduate computer engineering program of a U.S. public research university. In spring 2010 and spring 2011, data provided were through focus group interviews; written student reflections were used in fall 2011 and spring 2012. Although both student reflections and focus group data were available for spring 2012, only focus group data were used for this article due to collection issues with the student reflection data. Table 1 shows the data collected in each of the sections – this paper utilizes just the reflections and focus group interviews.

Term	Course Name	Pre-Post Quiz	Student Reflections	Focus Group	Wiki	Video of Lab	Student Peer Evals
S 2010	Comp. Arch.	X		<u>X</u>			
S 2011	Comp. Arch.	X		<u>X</u>	X		X
F 2011	Microprocessors	X	<u>X</u>			X	
S 2012	Comp. Arch.	X	X		X	X	X
S 2012	Microprocessors	X	<u>X</u>	<u>X</u>	X		X

Table 1. Data collected in different sections of the senior level Computer Architecture and junior level Microprocessors courses. The bold and underlined X's denotes data used in this article.

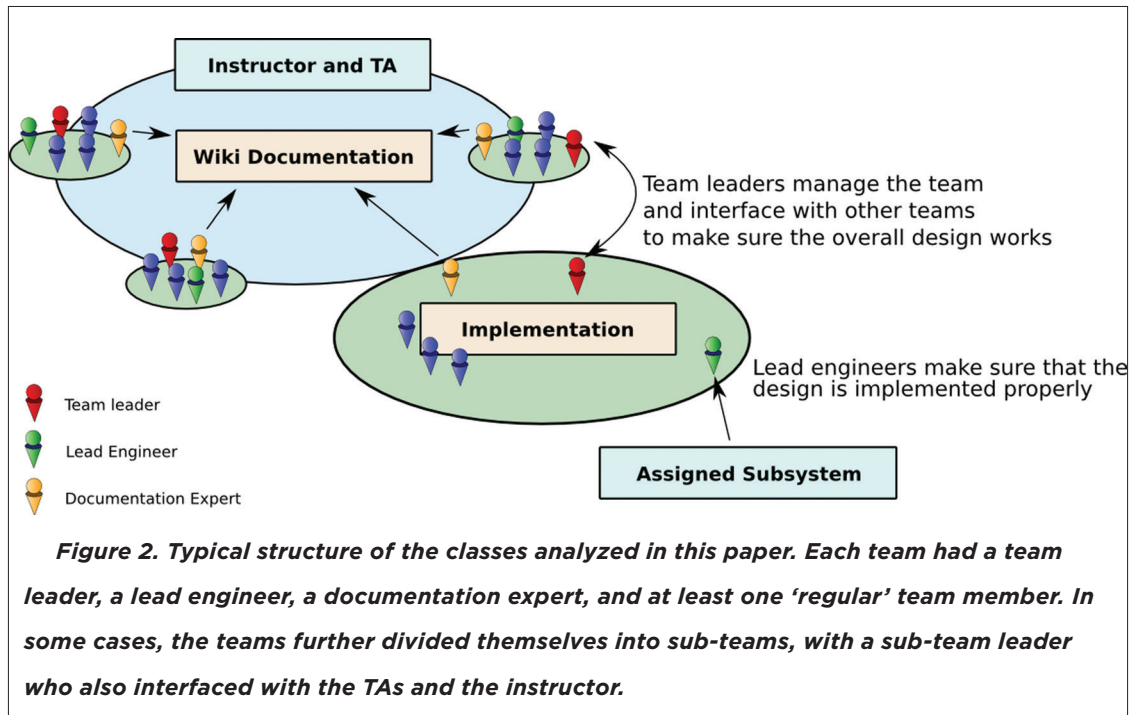


The project for the senior level computer architecture course in 2010 and 2011 was a semester-long class-wide project that involved the design of the pipelined version of the PLP CPU (Fritz et al. 2011). The project was divided into four phases, with team presentations after each phase. The final phase was an integration of the designs produced by each of the teams into one final class-wide deliverable. The project was successful in both years, yielding a functional CPU in both cases. The project for the microprocessors course in 2011 and 2012 involved the interfacing of the PLP CPU with a robot, to program the robot to navigate an obstacle course. While this was not a class-wide common deliverable, it divided the class into large teams that competed with each other. Most teams succeeded in interfacing and programming the robot. Some were more successful than others, and one of the teams won an independent competition called the Mercury Robot Challenge (Mercury 2014).

Natural progressions of the course curriculum, as well as shifting instructors and class enrollment, caused variations in delivery across course sections. In general, some senior-level sections had teams large enough to be broken into sub-teams while junior-level students started worked in pairs (first seven weeks) that later formed into into groups/teams (last eight weeks). Teams in the junior-level class were also large enough to form sub-teams based on the sub-tasks for each team. Overall, team sizes were between 6 to 15 students per team, and most large teams formed sub-teams. In some course sections, collaboratives completed the same task and were in competition against each other; while, in other sections, collaboratives worked in inter-team ways for the class to accomplish one overarching goal. However, in all sections, students were grouped and asked to work collaboratively on either a single deliverable or a large group deliverable, and emphasis was placed on the highly collaborative small-group work. Likewise, data used for this study were concentrated in either the latter half or the end of the semester when all sections were working in collaboratives. Because the intent of this article was not to compare sections but, instead, to consider qualitative themes (trends) across sections, additional and specific course-to-course differences are not further detailed. Figure 2 shows an illustration of the class structure.

TRUSTWORTHINESS

Accurate representation in qualitative inquiry depends upon adherence to established quality criteria, often called trustworthiness criteria (Lincoln and Guba 1985) that are analogous to quantitative research concerns with validity, generalizability, reliability, and objectivity. Qualitative research criteria include: credibility, transferability, dependability, and confirmability. Prolonged engagement and observation, triangulation, and peer debriefing were used to ensure credibility. Triangulation also contributed to confirmability, as did researcher reflexivity. External audits were used for ensuring dependability.



Transferability in qualitative research refers to the applicability of findings to settings or circumstances other than those at the study site. While the onus of judging generalizability in quantitative research (analogous to transferability) typically lies with the researcher, qualitative research places the burden of judging transferability of findings onto the reader. As qualitative research is carried out on an example of a larger population or circumstance, its findings may be transferable within those broader boundaries (Stake 2010). Assisted by a detailed description of the study site and circumstances, it is the readers who judge the similarity to other sites. This study, as a qualitative research design, details the environment and describes students in order to provide readers with the ability to judge application of the findings to their own settings.

DATA COLLECTION

Perhaps the greatest value of qualitative inquiry (see Creswell 2009; Patton 2002; Stake 1995, 2010) is its ability to discern the individual experiences and perspectives that sit beneath quantitative measures. Because the classroom and, when considering groups and teams, the workplace environment have a clear focus on human perception, beliefs, and behaviors, this article reports findings based primarily upon qualitative inquiry (although quantitative data were collected for the larger



study with its differing focus). Because the qualitative data were captured within defined time and space, the study design is a case study.

For all students, this was their first exposure to the Progressive Learning Platform (PLP). Because the use of PLP, a knowledge unifying hardware/software system, has been found to blur the traditional lines between classroom and engineering lab (Sohoni, Fritz and Mulia 2011; Damron et al. 2013; Mulia et al. 2013; Sohoni, Damron and Kearney 2014), data were collected in both environments. When instructors used a specific term, “team” was chosen for communicating with students (and was the term most aligned with the language being used by all engineering faculty). Students were *not* taught the differences between groups and teams.

Written Reflections

As a part of regular class activities, students wrote reflections throughout each semester. In the junior-level class, reflection prompts that encompassed project work from the last 8 weeks of the semester (labeled Lab 5, A-G) were used. The first eight weeks of the semester, the lab work focused on work in pairs and the reflections focused on the individual learning. Table 2 presents the prompts.

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- 5A How has your group worked together toward developing a complete understanding of your subsystem? How did individual team members contribute to this understanding?
 - 5B Did your group have any “false starts” or begin down a path only to have to turn back when conducting research for your program? Describe in detail what happened. For example, what specific decision led you to the “false start”? If not, why do you think your team was able to progress so smoothly? Give a specific example.
 - 5C In the process of learning about your subsystem and planning your program, what problems did your team have to resolve? Describe the problems and why you think they occurred. What about working as a team made it more difficult to resolve the problems? What about working as a team made it easier to resolve the problems?
 - 5D So far, has having designated team member roles been useful to the overall progress of your program? In what ways? Give specific examples. Do you feel restricted by your designated role? Why or why not? Remember your team members won’t see this, so feel free to be honest.
 - 5E Now that the program is done, what have you learned about researching, planning, and documenting the project? Say something about each of these phases. How does this learning process compare to the partnered lab work you completed during the first half of the semester? Which do you prefer and why?
 - 5F This week, you came together to integrate the parts of the project. What are the benefits of dividing the work on this project? Give examples from your group work. What are the drawbacks of dividing the work on this project? Give examples from your group work. What have you learned about implementing and documenting your design?
 - 5G This project is complicated. Now that you see your work as part of this larger piece, do you feel like your individual work contributed to the success of the overall project? How so? Describe your overall experience with this group project. What strengths and weaknesses did you observe about teamwork? What problems did you experience when you put the bot together? When you work in teams in the future, what would you apply from this experience? And what would you avoid doing?
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Table 2. Reflection prompts used during last 8 weeks of the junior-level sections.



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- 1 Describe your learning experience in this class. How does it compare to other learning experiences in your engineering coursework?
- 2 In what ways were you able to link learning from other classes to this one? What are the areas that applied? How did you apply your previous knowledge?
- 3 How would you describe your interest level within and across the time of this class? What caused your interest to increase or decrease at varying points in the class?
- 4 Describe the level of collaboration that was required with your classmates. In what ways was this alike or different from experiences in your other coursework? What do you see as the effects or impacts?
- 5 In what aspects did this class help you to prepare to work in engineering in the “real world”?

Table 3. Focus Group Question Guide.

Focus Groups

A total of 28 students participated in three focus groups; six were women. Focus groups engaged in open-ended discussion, guided by a focus group question guide, and led by a faculty researcher from outside of the engineering college. Sessions were audio-taped and transcribed verbatim. The focus group dialogue guide is presented in Table 3.

DATA ANALYSIS

This study used standard methods of qualitative analysis. Inductive (or open) coding for focus group data produced 12 first-order codes. Closed (deductive) coding of the students' written reflective pieces (using codes from focus groups), additional open coding of the written reflections, and axial coding resulted in a total of 8 first-order codes, 16 second-order codes, 7 third-order codes and 1 fourth-order code. Deductive coding using the group development theory (Tuckman 1965; Tuckman and Jensen 1977), without concern for time or order of the stages, added an additional 6 third-order codes. At this point in the analysis, there were a total of 433 pieces of coded data. One additional round of deductive coding was performed using items provided by two validated self-report retrospective surveys specific to assessment according to the Tuckman (1965) and similar stage models (see Miller 2003; Wheelen and Hochberger 1996, 154–156).

Analytical and coding-related memos were created throughout the coding process and in a re-consideration of all coded data. For the purpose of this article, a small number of codes unrelated to the group or team development process were set aside.

Corpus Linguistics

Corpus linguistics is a subfield of linguistics in which the researcher examines large sets of text produced through written and oral communication for patterns of language use (see Hunston 2011;



Hunston 2003; Partington 1998). In this particular study, the large sets of texts were student reflections, which were specifically elicited to determine student perspectives on their learning and their group/team participation. The analysis presumes that language reveals more than just the propositions contained in the language: “Communication is more than just the exchange of information, goods or services; communication also involves personalities, attitudes and assumptions of those who are communicating” (Hyland 2005, 3). In particular, these attitudes are referred to as “stance”. DuBois (2007) proposes a stance triangle in which the stance taker 1) evaluates an object 2) positions a subject (usually the self) and 3) aligns with other subjects. There are various grammatical devices that express stance (Biber et al. 1999), one of which is modal auxiliaries. Modals (can, could, will, would, shall, should, may, must, might) are a type of word that helps the speaker add a layer of meaning that indicates ability, necessity, obligation or volition, as well as other meanings. A category of modals is the lexico-modal. These are idiomatic expressions that express modal meanings (Collins 2009). Included in this category are *need to*, *have to*, *want to* and *able to* and their past tense versions *needed to*, *had to*, *wanted to*, *were able to*. Table 4 shows the meanings of the lexico-modals.

When these lexico-modal forms are used, they indicate a position toward the information that follows. For example, when a speaker ‘has to’ do something, there is an obligation, sometime externally motivated, sometimes internally motivated. ‘Need to’ on the other hand, is mainly internally motivated necessity or obligation. ‘Want to’ shows that the speaker is internally motivated to take action and ‘able to’ indicates that there is an ability on the part of the speaker to do something. The value of analyzing these forms for this study on group work is that the lexico-modals could help show the extent to which individuals are expressing their obligations, needs, agency and ability in relation to the groups. To study the stance of the students toward collaborative work in the latter part of the junior-level course, Lab 5 student reflections (a total of 44,358 words) were analyzed using a corpus-based approach and the concordancing program AntConc. Concordancing software considers word counts, words in context and clusters of words. “We” was examined for collocates (words that co-occurred with this pronoun) to determine the students’ group perspectives or attitudes toward an object (Examining ‘we’ rather than ‘I’ would help determine the individual

Lexico-modal	Meaning
Have to	Obligation/necessity
Need to	Obligation/necessity
Want to	Volition
Able to	Ability

Table 4. Meanings of lexico-modals.



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student's team/group stance). To deduce further meaning, the occurrences of the lexico-modals were then examined within the context of the sentences in which they occurred. For this section of data analysis, the progression of time in each semester, as related to the data, was considered.

DATA PRESENTATION

Data analysis across all three years of data showed that varying elements of the stages (Tuckman 1965; Tuckman and Jensen 1977, 2010) were present in every semester. Across the course sections (in a meta-analysis), the stages of forming and performing were most prominently supported by both qualitative analysis and corpus linguistic methods. The presence of the stage adjourning was almost non-existent in some semesters and completely missing in others. This was likely a function of the fact that the collaborations were still intact at the time of data collection; thus this last stage, *while considered an important stage for attention in the work environment*, was dropped from further consideration for this data.

Linguistic analysis of selected data from junior-level sections showed that lexico-modals were present in the top ten three-word clusters; *we* is the first item of the three-word cluster. Table 5 shows the ranking of top ten three-word clusters for the seven reflections of Lab 5 in the junior-level sections.

Have/had to is the most frequently occurring lexico-modal in English (Biber et al. 1990; Collins 2009), and forms of *had to* were the most widespread across student reflections. The lexico-modals *have/had to*, *need(ed) to*, *(were) able to*, and *wanted to* were the most frequently occurring and,

Rank	5A	5B	5C	5D	5E	5F	5G
1	need to	had to	had to	all contribute	needed to	had to	had to
2	needed to	decided to	had a	all share	were doing	didn't	did not
3	had to	didn't	ran into	are all	got to	ended up	didn't
4	were able (to)	wanted to	wanted to	couldn't	had a	were able (to)	put the
5	didn't	did not	were able (to)	didn't	wanted to	would have	were able (to)
6	have to	have had	weren't	had a	had to	want future	could have
7	should use	decided on	also had (to)	have to	came together	were doing	do not
8	talked about	had a	also need (to)	needed to	did at	were not	got it
9	all met	needed to	decided on	were to	didn't	actually presented	had a
10	are going	were able (to)	did not	wouldn't	need to	also have	had no

Table 5. Ranking of top ten three-word clusters for Lab 5 Reflection Prompts A-G (*we* is the first word).



therefore, the focus of study. It was not surprising that the past tense versions of these lexico-modals were most frequently represented, as reflection prompts required writing about past thoughts and actions. This makes the present tense use interesting. In this case, uses of present tense *have* and *need* in the lexico-modals indicated future action.

The following subsections present the outcomes of both qualitative analysis and linguistic analysis according to stage.

Forming

Students seemed to interpret instructor-designed team building, held first in the semester, as time specific to “building the actual teams . . . not in the sense of building relationships.” Students referred to specific tasks that appeared closely associated with the group development stage of Forming such as matching abilities of team members to task. One student said “It wasn’t so much one person choosing what position they wanted but rather the entire team had a say in who they thought should take each role.” The task at hand was matching expertise to task, a designated function of the stage of Forming; although this task is often directed by a leader during Forming, in this case, designated leadership was not in place, which forced the members to fill the role as a collective.

About the first week, a second student reported his team was: “. . . sitting down and brainstorming. Each person in my team would give their idea about what should be done and after each person said what they thought we talked about as a group.” In this case the effort to orient members toward the task at hand was individually driven, then discussed as a group. This statement exemplifies the careful and often polite efforts to sort roles and tasks that exemplify Forming behaviors.

Linguistic analysis of the junior-level students’ reflections showed an early stance toward goal-setting around the task at hand with a need to understand or “get an idea” of what they needed to know or do. Language was initially individualistic and task related rather than reflective of an intact working unit of people, although some elements of collective action began to occur late in this set of reflections. Table 6 shows the lexico-modals occurring in the top ten three word clusters, and their contextual analysis for Reflections 5A-C (weeks 8-10 of the semester, corresponding to the first 3 weeks of the final project). Frequency of occurrences is included as a means of comparison only.

In these early reflections, the sense of obligation and necessity are externally motivated: the class requirements drove the task orientation. Volitionality revolved around discovering how and what the tasks required of them as a group. In Reflections A and B, the focus was on accomplishing and doing—action-based work initiated by the task at hand. As the lab progressed, the reflections showed that groups were learning to think as groups. For example, as Table 6 shows, the verbs that collocated with ‘had to’ in Reflection C were cognitive verbs—they had to figure things out or understand something or coordinate, make sure or solve problems together.



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Reflection	Lexico-Modals	Number	Outcome of Analysis
A	Need to	7	<i>Need to</i> and <i>needed to</i> show that the students were future oriented with their obligations and goals. They needed to “do” and “accomplish.” The instances of <i>had to</i> in early reflections were grouped around logical necessity; that is, the students were task oriented. They <i>had to</i> understand what the specific sensors did and the components of the robot they <i>had to</i> use; they <i>had to</i> research how to implement what they <i>had to</i> do. [italics added]
	Needed to	6	
	Had to	4	
B	Had to	8	The instances of <i>had to</i> were generated by external need, for example they <i>had to</i> “redo a lot of code.” <i>Wanted to</i> expressed a kind of agency and internal necessity but with a focus primarily on the task. Even when language suggested that some groups were beginning to form as decision making units (“From that point forward, we knew the path we <i>wanted to</i> take and took it.”) or units of action (“We were <i>able to</i> run through this project smoothly by assigning simple tasks to everyone”), decisions revolved around tasks. [italics added]
	Wanted to	6	
	Needed to	4	
	Able to	4	
C	Had to	21	Of the 21 uses of <i>had to</i> , seven showed the beginnings of team decision-making. The verbs associated with <i>had to</i> were <i>change</i> , <i>coordinate</i> , <i>decide</i> , <i>make sure</i> , <i>resolve</i> (also language used in the prompt), <i>understand</i> , <i>figure out</i> . In general, <i>had to</i> indicated external necessity, whether team or task-oriented. Only three examples of <i>wanted to</i> occurred; unlike the previous task focus, these expressed the process of team decision-making. The instances of <i>need to</i> focused on internal necessity toward the task for the future: “We also <i>need to</i> determine how we will sample from the sensors to obtain useful information.” [italics added]
	Wanted to	3	
	Need to	2	

Table 6. Key Lexico-Modals for Lab 5 Reflections A-C.

Storming

One student stated, “Of course, like with any team, there will always be some issues.” Another said, “The team started to get angry at each other and was trying to figure out what was wrong.” A third student reported “some separation happening within our group.” However, whether because it did not occur in distinct form or because students did not comment on it in the data, evidence of the stage of storming was minimal in the qualitative analysis of data.

Linguistic analysis also showed minimal data for the stage of Storming. In seven of the eight cases, *had to* was expressing the negatives of the work but in the context of the process. These instances showed a much more nuanced understanding of the team/group work, “Making sure that each program interacted correctly wasn’t always easy, because we *had to* understand what the other parts of the code were doing”, “However, in the end, we *had to* do some changes with people’s coding because we didn’t write each part”. As these examples show, the negative context of the sentence motivated having to do something. When negatives became prominent in student language, this was initially thought to be an indicator of some level of Storming; however, further analysis showed the negatives were related to how students learned about the collaborative problem-solving process rather than intra-team conflict.



Norming

Evidence of Norming (the third stage in Tuckman's model) was greater than in Storming but much less than the Forming and Performing. Some examples of data related to Norming were: "One of the critical points we emphasised [sic] was having effective meetings and planning sessions," "We made sure everyone in the group knew what we were doing and what was expected of them," and "This was our common understanding. Everyone cared, everyone wanted to be there, and everyone wanted the bot to succeed."

Linguistic analysis also showed evidence of Norming in Reflection D. The only lexico-modal to appear as a frequently occurring 3-word cluster was *we needed to*, and it occurred only twice. Both instances were oriented toward the groups, one negatively and one positively. Despite few three-word clusters in Reflection D, the word *all* repetitively occurs. This may have been an indication of some Norming—an acceptance of the collaboration.

Performing

The stage of Performing, arguably the most desirable of the stages, was also the most prominent in the reported data. The methods through which data were collected did not allow us to specifically determine whether collaborations resulted in true teams or groups in this particular environment; however, group (vs. team) structure was evident through continued references to which an individual was responsible for specific tasks or outcomes (a characteristic of Performing groups vs. Performing teams); in other words, the tasks, in these reflections, were not owned by the collective, but the relationships of members were established and members focused on the task with a willingness to play the roles needed to achieve it together.

I felt like [teammate 1] did a good job of being the project leader... [teammate 2] did a great job writing his C# application... [teammate 3] did his part by creating the power point [sic] presentation in the beginning of the project, and all of the documentation at the end of the project.

Another student suggested that separate (individual) performance measures were associated with each individual's work, "Because we split the work up it was also easier to see who did their fare [sic] share of the work and who did not." Even when the group tasks solved a problem, the language used showed the work was additive – each person added a specific, individual task.

The multiply algorithm I had written on my own was pretty slow and the divide one I was about to write was going to be even slower... my teammate found an... algorithm that was probably



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one of the most efficient fixed point multiply/divide algorithms I have ever seen. We were able to test out these functions thanks to [another teammate], who wrote Matlab GUIs to test them out.

Other data related to Performing strongly suggested that elements of true teaming were in action for some collectives. Individual credit was largely absent from the language used even when students mis-applied the terms group and team: “Someone brought up the idea that because we have values that are all similar, the motors might pick up the wrong values and cause sudden turns when we didn’t want them. We sat down and as a group decided the best way to fix this problem,” “As a group we decided to have the bot going in reverse,” and “Blame’ was not a thing that could be properly assigned... everyone did have their hand in all parts of the project, for the most part.”

Likely because of a reference to roles in the reflection prompt, there were numerous references to roles within the team: “None of us really stick to one role. We were helping each other,” Student language showed that even when specific roles were assigned in the Forming stage, those fell away as the work progressed, “We did not really stick with strictly defined roles for teammates... we all did whatever work needed to be done, whether it was figuring out a section of code or simply running up to the fourth floor and back to grab the bot for testing,” and “We worked not like parts of a machine, but more like humans trying to accomplish a goal, doing what needed to be done when we needed it done instead of acting within our role.” An additional student said, “For our purposes, the assigned team roles really weren’t that useful . . . we were all responsible for leadership roles and we were all responsible to make sure our algorithms were formatted correctly and compatible.”

Some components of data did not specifically describe team-like attributes, however, the language used strongly suggested that the successes were shared by all: “Within minutes, we had incorporated this code, re-downloaded to the robot, and were sensing changes in the line location instantaneously!” Other challenges and failures also appeared to be owned by everyone, perhaps indicative of the teaming mentality that the team either rises or falls together:

Somewhere right around midnight . . . the bot starts to slow down . . . This was very frustrating for the group, because only a few days ago the bot ran like a champ . . .

The team spent hours trying to analyse [sic] the responses and the best model we made was able to obtain a pulse that matched the speed of the bot, that pulse would repeat faster and faster as the bot increased in speed.

By Reflection E, linguistic analysis also showed students’ language was reflecting collaborative effort (whether group or team). This language was prominent throughout the remaining Reflections E-G, as shown in Table 7.



Lab Reflection	Lexico Modals	Frequency	Outcome of Analysis
E	Needed to	8	The lexico-modals <i>needed to</i> , <i>need to</i> and <i>wanted to</i> showed internal compulsion from a group source: “We knew what we <i>wanted to</i> do and how we <i>wanted to</i> do it.” Two of the three instances of ‘had to’, expressed external necessity, “We <i>had to</i> figure out how to connect the joystick”, “In that time, we <i>had to</i> do extensive debugging”. However, the third instance shows a kind of group internal necessity “we <i>had to</i> decide how we wanted to make the communication protocol.” [italics added]
	Wanted to	4	
	Had to	3	
	Need to	2	
F	Had to	8	In seven of the eight cases, <i>had to</i> expressed the negatives of the work; these instances showed a greatly nuanced understanding of the collaborative work: “Making sure that each program interacted correctly wasn’t always easy, because we <i>had to</i> understand what the other parts of the code were doing” and this “allowed us more time to work on each part of our work thoroughly than if we <i>had to</i> do everything.” The other lexico-modal in this set of reflections, <i>able to</i> , occurred three times: the students were <i>able to</i> solve problems, divide up the work, and split up the math library. [italics added]
	Able to	3	
G	Had to	7	<i>Had to</i> was the most frequently occurring lexico-modal but continued to show a nuanced understanding of the group work: “Working together allowed us to divide up the work and get code done faster, but we <i>had to</i> communicate to make sure the code worked together.” Four instances of <i>able to</i> included one that was a repeated instance and thrown out. Of the three remaining, two focused on group work: “We were able to solve a number of problems as a group” and “One of the big strengths that we had was that we <i>were able to</i> get a lot done with the different groups.” [italics added]
	Able to	4	

Table 7. Key Lexico-Modals for Lab 5 Reflections A-C.

Obligation and necessity were internally motivated at this point in the semester. The use of the lexico-modal ‘had to’ in Reflections F and G occurred in subordinate clauses in the sentences in which they occurred—shifting to provide emphasis to the main clause actions the groups were doing. In short, the groups are working together. At this point they are able to perform both communicative and problem-solving tasks in inter and intra group situations.

DISCUSSION OF STAGE DEVELOPMENT DATA

The presence of the group development stages Forming and Performing were clearly found in the data, with the greater volume of data supporting Performing. Storming and Norming, while identifiable in some form, had a diminished presence in the data. It is possible that students simply chose to emphasize reports about Performing; however, as early as 1965, Tuckman may have foreshadowed the rapid movement of some similar groups or teams to Performing:

The relatively short life of the laboratory group imposes the requirement that the problem-solving stage be reached quickly... Consequently, [they] are forced to develop at a rapid rate. The possibility of such rapid development is aided by the impersonal and concrete nature of the laboratory task... One would expect the laboratory group to spend relatively



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more time in the fourth stage relative to the first three stages because of the task orientation in the laboratory setting. (p. 397-398)

Shortly after Tuckman's statements in 1965, Smith observed seven men stationed in Antarctica over a period of four months and also concluded that "development would be different for various groups... task activity was stressed by the men in Antarctica... suggest[ing] that those aspects related to the primary purpose of the group develop first" (Smith 1966, as reported by Tuckman and Jensen 1977, 44).

Other researchers, too, have reported evidence that "groups performing different tasks may differ in the way they develop" (Chidambaram and Bostrom 1996, 175-176). That context and task *matter* is further supported by the data in the current study where numerous students had prior interactions with each other: "At the start of the project it was not difficult to establish a plan of action as we have all experienced working in groups in previous engineering classes." These factors, combined with the nature of the technical task assigned, may mean that the engineering students in the current study did, indeed, move very quickly through early group development stages. And this, a modification at least in emphasis on Tuckman's developmental stages, may be a common occurrence that engineering instructors in similar circumstances should expect.

Regardless of the speed at which the stages may have occurred, data suggest that Tuckman's (1965) stages are identifiable. Surprisingly one student *without knowledge of the group or team development process* seemed to outline the stages quite clearly:

Our group all started together and were somewhat energetic... We made sure everyone in the group knew what we were doing and what was expected of them... [then] you see some separation happening within our group... We had group members who... took up our time and focus and that caused some division in the group... We got through everything. Were there bumps in the road? Yes. Did the group always work perfectly? No. But when push came to shove and we had to finish our portion of the project, we worked hard, asked questions, and tried to do the absolute best we could. Was it perfect? No. Were there times during the presentation week that things got hectic? Yes. But overall, as a team, I would have no problem working with this team again.

OTHER DEVELOPMENTAL ISSUES FOR GROUPS AND TEAMS

In addition to a consideration of the stages of group development, qualitative themes in the data also addressed a number of other group/team development-related issues that will be briefly highlighted in this section.



Diminishing Role of Outside Directives

Qualitative data showed that the role of the teaching assistant (TA) in this particular structure was viewed as different from other classes. Students reported that TAs served “as a bridge between lecture and lab” and generally agreed that the TA’s role (and teaching style) was critical in this particular structure. As described by students, the TA and course instructor may have been viewed as the initial leaders, or proxy managers:

If I looked at [the TA] and [the instructor] as supervisors, at some point there should be a “come to Jesus” moment from them . . . There was no way to escalate the problems or take it to our supervisors – they didn’t do this automatically from the peer evals. Supervisors need to address the big issues – students not comfortable telling peers that they need to change performance – will put it on a peer evaluation . . . That is more how it works in the real world.

Group development theory suggests that formal leaders provide initial structure and strong direction, and their roles will fade as collaboratives take ownership of their identities and tasks (as they develop into work groups or teams). This seemed evident in one student’s comments about a problem encountered late in the semester, “We immediately called the project leader, [Andrew], and talked to him about what we could do.” It is important to note that Andrew (a pseudonym) was a member of the team, not a TA in the classroom; in this instance the team was relying primarily on their own members rather than a more traditional student’s response of going to the teacher for help with the problem.

Linguistic analysis seemed to also support the idea that the role of the external manager/leader diminished as the collaborative took ownership; verbs used by students shifted from an external, task focus to an internal, collaborative focus. This changing use of language indicated that reliance on the TA and instructor, and perhaps the perception they were in authority, diminished over the semester as groups/teams spoke in ways that suggested they relied on their own members.

Size Matters

The issue of size (the number of people on the group or team) was a common theme for students, particularly in focus group discussions. Because of unexpectedly large class enrollments, teams were larger than intended by instructors. Students found this to be cumbersome and perhaps a negative intervener in their abilities to develop and work together toward the goals: “So many people in my group – 8 – there were four of us that steadily researched and wrote code and understood the code. The other 4 – even if they wanted to – there just wasn’t enough for them to do.” Another student said only “two or three are really involved, rest are hanging out. Not enough work to keep everyone



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busy. Teams were too big for what we had to do.” A third student said, “We have 15 member team and now 5 people are dragging their ass . . . we have 33% of our workforce not doing anything.”

Most students reported the large size of collaboratives as a problem – a negative in the process. There were, however, occasional reports that students found ways to cope, “Even when there was no work for 90 percent of the group, no one just left the one member to do work on his own.”

While there is evidence of links among group or team size, group development (ability to reach the latter stages of development), and productivity (Wheelan 2009), the interdisciplinary literature is not clear on the ideal number of members—neither in general nor in relation to specific kinds of tasks. Large collaboratives are faced with increasing hierarchical, logistical and relational issues as well as decreased ability to make space for all viewpoints to be heard (Adams 2003; Katzenbach and Smith 2005). Discussions with colleagues at various engineering conferences and symposia often yield an ideal size of 4, but published literature cites various sizes; between 2 to 8 (Michaelsen 2002, 10; Johnson, Johnson and Smith 1998).

A 2009 OB study by Wheelan attempted to better identify “ideal” size. Although “ideal” size proved to be a moving target, results did show somewhere between 4 and 8 members seemed to be critical mass in terms of reaching higher levels of productivity (greater group development). While the OB literature specifically discusses different group sizes, the take away message is that the ideal size depends on the type of task and the purpose of the team (for example, decision making, or planning, or product development or troubleshooting), but with the general consensus that larger groups tend to suffer from social loafing, poor communication and loss of clarity of objective (Carral et al. 2001). In the current study, the number of students assigned within each collaborative was consistently greater than 6 and, in some cases, more than double that number. Thus, it is in keeping with the literature, that students were innately pointing to size as a challenge or problem. At minimum both the literature and this study support Wheelan’s (2009) recommendation for “leaders and managers to limit work group size to the smallest number of members necessary to accomplish group goals” (p. 260).

Time Matters

Although the time periods in the current study were capped at the traditional 16-week semester (a timeline that is further shortened by opening and closing semester activities), the data strongly suggest that collaboratives reached the performing stage; in fact, the predominance of data collected represents activities and actions associated with the performing stage. Some groups and teams literature suggests that the length of time a collaborative is together must matter in terms of reaching latter stages of group development and, thus, impacts productivity. Indeed, Wheelan (2009) specifically states that “in general, it takes about 6 months to traverse the stages of group



development” (p. 251). Adams (2003) stated time as a specific challenge for classroom-based groups or teams, citing concerns that, unlike in industry, students do not have the opportunity to build long-term reputations and/or have extensive personal connections that go beyond the start or end of any one team. Initially these components of the literature and, perhaps even common sense suggested that limited time would be a problem. However, other researchers (e.g. Ginnet 1990) show that context (issues such as intensity of task, type of task and scaffolding that speeds time through early stages) may change the importance of time.

In the academic environment, “facilitation of group working structures” (Livingstone and Lynch 2000), or deliberate assistance from instructors, is important and allows collaboratives to progress more quickly to latter stages. This may range from instructor-assigned teams (as in the current study), scaffolded activities that lend themselves to rapid team building, prior experience working in teams (and whether previous teams were indeed meant to be teams or groups that were mistakenly called teams, leading to negative experiences for the participants), and type of task. Likewise, the tendency to consider the start and finish of a specific class as impermeable boundaries may be a false construct. As students work in a variety of ways with each other throughout a program, they form relationships and beliefs about teams. They naturally carry these relationships and beliefs to subsequent classes. This may mean that by latter years in a program (e.g. junior and senior years), and particularly with cohort-types of programs, early developmental stages of team building in a particular class may begin from an already partially developed state brought forward from previous interactions.

Tuckman never associated time with the stages of group development. Instead, he stated that any collaborative focused on a task will attempt to traverse the stages. This is illustrated in Chidambaram and Bostrom’s (1996) review of Tuckman’s model.

Therefore, a way of understanding the group development-performance relationship is to view the former as the means and the latter as the end... high performance—now can be regarded as a process that can either be speeded up... or slowed down... based on contextual variables. Therefore, the length of time a group spends together in itself is neither an indicator of how well developed a group is nor an indicator of how well it can perform. (Chidambaram and Bostrom 1996, 182)

This may help to offset some commonly held concerns that the time-related structure of academia does not allow for full development of student collaboratives; instead instructors may be able to control for this perceived limitation through deliberate choices and increased understanding of how groups and teams work.



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Performance Measurements Matter

Reward systems, including performance measurements, are closely associated with one of the reasons for careful differentiation between groups and teams. As a reminder, the work of groups could be described as additive wherein each member has a specifically identifiable task that, added together, creates a shared group product; in this case, and in general, individual measures (that remain external) best support the structure. In the case of true teams, work is evolving through the interactions of members, and “ownership” of work becomes blurred to the extent that it becomes difficult or even impossible to differentiate individual work from the work of the team; in this case the team rises or falls as a collective making external and *internal* collective measurables (with perhaps some individual element remaining) the evaluation standard that best supports the intended structure (Katzenbach and Smith 2005).

In the current study, the issue of performance measures (resulting in grades) was a common focus of student comments. The stated intent of the instructor was to build teams, and much of the evaluative emphasis was appropriately placed upon collaborative effort. Based upon theory, this should have caused students to seek true team behavior, and student comments showed that the structure was, indeed, recognized as making them heavily dependent upon each other, “It made all of us feel responsible for the entire project... everyone did have their hand in all parts of the project, for the most part. I feel like this made us work more like a team than as a group of individuals.” The emphasis on evaluation of collective (rather than strictly individual) effort was not always a welcome factor within the heavily competitive arena of engineering, “I contributed but other people who contributed nothing got the same points. Especially on Phase III, individuals who didn’t show up at all got same points as those who put in 40 hours in the lab,” and “I don’t mind a team but I also like being responsible for my own grade – a little weird knowing 90% of the grade came down to the team.”

Despite the imposed performance system, a small number of groups appeared to hold tightly to a structure of individual accountability, “We also divided the work between the members about equally to ensure that one person wouldn’t get loaded down with work and others wouldn’t do anything.” It is possible that the individualistic nature of the academic environment worked to balance the effects of collective measures of evaluation, and it is not known how this may differ in the workplace.

For now, and for all of the reasons previously discussed, it is *not* our opinion that teams should be the only goal within the classroom or the only or best outcome for success. Gaining the level of a true team, especially within particularly competitive and individualistic cultures such as the United States, can be quite difficult and expensive. Effective work groups appropriately carry more of the load and this should be recognized when devising evaluation systems in the classroom (as well as within industry). Perhaps the most important thing we are *not* teaching most engineering students is that there is, indeed, a difference between structure and expectations for work groups versus teams. Whether one or the other is better depends upon task and context; however, decisions like how to evaluate collaboratives will either work toward or against the goal. Thus, the method of evaluation is a critical decision.



CONCLUSIONS AND IMPLICATIONS

This paper investigated group/team development in computer engineering courses at a University in the Central USA from the perspective of organization behavior theory, specifically Tuckman's model of the stages of group development. The investigation was conducted through linguistic and qualitative analysis of reflection essays, and through focus group interviews. Our analysis shows that we did indeed observe evidence of the different group development stages as the semester progressed, with clear indications of collaboratives that were performing. The observations support existing literature, for example, shorter storming phases in groups working on impersonal, intellectual tasks, and large teams tending to allow students to 'coast' or 'loaf' through a project without contributing much. For researchers in engineering/STEM education, the paper also presents the combination of linguistic analysis and focus group interviews as a method to obtain nuanced information about how groups and teams function. This method can also be used to study specific treatments or interventions. The third contribution the paper makes is to provide a discussion of the organizational behavior literature on teams and groups.

Given the importance of exposing students to collaborative work and having them achieve the interpersonal skills necessary, we make some predictions and recommendations from organization behavior theory. Knowledge of the group development process, as well as the difference between work groups and teams, is important interdisciplinary information that, ideally, should be well understood by engineering faculty. Because of its communicability, the Tuckman (1965) and Tuckman and Jensen (1977) model may remain the "best" model for bridging research and practice. Engineering instructors (as well as managers in industry!) need to develop a more nuanced understanding of the meaning, structure and work of groups versus teams. The social pressure to think teams are the goal undermines the critical role and work of the work group - the structure that will likely be the primary experience, at least for the American worker. This point also illustrates the importance of sharing interdisciplinary knowledge and the benefits for faculty to engage in interdisciplinary teams while conducting their research in engineering and STEM education, as some of the issues faced by engineering instructors have been discussed in great depth by researchers in related fields such as organization behavior.

Instructors with similar engineering classroom environments should expect group development to move quickly through early stages. Indeed, given the time limitations of the traditional academic semester (and the possibility of some courses being taught in even more tightly compressed time periods) it may be helpful for instructors to deliberately encourage conditions that move groups and teams quickly to performing. Supporting this, also, is Livingstone et al's (2000) finding that individual abilities (less capable or more capable) are less of a factor when the group is performing; this may lessen student concerns about grading schemes that emphasize collective over individual effort.



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The way the collaboratives progressed through the stages in the current study was likely affected by prior knowledge of other team members, prior work in groups in other engineering classes, and the technical nature of the task assigned. Interestingly, the analysis revealed that students were much more aware of the group's development than expected, and their understanding was quite nuanced, without any formal guidance from the instructors. To the best of our knowledge, formal training on teamwork was not covered in prior coursework. With a clear understanding of the differences between groups and teams on the instructor's part, careful planning of the course project accordingly, and a dialogue about this with the students, we expect students to function even better in collaboratives in the classroom that may better transfer to authentic workplace skills.

Additional research is needed on what factors cause groups or teams to develop at different paces or with differing emphasis on particular stages. This knowledge would allow engineering faculty to further structure classroom/lab processes so as to give students the best preparatory experience for the real working environment. While (due to the data collected) this article has focused on intra (single)-group or team development, it is important to note the criticality of collaboration across teams (inter-group or cross-functional collaboration) (Salas et al. 2008). Our data (and those of other researchers) suggest this can be structured into the student experience in the classroom and is perhaps most driven by the type of task assigned (whether it requires that collaboratives communicate with each other to reach the overall objective). Certain portions of our data suggested that this next layer of inter-group collaboration (that of groups/teams with each other) may occur naturally based upon the demand to complete an overall task that requires input from all. As stated earlier, the onus of transferability of qualitative research findings is usually placed on the reader, and not on the researcher, but broadly speaking, we expect the findings of this study to be applicable to other disciplines and other courses in engineering educational settings.

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